

International Energy Outlook and Projections



James R. Plunkett
Editor

NOVA

Energy Science,
Engineering and
Technology

ENERGY SCIENCE, ENGINEERING AND TECHNOLOGY

INTERNATIONAL ENERGY OUTLOOK AND PROJECTIONS

JAMES R. PLUNKETT

EDITOR



Nova Science Publishers, Inc.

New York

Copyright © 2011 by Nova Science Publishers, Inc.

All rights reserved. No part of this book may be reproduced, stored in a retrieval system or transmitted in any form or by any means: electronic, electrostatic, magnetic, tape, mechanical photocopying, recording or otherwise without the written permission of the Publisher.

For permission to use material from this book please contact us:

Telephone 631-231-7269; Fax 631-231-8175

Web Site: <http://www.novapublishers.com>

NOTICE TO THE READER

The Publisher has taken reasonable care in the preparation of this book, but makes no expressed or implied warranty of any kind and assumes no responsibility for any errors or omissions. No liability is assumed for incidental or consequential damages in connection with or arising out of information contained in this book. The Publisher shall not be liable for any special, consequential, or exemplary damages resulting, in whole or in part, from the readers' use of, or reliance upon, this material. Any parts of this book based on government reports are so indicated and copyright is claimed for those parts to the extent applicable to compilations of such works.

Independent verification should be sought for any data, advice or recommendations contained in this book. In addition, no responsibility is assumed by the publisher for any injury and/or damage to persons or property arising from any methods, products, instructions, ideas or otherwise contained in this publication.

This publication is designed to provide accurate and authoritative information with regard to the subject matter covered herein. It is sold with the clear understanding that the Publisher is not engaged in rendering legal or any other professional services. If legal or any other expert assistance is required, the services of a competent person should be sought. FROM A DECLARATION OF PARTICIPANTS JOINTLY ADOPTED BY A COMMITTEE OF THE AMERICAN BAR ASSOCIATION AND A COMMITTEE OF PUBLISHERS.

Additional color graphics may be available in the e-book version of this book.

Library of Congress Cataloging-in-Publication Data

International energy outlook and projections / editor, James R. Plunkett.
p. cm.

Includes bibliographical references and index.

ISBN 978-1-61324-143-1 (hardcover)

1. Power resources--Forecasting. I. Plunkett, James R. II. United States. Energy Information Administration.

TJ163.2.I537 2011

333.7909'051101--dc22

2011008468

Published by Nova Science Publishers, Inc. † New York

ENERGY SCIENCE, ENGINEERING AND TECHNOLOGY

INTERNATIONAL ENERGY OUTLOOK AND PROJECTIONS

ENERGY SCIENCE, ENGINEERING AND TECHNOLOGY

Additional books in this series can be found on Nova's website
under the Series tab.

Additional E-books in this series can be found on Nova's website
under the E-books tab.

PREFACE

This new book presents an assessment by the U.S. Energy Information Administration (EIA) of the outlook for international energy markets through 2035. The projections are based to the extent possible on U.S. and foreign laws, regulations, and standards in effect at the start of 2010. The potential impacts of pending or proposed legislation, regulations, and standards are not reflected in the projections, nor are the impacts of legislation for which the implementing mechanisms have not yet been announced.

Chapter 1- This report presents international energy projections through 2035, prepared by the U.S. Energy Information Administration, including outlooks for major energy fuels and associated carbon dioxide emissions.

The International Energy Outlook 2010 (IEO2010) presents an assessment by the U.S. Energy Information Administration (EIA) of the outlook for international energy markets through 2035. U.S. projections appearing in IEO2010 are consistent with those published in EIA's Annual Energy Outlook 2010 (AEO2010) in April 2010.

Chapter 2- This documentation provides a summary description of the World Energy Projection System Plus (WEPS+), a system that was used to generate the projections of energy consumption, prices, and production through the year 2035 for the *International Energy Outlook 2010 (IEO2010)*. IEO2010, released in May 2010 under publication number DOE/EIA-0484(2010), presents regional world projections of energy markets for five primary cases – a reference case, plus four additional cases that assume higher and lower economic growth and higher and lower world oil prices than the reference case. This overview presents a brief description of the methodology and scope of each of the component modules of WEPS+, along with some description of the modeling system. Further details on each of the component modules of WEPS+ are provided by individual model documentation reports. This document serves three purposes. First, it is a reference document providing a detailed description for model analysts, users, and the public. Second, it meets the legal requirement of the Energy Information Administration (EIA) to provide adequate documentation in support of its models (*Public Law 93-275, section 57.b.1*). Third, it facilitates continuity in model development by providing documentation from which energy analysts can undertake and analyze their own model enhancements, data updates, and parameter refinements for future projects.

