“十三五”新能源科学与工程专业系列教材

ENGLISH FOR RENEWABLE ENERGY

新能源专业英语

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新能源科学与工程专业
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（按拼音排序）

前言

Preface

新能源专业英语是新能源科学与工程专业及相关专业的专业课程，是本科英语教学中必不可少的一个教学环节。为了使学生较全面地熟悉和掌握新能源各领域中符合专业国际标准的专业词汇、词组及段落的英文表述，培养学生专业文献阅读、专业文献翻译及专业信息交流等能力，了解国内外前沿的新能源技术，特编写了《新能源专业英语》一书。

本书的主要特点体现在：① 选材内容丰富多样，涉及新能源各领域的发展历史、国内外现状、基本技术原理及最新技术应用方面的专业英语。知识覆盖面广，内容具有全面性、系统性和代表性。② 大多数资料参考了国外原版教材、专著、论文及相关网站，保证了课文的准确性和可读性。③ 在各能源领域章节内加入新能源技术的最新应用，增强了实用性和趣味性。④ 设计了针对新能源各专业领域英语知识的简答题与开放性思考题，有利于学生真正掌握专业英语知识，提高综合表达能力。⑤ 主编及参编人员为新能源领域的海外博士及优秀教师，涉及风能、太阳能、水能和生物质能等多个新能源领域，很大程度上保证了本教材在编写内容上具有较强的专业性和国际化水平。本书提供了风能、生物质能、水能、太阳能及地热能和新核能领域内较为系统、全面的专业英语内容，配有专业词汇、词组、句型的翻译题、简答题和思考题，便于各学校根据自身特点灵活地进行教学。

本书由扬州大学李迺璐副教授、江苏大学王爽副教授、乔芬副教授主编，具体编写分工为：扬州大学风能领域的海外博士李迺璐副教授编写第一章和第二章，江苏大学太阳能领域的海外博士乔芬副教授和徐谦副教授编写第三章，江苏大学生物质能领域的王爽副教授、吉恒松副教授编写第四章，扬州大学水能领域的海外博士李帆副教授编写第五章，江苏大学新能源专业的赵炜讲师编写第六章。全书由美国安柏瑞德航空航天大学航天学院的 Mark J. Balas 教授、江苏大学王谦教授和扬州大学新能源专业的杨华教授主审。Balas 教授作为 IEEE Fellow、AIAA Fellow、ASME Fellow，在美国及全球新能源行业具有影响力。Balas 教授、王谦教授和杨华教授一起对本书进行了认真审阅，提出了许多宝贵意见。在此，编

者表示衷心感谢。

该教材由江苏大学“江苏高校品牌专业建设工程”项目、国家自然科学基金项目(51306078)、江苏省高校自然科学研究面上项目(14KJb480006)和教育部留学回国人员科研启动基金资助项目资助,参编单位的领导和老师们也给予大力支持,在此一并感谢。

在编写过程中,我们参考引用了一些外文教材、专著、论文及相关网站的内容。由于内容庞杂无法一一联系原文作者,在此向他们表示歉意,并致以衷心地感谢。

本书难免有不当之处,欢迎广大读者多提宝贵意见。

编　者

2015.10

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Chapter 1

Introduction of Renewable Energy

1.1 Energy

In physics, energy is a property of objects which can be transferred to other objects or converted into different forms, but cannot be created or destroyed. Energy, like mass, is a scalar physical quantity. The joule is the International System of Units (SI) unit of measurement for energy. It is a derived unit of energy, work, or amount of heat. It is equal to the energy expended in applying a force of one newton through a distance of one metre. However, energy is also expressed in many other units such as calories, kilowatt-hours and kilocalorie, etc.

Energy sources can be classified in primary energy sources and secondary energy sources to meet the needs of society, as shown in Table 1-1. These forms include those which provide for the production of conventional, alternative and renewable sources of energy (primary energy sources), and for the recovery and reuse of energy that would otherwise be wasted (secondary energy sources).

