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Digest

Renewable energy sources

How they work and what they deliver

Part 1: Photovoltaics

John Holden and Abhilash Rajan

This Digest provides a basic understanding for people who have little or no prior knowledge of solar photovoltaics, and for engineers and architects who wish to know more about the technical details of photovoltaic modules.

It includes an introduction to different types of solar photovoltaics, their properties, operating characteristics, annual energy performance, standards and certification. The Digest will also discuss the components of PV systems and their purpose. However, this Digest is not intended to be used as a technical guide for the installation of photovoltaic systems.

This is one in a series of four related Digests. Each focuses on a renewable energy technology commonly used in domestic buildings. The other Digests in the series cover wood fuel, heat pumps and solar thermal collectors.

Solar PV installation at the BRE Group site at Garston

Introduction

Climate change and depleting resources of fossil fuels have increased the significance of renewable energy in the sources of energy that we use. Renewable energy can be generated from a number of sources including wind, sunlight, moving water, biomass and heat contained in the ground or in water. These sources are universally available, albeit with variations, and generating renewable energy from them can significantly reduce carbon emissions.

Solar photovoltaic (PV) modules generate electricity from sunlight and have emerged as one of the most widely accepted and used renewable technologies[1]. Currently there is a significant amount of research[2] aimed at improving the efficiency of the technology and reducing the cost of solar PV systems.

Overview of types of PV modules

PV modules have become one of the most popular sources of renewable energy in domestic buildings partly because of the availability of financial incentives (eg Feed-in Tariffs (FiTs)) and also reductions in cost arising from the increasing number of PV modules and other systems components (such as inverters) being produced. PV modules are relatively straightforward to install[3] and have low maintenance requirements.

Different types of PV modules and mounting mechanisms are discussed in this Digest.

Crystalline silicon PV modules

Silicon is used to make PV cells – the electricity generating components of PV modules.

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Part 2: Wood fuels

John Holden

This Digest has been written to provide an overview of the technical and operational characteristics of biomass systems within the scope of the Microgeneration Certification Scheme (MCS). Standards and specifications are covered, including certification, safety and incentives (such as the Renewable Heat Incentive and Green Deal). Although some technical information is given, it is not intended as an installation guide. The intended readership includes landlords, housing associations, local authorities, developers, architects and consultants.

This is one in a series of four related Digests focusing on a renewable energy technology commonly used in domestic buildings. The other technologies covered include photovoltaics, heat pumps and solar thermal collectors.

A wood fuel is matter that can be burned which is derived from recently living organisms, a marked difference to fuel derived from fossil fuels

Introduction

Biomass energy is generated from burning biomass fuel (sometimes abbreviated to wood fuel) that is derived from recently living organisms to produce usable heat. They differ markedly from fossil fuels such as gas, heating oil and coal, in that they do not require millions of years of processing within the earth before they can be used. This results in a short cycle from living organism to usable product, allowing for a sustainable supply where it is possible to match the rate of consumption to the rate of production. Biomass can be of animal or plant origin, but in the context of MCS and the built environment, the biomass fuel is typically derived from wood or cereal.

The carbon neutral status of biomass fuel is the subject of debate. The carbon contained within a biomass fuel has only recently been drawn from the atmosphere, and so any CO_2 released during its combustion is not considered as a contributor to atmospheric levels. However, CO_2 is generated during processing and transport of these fuels. This should be considered when assessing their impact. The amount of this CO_2 will be dependent on the type of biomass being produced as well as the location of the harvesting of the biomass relative to the location of the system in which it is to be burned.

Typically, wood fuel used in those installations falling within the scope of MCS will be in one of three forms: logs, wood chip and pellets; the amount of carbon emitted during processing is different in each case.

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Renewable energy sources

How they work and what they deliver

Part 3: Electrically driven heat pumps

John Holden and Patrick Robinson

This Digest describes the different types of heat pump system and how they operate. Installation requirements, including integration with the building's heating system and the steps that should be taken to ensure their safe and efficient operation, are also discussed and methods for estimating their annual energy performance are identified. Reference is made to European Standards and certification schemes relevant to heat pump systems to indicate the assurances that system owners and operators should expect. Financial incentives are also outlined.