CONTENTS

Preface		vii
Chapter 1	International Energy Outlook 2010 <i>U.S. Energy Information Administration</i>	1
Chapter 2	The World Energy Projection System Plus (WEPS+): An Overview 2010 <i>Energy Information Administration</i>	411
Chapter Sources		443
Index		443

Chapter 1

INTERNATIONAL ENERGY OUTLOOK 2010*

U.S. Energy Information Administration

ABSTRACT

This report presents international energy projections through 2035, prepared by the U.S. Energy Information Administration, including outlooks for major energy fuels and associated carbon dioxide emissions.

The International Energy Outlook 2010 (IEO2010) presents an assessment by the U.S. Energy Information Administration (EIA) of the outlook for international energy markets through 2035. U.S. projections appearing in IEO2010 are consistent with those published in EIA's Annual Energy Outlook 2010 (AEO2010) in April 2010.

The IEO2010 projections are based to the extent possible on U.S. and foreign laws, regulations, and standards in effect at the start of 2010. The potential impacts of pending or proposed legislation, regulations, and standards are not reflected in the projections, nor are the impacts of legislation for which the implementing mechanisms have not yet been announced. In addition, mechanisms whose implementation cannot be modeled given current capabilities or whose impacts on the energy sector are unclear are not included in IEO2010. For example, the European Union's Emissions Trading System, which includes non-carbon dioxide emissions and nonenergy-related emissions, are not included in this analysis.

IEO2010 focuses exclusively on marketed energy. Non-marketed energy sources, which continue to play an important role in some developing countries, are not included in the estimates.

The IEO2010 consumption projections are grouped according to Organization for Economic Cooperation and Development membership. (OECD includes all members of the organization as of March 1, 2010, throughout all time series included in this report. Chile became a member on May 7, 2010, but its membership is not reflected in IEO2010.) There are three basic groupings of OECD countries: North America (United States, Canada, and Mexico); OECD Europe; and OECD Asia (Japan, South Korea, and Australia/New Zealand). Non-OECD is divided into five separate regional subgroups: non-OECD Europe and Eurasia, non-OECD Asia, Africa, Middle East, and Central and South America. Russia is represented in non-OECD Europe and Eurasia; China and India

* This is an edited, reformatted and augmented version of a U.S. Energy Information Administration's publication, dated July 2010.

are represented in non-OECD Asia; and Brazil is represented in Central and South America. In some instances, the IEO2010 production models have different regional aggregations to reflect the important producer regions (for example, Middle East OPEC is a key region in the projections of liquid supplies). The complete regional definitions are listed in Appendix M.

The report begins with a review of world trends in energy demand and the major macroeconomic assumptions used in deriving the IEO2010 projections, which—for the first time—extend to 2035. In addition to Reference case projections, High Economic Growth and Low Economic Growth cases were developed to consider the effects of higher and lower growth paths for economic activity than are assumed in the Reference case. IEO2010 also includes a High Oil Price case and, alternatively, a Low Oil Price case. The resulting projections—and the uncertainty associated with international energy projections in general—are discussed in Chapter 1, “World Energy Demand and Economic Outlook.”

Projections for energy consumption and production by fuel—liquids (primarily petroleum), natural gas, and coal—are presented in Chapters 2, 3, and 4, along with reviews of the current status of each fuel on a worldwide basis. Chapter 5 discusses the projections for world electricity markets—including nuclear power, hydropower, and other commercial renewable energy resources—and presents forecasts of world installed generating capacity. Chapter 6 provides a discussion of industrial sector energy use. Chapter 7 includes a detailed look at the world’s transportation energy use. Finally, Chapter 8 discusses the outlook for global energy-related carbon dioxide emissions.