Table 1-1 Classification of Energy Resources

<table>
<tr><td rowspan="7">Primary energy sources</td><td rowspan="3">Non-renewable sources</td><td rowspan="2">Fossil fuels</td><td>Petroleum</td></tr>
<tr><td>Coal or natural gas</td></tr>
<tr><td>Mineral fuels</td><td>Natural uranium</td></tr>
<tr><td colspan="2">Nuclear Energy</td></tr>
<tr><td rowspan="4">Renewable sources</td><td colspan="2">Solar Energy</td></tr>
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<tr><td colspan="2">Biomass sources</td></tr>
<tr><td colspan="2">Geothermal Energy</td></tr>
<tr><td>Secondary energy sources</td><td colspan="3">Electrical Power, Biogas, Gasoline, Diesel oil , Hydrogen Energy</td></tr>
</table>

Primary energy sources is an energy form found in nature that has not been subjected to any conversion or transformation process. It is energy contained in raw fuels, and other forms of energy received as input to a system. Primary energy can be non-renewable or renewable.

The renewable energy is clean sources that do not pollute the environment during consumption and have minimum impact on human health and the ecosystems. And it can also be the sustainable energy, such as wind energy, solar energy, tidal energy and geothermal energy.

A non-renewable resource is a resource that does not renew itself at a sufficient rate for sustainable economic extraction in meaningful human time-frames. The examples include carbon-based fuel, earth minerals, fossil fuels (such as coal, petroleum, and natural gas), and nuclear fuels.

Secondary energy sources are energy forms which have been transformed from primary energy sources. Electricity is one of the most common energy carriers, being transformed from various primary energy sources.

1.1.1 Conventional Energy

The conventional energy is usually non-renewable. They are coming from limited energy sources on Earth in quantity and, therefore, are exhaustible. The fossil fuels (coal, natural gas) and nuclear energy are all conventional energy.

1.1.1.1 Fossil fuels

Natural resources such as coal, petroleum (crude oil) and natural gas take thousands of years to form naturally and cannot be replaced as fast as they are being consumed. Fossil fuels make up the bulk of the world's current primary energy sources. The technology and infrastructure already exist for the use of fossil fuels. Conventional production of oil has peaked between 2007 to 2010 conservatively.

However, fossil fuels are also the source of greenhouse gas emissions, leading to concerns about global warming if consumption is not reduced. The combustion of fossil fuels leads to the release of pollution into the atmosphere. The fossil fuels are mainly based on organic carbon compounds. They are the causes of the global warming. During the combustion with oxygen in the form of heat energy, carbon dioxide is released.

At present, the main energy source used by humans is non-renewable fossil fuels, as shown in Figure 1-1. Since the dawn of internal combustion engine

technologies in the 17th century, petroleum and other fossil fuels have remained in continual demand. As a result, conventional infrastructure and transport systems, which are fitted to combustion engines, remain prominent throughout the globe.

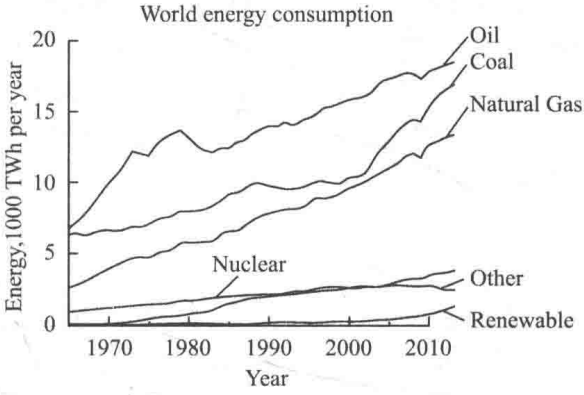

Figure 1-1 World energy consumption

The continual use of fossil fuels at the current rate is believed to raise serious environmental concerns. The burning of fossil fuels produces around 21.3 billion tonnes (21.3 gigatonnes) of carbon dioxide (CO_2) per year, there is a net increase of 10.65 billion tonnes of atmospheric carbon dioxide per year. Carbon dioxide is one of the greenhouse gases that enhance radiative forcing and contribute to global warming, causing more severe climate change. Therefore, a global movement towards the generation of renewable energy is under way to help reduce global greenhouse gas emissions.

1.1.1.2 Nuclear Energy

Nuclear energy or nuclear power, is the use of nuclear reactors to release nuclear energy, and thereby generate electricity. The term includes nuclear fission, nuclear decay and nuclear fusion. Like many conventional thermal power stations which generate electricity by harnessing the thermal energy released from burning fossil fuels, nuclear power plants convert the energy released from the nucleus of an atom via nuclear fission that takes place in a nuclear reactor.