This is one in a series of four related BRE Digests focusing on renewable energy technologies commonly used in domestic buildings. The other technologies covered include photovoltaics, wood fuels and solar thermal hot water systems. These publications complement an earlier series of BRE Information Papers[1, 2, 3, 4] that cover the installation of renewable energy technologies.

Introduction

Electrically driven heat pumps are devices that may be used to generate heat for domestic hot water (DHW) and space heating. They achieve this by extracting heat from environmental sources such as the air or the ground. The heat is transferred to a refrigerant circuit where compression raises the fluid's temperature and useful heat is extracted, providing an alternative to conventional (eg gas- or oil-fired) heating systems.

Since heat pumps consume a lower amount of electrical energy than the heat energy they generate, and exploit heat from the environment, they are generally regarded as a low-carbon renewable energy technology, and the higher the ratio of heat output to electrical power consumed (known as the 'coefficient of performance' or 'COP'), the greater the efficiency.

Heat pump installations use a variety of heat sources and adopt a range of configurations to suit the user. Heat can be extracted from the outside air, from water sources such as lakes or rivers, from the ground (using a buried collector) or from adapted sources such as exhaust air. The generated heat output is then distributed from the heat pump as warm air or as warm water for storage or for circulation in a heating system. Heat pumps generally operate most efficiently when delivering heat at lower temperatures than traditional sources such as gas- or oil-fired boilers, and may require the use of special low-temperature heating delivery systems such as underfloor heating or low-temperature radiators that have larger heat exchange areas.

Figure 1: Installing a heat exchanger for a ground source heat pump

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Renewable energy sources

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Part 4: Solar thermal hot water systems

John Holden

Solar thermal systems are an established source of renewable energy for heating water. Working in conjunction with more traditional water heating systems, such as gas boilers, they can provide a significant proportion of a building's hot water needs. This Digest focuses on solar thermal systems in domestic buildings (ie dwellings), but the information provided may also be applied to equivalent non-domestic applications.

This Digest describes the different types of solar thermal system and how they operate. Installation requirements, including integration with the building's hot water system and the steps that should be taken to ensure their safe and efficient operation, are also discussed and methods for estimating their annual energy performance are identified. Reference is made to European Standards and certification schemes relevant to solar thermal systems to indicate the assurances that system owners and operators should expect. Financial incentives are also outlined.

This is one in a series of four related BRE Digests focusing on renewable energy technologies commonly used in domestic buildings. The other technologies covered include photovoltaics, wood fuels and electrically driven heat pumps. These publications complement an earlier series of BRE Information Papers[1, 2, 3, 4] that cover the installation of renewable energy technologies.

Introduction

Solar thermal systems are designed to convert sunlight (solar radiation) into useable heat energy, usually in the form of domestic hot water. Solar collectors (also commonly referred to as 'solar thermal panels') are positioned where they will be exposed to the sun's rays. Generally speaking a heat transfer fluid and pump move the collected heat to a hot water storage tank, where it can be distributed throughout a building as it is required, although some systems are designed to circulate the fluid by convection and so do not incorporate a pump. Because the fuel source (in this case the sun) is not depleted by this process, solar thermal systems are considered a source of renewable energy.

Figure 1: A solar thermal installation

Traditional water heating systems commonly use fossil fuels as an energy source. Even boilers powered by electricity draw the required energy from sources currently dominated by fossil fuel power stations. Fossil fuels are carbon based; heat is generated through combustion, which also produces carbon dioxide (CO_2). The CO_2 is generally released into the atmosphere and is considered to be a 'greenhouse gas', which contributes to climate change.

In contrast, solar thermal systems produce no CO_2 during the conversion of sunlight to heat energy. Systems that use pumps to move the heat transfer fluid may use some fossil fuel-derived energy to create the kinetic energy required, although solar-powered pumps are sometimes used. Carbon-based fuels are also likely to have been utilised in the manufacture of system components.

Types of solar thermal collector and how they work

Solar thermal collectors will typically be one of two types: either flat plate collectors or evacuated tube collectors, each containing