Appendix A contains summary tables for the IEO2010 Reference case projections of world energy consumption, gross domestic product, energy consumption by fuel, carbon dioxide emissions, and regional population growth. Summary tables of projections for the High and Low Economic Growth cases are provided in Appendixes B and C, respectively, and projections for the High and Low Oil Price cases are provided in Appendixes D and E, respectively. Reference case projections of delivered energy consumption by end-use sector and region are presented in Appendix F. Appendix G contains summary tables of projections for world liquids production in all cases. Appendix H contains summary tables of Reference case projections for installed electric power capacity by fuel and regional electricity generation. Appendix I contains summary tables for projections of world natural gas production in all cases. Appendix J includes a set of tables for each of the four Kaya Identity components. In Appendix K, a set of comparisons of projections from the International Energy Agency’s World Energy Outlook 2009 with the IEO2010 projections is presented. Comparisons of the IEO2010 and IEO2009 projections are also presented in Appendix K. Appendix L describes the models used to generate the IEO2010 projections, and Appendix M defines the regional designations included in the report.

The IEO2010 projections of world energy consumption were generated from EIA’s World Energy Projections Plus (WEPS+) modeling system. WEPS+ is used to build the Reference case energy projections, as well as alternative energy projections based on different assumptions for GDP growth and fossil fuel prices. The IEO2010 projections of global natural gas production and trade were generated from EIA’s International Natural Gas Model (INGM), which estimates natural gas production, demand, and international trade by combining estimates of natural gas reserves, natural gas resources and resource extraction costs, energy demand, and transportation costs and capacity in order to estimate future production. The Generate World Oil Balance (GWOB) application is used to create a “bottom up” projection of world liquids supply—based on current production capacity, planned future additions to capacity, resource data, geopolitical factors, and oil prices—and to generate conventional crude oil production cases.

Objectives of the *IEO2010* Projections

The projections in *IEO2010* are not statements of what will happen, but what might happen given the specific assumptions and methodologies used for any particular scenario. The Reference case projection is a business-as-usual trend estimate, given known technology and technological and demographic trends. EIA explores the impacts of alternative assumptions in other scenarios with different macroeconomic growth rates and world oil prices. The *IEO2010* cases generally assume that current laws and regulations are maintained throughout the projections. Thus, the projections provide policy-neutral baselines that can be used to analyze international energy markets.

While energy markets are complex, energy models are simplified representations of energy production and consumption, regulations, and producer and consumer behavior. Projections are highly dependent on the data, methodologies, model structures, and assumptions used in their development. Behavioral characteristics are indicative of real-world tendencies, rather than representations of specific outcomes.

Energy market projections are subject to much uncertainty. Many of the events that shape energy markets cannot be fully anticipated. In addition, future developments in technologies, demographics, and resources cannot be foreseen with certainty. Key uncertainties in the *IEO2010* projections for economic growth and oil prices are addressed through alternative cases.

EIA has endeavored to make these projections as impartial, reliable, and relevant as possible. They should, however, serve as an adjunct to, not a substitute for, a complete and focused analysis of public policy initiatives.

HIGHLIGHTS

World marketed energy consumption increases by 49 percent from 2007 to 2035 in the Reference case. Total energy demand in non-OECD countries increases by 84 percent, compared with an increase of 14 percent in OECD countries.

In the *IEO2010* Reference case, which does not include prospective legislation or policies, world marketed energy consumption grows by 49 percent from 2007 to 2035. Total world energy use rises from 495 quadrillion British thermal units (Btu) in 2007 to 590 quadrillion Btu in 2020 and 739 quadrillion Btu in 2035 (Figure 1).

The global economic recession that began in 2008 and continued into 2009 has had a profound impact on world energy demand in the near term. Total world marketed energy consumption contracted by 1.2 percent in 2008 and by an estimated 2.2 percent in 2009, as manufacturing and consumer demand for goods and services declined. Although the recession appears to have ended, the pace of recovery has been uneven so far, with China and India leading and Japan and the European Union member countries lagging. In the Reference case, as the economic situation improves, most nations return to the economic growth paths that were anticipated before the recession began.

The most rapid growth in energy demand from 2007 to 2035 occurs in nations outside the Organization for Economic Cooperation and Development¹ (non-OECD nations). Total non-

OECD energy consumption increases by 84 percent in the Reference case, compared with a 14-percent increase in energy use among OECD countries. Strong long-term growth in gross domestic product (GDP) in the emerging economies of non-OECD countries drives their growing energy demand. In all non-OECD regions combined, economic activity—as measured by GDP in purchasing power parity terms— increases by 4.4 percent per year on average, compared with an average of 2.0 percent per year for OECD countries.