There is an ongoing debate about nuclear power. Supporters contend that nuclear power is a safe, sustainable energy source that reduces carbon emissions. Nuclear power is a low carbon power generation method of producing electricity, with an analysis of the literature on its total life cycle emission intensity finding that it is similar to other renewable sources in a comparison of greenhouse gas (GHG)

emissions per unit of energy generated. In 2011 nuclear power provided 10% of the world's electricity In 2007, the IAEA reported that there were 439 nuclear power reactors in operation in the world, operating in 31 countries.

Opponents claimed that nuclear power poses many threats to the environment and people. At the same time, nuclear power plants typically have high capital costs for building the plant. In recent years, with large costs and long project cycles which carry a large variety of risks, worldwide nuclear output fell by 4.3%, the largest decline on record of sharp declines in Japan (-44.3%) and Germany (-23.2%). Many have now ceased operation in the wake of the Fukushima nuclear disaster while they are assessed as safety.

A new generation of designs for nuclear power plants, known as the Generation IV reactors, becomes the subject of active research. Many of these new designs specifically attempt to make fission reactors cleaner and safer. Passively safe plants are available to be built and fusion reactors, which are still in the early stages of development, diminish or eliminate some of the risks associated with nuclear fission.

1.1.2 Renewable Energy

As of 2013, the renewable energy, particularly solar and wind energy, arises unprecedented attention, as they can provide electricity without giving rise to any carbon dioxide emission. Even the cost of the early construction cost of the renewable energy is relatively high, harnessing these for electricity depends on the cost and efficiency of the technology, which is constantly improving, thus reducing costs per peak kilowatt.

Renewable electricity production, from sources such as wind power and solar power, is sometimes criticized for being intermittent or variable. However, deployment of renewable technologies contributes to the flexibility of the system when it increases the diversity of electricity sources. And more importantly, all forms of renewable energy are sustainable with very large energy potential while the conventional energy with limited reserves can be totally used up in the future. The global energy potential is indicated in Figure 1-2.

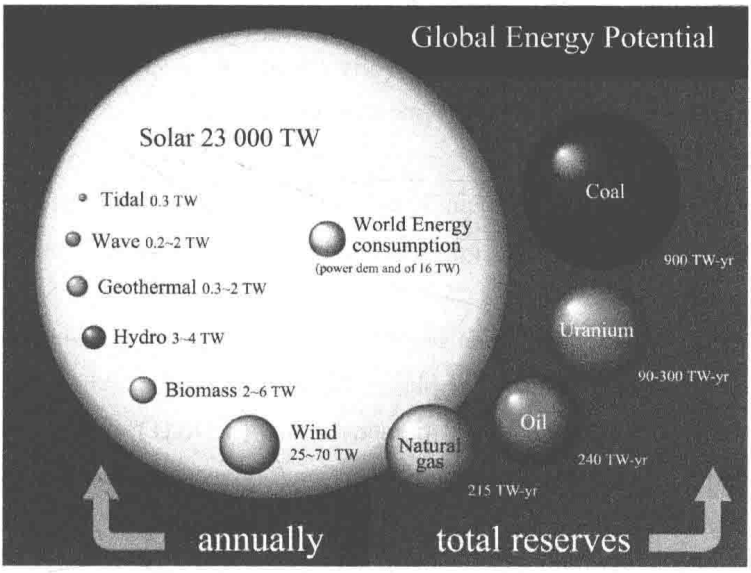

Figure 1-2 Global energy potential by source

Another issue of the renewable energy is that the high levels of grid penetration can pose challenges for grid management. This characteristic may affect how, and the degree to which, the renewable electricity production can displace fossil fuels and nuclear capacities in power generation.

1.2 Overview of Renewable Energy

1.2.1 Definitions

1.2.1.1 Definition of Renewable Energy

Renewable energy is generally defined as energy that comes from resources which are naturally replenished on a human timescale such as sunlight, wind, rain, tides, waves, and geothermal heat. As explained by the International Energy Agency, renewable energy is derived from natural processes that are replenished constantly. In its various forms, it derives directly from the sun, or from heat generated deep within the earth. Included in the definition are electricity and heat generated from solar, wind, ocean, hydropower, biomass, geothermal resources, and biofuels and hydrogen derived from renewable resources.