The *IEO2010* Reference case projects increased world consumption of marketed energy from all fuel sources over the 2007-2035 projection period (Figure 2). Fossil fuels are expected to continue supplying much of the energy used worldwide. Although liquid fuels remain the largest source of energy, the liquids share of world marketed energy consumption falls from 35 percent in 2007 to 30 percent in 2035, as projected high world oil prices lead many energy users to switch away from liquid fuels when feasible. In the Reference case, the use of liquids grows modestly or declines in all end-use sectors except transportation, where in the absence of significant technological advances liquids continue to provide much of the energy consumed.

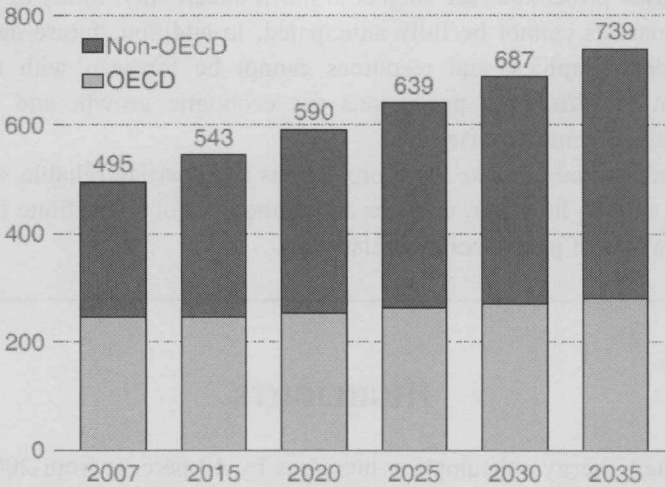


Figure 1. World marketed energy consumption, 2007-2035 (quadrillion Btu).

Average oil prices² increased strongly from 2003 to mid-July 2008, when prices collapsed as a result of concerns about the deepening recession. In 2009, oil prices trended upward throughout the year, from about \$42 per barrel in January to \$74 per barrel in December. Oil prices have been especially sensitive to demand expectations, with producers, consumers, and traders continually looking for an indication of possible recovery in world economic growth and a likely corresponding increase in oil demand. On the supply side, OPEC’s above-average compliance to agreed-upon production targets increased the group’s spare capacity to roughly 5 million barrels per day in 2009. Further, many of the non-OPEC projects that were delayed during the price slump in the second half of 2008 have not yet been revived.

After 2 years of declining demand, world liquids consumption is expected to increase in 2010 and strengthen thereafter as the world economies recover fully from the effects of the recession. In the *IEO2010* Reference case, the price of light sweet crude oil in the United

States (in real 2008 dollars) rises from \$79 per barrel in 2010 to \$108 per barrel in 2020 and \$133 per barrel in 2035.

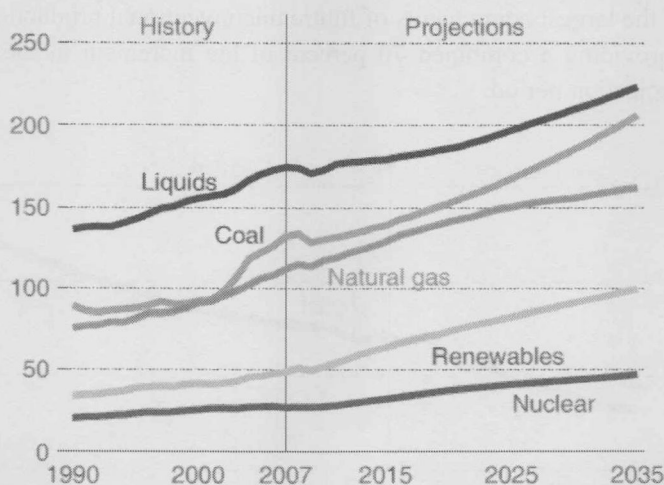


Figure 2. World marketed energy use by fuel type, 1990-2035 (quadrillion Btu).

World Energy Markets by Fuel Type

Liquid Fuels

Liquids remain the world's largest energy source throughout the *IEO2010* Reference case projection, given their importance in the transportation and industrial end-use sectors. World use of liquids and other petroleum³ grows from 86.1 million barrels per day in 2007 to 92.1 million barrels per day in 2020, 103.9 million barrels per day in 2030, and 110.6 million barrels per day in 2035. On a global basis, liquids consumption remains flat in the buildings sector, increases modestly in the industrial sector, but declines in the electric power sector as electricity generators react to rising world oil prices by switching to alternative fuels whenever possible. In the transportation sector, despite rising prices, use of liquid fuels increases by an average of 1.3 percent per year, or 45 percent overall from 2007 to 2035.