1.2.1.2 Definition of Renewable Energy Technologies

Renewable energy technologies generally contribute to reducing dependence on fossil fuel resources and providing opportunities for mitigating greenhouse gases. Conceptually, three generations of renewable technologies can be defined as:

First-generation technologies emerged from the industrial revolution at the end of the 19th century and include hydropower, biomass combustion, and geothermal power and heat.

Second-generation technologies include solar heating and cooling, wind power, modern forms of bioenergy, and solar photovoltaic. These are now entering markets as a result of research, development and demonstration (RD&D) investments since the 1980s. The initial investment was prompted by energy security concerns linked to the oil crises of the 1970s.

Third-generation technologies are still under development and include advanced biomass gasification, bio-refinery technologies, concentrating solar thermal power, and ocean energy. Advances in nanotechnology may also play a major role.

1.2.2 Utilization of Renewable Energy

Rapid deployment of renewable energy, energy efficiency, and technological diversification of energy sources would result in significant energy security and economic benefits. In contrast to other energy sources which are concentrated in a limited number of countries, renewable energy resources exist over wide geographical areas, and can be used to benefit the people around the world. It would not only reduce the emission of greenhouse gas to avoid the environmental pollution such as air pollution, but also reduce premature mortalities due to pollution and save associated health costs.

1.2.2.1 Global Renewable Energy Usage

The utilization of renewable energy is diverse in many forms, such as biomass heat, solar PV power, ocean power, wind power, hydropower and so on. The total world energy consumption and the renewable energy consumption in 2010 are revealed in Figure 1-3. Generally, compared with conventional fossil fuels, the utilization of renewable energy can be emphasized in three distinct areas: electricity generation, heating and transport fuels:

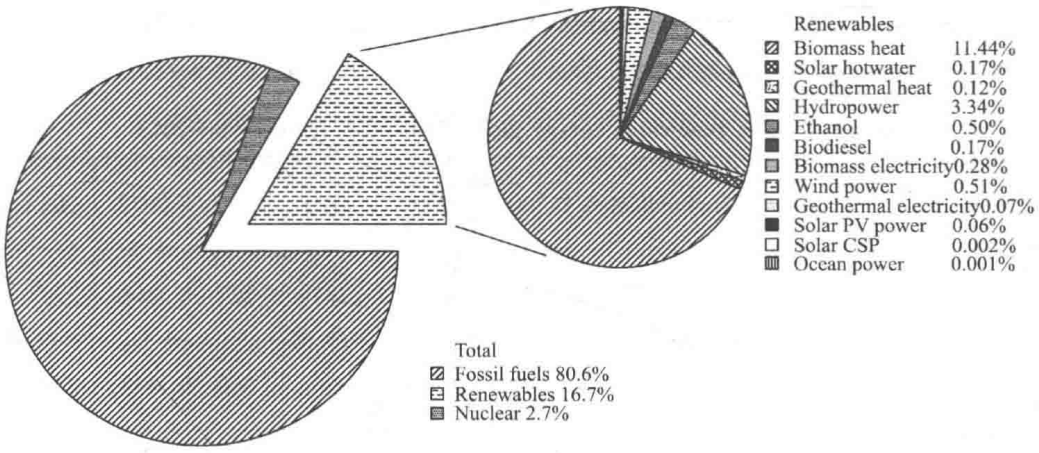

Figure 1-3 World energy consumption and renewable energy consumption in 2010

Renewable hydroelectric energy provides 16.3% of the world's electricity as of 2013. Renewable power generators are spread across many countries, and wind power alone already provides a significant share of electricity in some areas: for example, 14% in Iowa, USA, 40% in the northern German state of Schleswig-Holstein, and 49% in Denmark. Some countries get most of their power from renewables, including Iceland (100%), Norway (98%), Brazil (86%), Austria (62%), New Zealand (65%), and Sweden (54%).

Solar water heating makes an important contribution to renewable heat in many countries, most notably in China, which now has 70% of the global total. Most of these systems are installed on multi-family apartment buildings and meet a portion of the hot water needs of estimated 50 ~ 60 million households in China. Worldwide, total installed solar water heating systems meet a portion of the water heating needs of over 70 million households. The use of biomass for heating and direct geothermal for heating continues to grow as well.

Renewable energy technologies are getting cheaper, through technological change and through the benefits of mass production and market competition. Hydroelectricity and geothermal electricity produced at favourable sites are now the cheapest way to generate electricity. Renewable energy costs continue to drop for wind power, solar photovoltaic (PV), and some biomass technologies.

As the cleaner and cheaper energy, the renewable energy technologies stepped into the fast commercialization from the end of 2004. Worldwide renewable energy capacity began to grow at rates of 10% ~ 60% annually for many technologies, as

shown in Table 1-2. In 2010, renewable power constituted about a third of the newly built power generation capacities. U. S. oil use fell 8.5% from 2005 to 2014.

Table 1-2 The renewable energy global indicators from 2008—2013

Selected renewable energy global indicators	2008	2009	2010	2011	2012	2013
Investment in new renewable capacity (annual) (10^9 U. S. D)	130	160	211	257	244	214
Renewables power capacity (existing) (GWv)	1 140	1 230	1 320	1 360	1 470	1 560
Hydropower capacity (existing) (GW)	885	915	945	970	990	1 000
Wind power capacity (existing) (GW)	121	159	198	238	283	318
Solar PV capacity (grid-connected) (GW)	16	23	40	70	100	139
Solar hot water capacity (existing) (GW)	130	160	185	232	255	326
Ethanol production (annual) (10^9 litres)	67	76	86	86	83	87
Biodiesel production (annual) (10^9 litres)	12	17.8	18.5	21.4	22.5	26
Countries with policy targets for renewable energy use	79	89	98	118	138	144

Wind power growth accelerated in 2009 relative to the previous four years. Wind power is growing at the rate of 30% annually, with a worldwide installed capacity of 282 482 megawatts (MW) at the end of 2012, and is widely used in Europe, Asia, and the United States.

Grid-connected PV increased the fastest of all renewables technologies, with a 60% annual average growth rate. At the end of 2012 the photovoltaic (PV) capacity worldwide was 100 000 MW, and PV power stations are popular in Germany and Italy. Solar thermal energy stations operate in the USA and Spain, and the largest of these stations is the 354 MW Solar Energy Generating Systems power plant in the Mojave Desert.

Renewable biofuels have contributed to a significant decline in oil consumption since 2006. The 93 billion liters of biofuels produced worldwide in 2009 displaced the equivalent of an estimated 68 billion liters of gasoline, equal to about 5% of world gasoline production.

The world's largest geothermal power installation is the Geysers in California, with a rated capacity of 750 MW. Brazil has one of the largest renewable energy programs in the world, involving production of ethanol fuel from sugar cane, and ethanol now provides 18% of the country's automotive fuel. Ethanol fuel is also widely available in the U. S. A.

1.2.2.2 Renewable Energy Utilization in China

China is the world's largest producer of electricity, surpassing the United States in 2011 and installing 90 GW capacity at the end of 2013, with demand increasing alongside its strong, sustained growth in GDP. Coal-fired plants currently make up over two-thirds of power generation, which is partly the result of an abundance of coal in China. However, the growth in electricity production from coal-fired plants has resulted in an increase in air pollution and general lack of efficiency. China is now moving aggressively to curb pollution and increase the supply of renewable power.

The central government has prohibited new coal-fired plants to be built around Shanghai, Guangzhou and Beijing, which is currently in the midst of having all of its coal plants being converted to natural gas. Its 12th Five Year Plan, running through 2015, targeted non-fossil fuel energy to account for 15% of total energy consumption.

One of the key industries expected to help meet these goals is wind power. While 15% is the near term renewable target, the potential of wind in China is much greater. In 2009, researchers from Harvard and Tsinghua University found China could generate all of its power profitably from wind alone, making wind power an attractive alternative to coal power, especially as the government moves to reduce pollution.

As of 2040, the installed electricity capacity in China, as shown in Figure 1-4, is expected to reach around 2 265 GW totally to meet the needs of energy consumption for the continuous growing in GDP. Specifically, the hydropower capacity and wind capacity will account for 18% and 12% separately of the overall installed electricity capacity, as the two dominating renewable energy in China. At the same time, the conventional energy, such as coal and nuclear energy will reduce to 52% and 7% separately, weakening the strong reliance on fossil fuels. The solar energy and other renewables will share 5% of total electricity capacity as the natural gas does.