To meet the increase in world demand in the Reference case, liquids production (including both conventional and unconventional liquid supplies) increases by a total of 25.8 million barrels per day from 2007 to 2035. The Reference case assumes that OPEC countries will invest in incremental production capacity in order to maintain a share of approximately 40 percent of total world liquids production through 2035, consistent with their share over the past 15 years. Increasing volumes of conventional liquids (crude oil and lease condensate, natural gas plant liquids, and refinery gain) from OPEC producers contribute 11.5 million barrels per day to the total increase in world liquids production, and conventional supplies from non-OPEC countries add another 4.8 million barrels per day (Figure 3).

Unconventional resources (including oil sands, extra-heavy oil, biofuels, coal-to-liquids, gas-to-liquids, and shale oil) from both OPEC and non-OPEC sources grow on average by 4.9 percent per year over the projection period. Sustained high oil prices allow unconventional resources to become economically competitive, particularly when geopolitical or other "above ground" constraints⁴ limit access to prospective conventional resources. World

production of unconventional liquid fuels, which totaled only 3.4 million barrels per day in 2007, increases to 12.9 million barrels per day and accounts for 12 percent of total world liquids supply in 2035. Oil sands from Canada and biofuels, largely from Brazil and the United States, are the largest components of future unconventional production in the *IEO2010* Reference case, providing a combined 70 percent of the increment in total unconventional supply over the projection period.

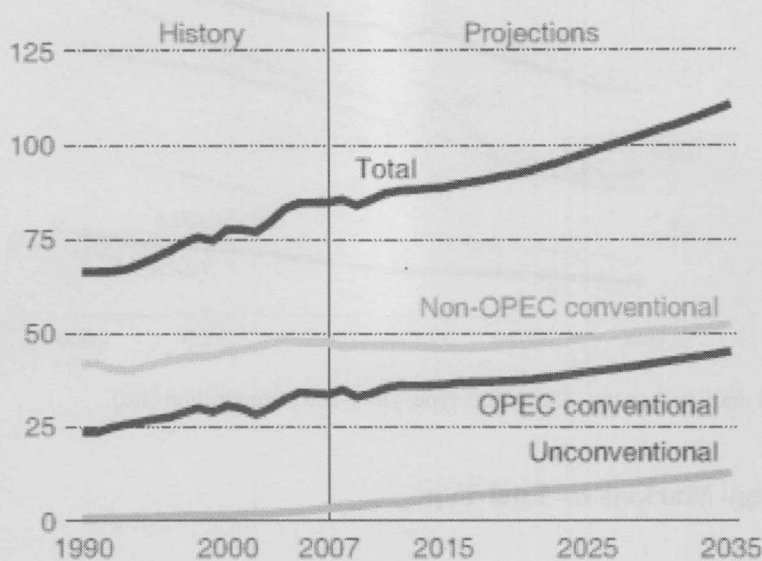


Figure 3. World liquids production, 1990-2035 (million barrels per day).

Natural Gas

Natural gas consumption worldwide increases by 44 percent in the Reference case, from 108 trillion cubic feet in 2007 to 156 trillion cubic feet in 2035. In 2009, world natural gas consumption declined by an estimated 1.1 percent, and natural gas use in the industrial sector fell even more sharply, by 6.0 percent, as demand for manufactured goods declined during the recession. The industrial sector currently consumes more natural gas than any other end-use sector, and in the projection it continues as the largest user through 2035, when 39 percent of the world's natural gas supply is consumed for industrial purposes. Electricity generation is another important use for natural gas throughout the projection, and its share of the world's total natural gas consumption increases from 33 percent in 2007 to 36 percent in 2035.

In the near term, as world economies begin to recover from the downturn, global demand for natural gas is expected to rebound, with natural gas supplies from a variety of sources keeping markets well supplied and prices relatively low. The largest projected increase in natural gas production is for the non-OECD region (Figure 4), with the major increments coming from the Middle East (an increase of 16 trillion cubic feet from 2007 to 2035), Africa (7 trillion cubic feet), and Russia and the other countries of non-OECD Europe and Eurasia (6 trillion cubic feet).

Although the extent of the world's tight gas, shale gas, and coalbed methane resource base has not yet been assessed fully, the *IEO2010* Reference case projects a substantial

increase in those supplies—especially from the United States but also from Canada and China. In the United States, one of the keys to increasing natural gas production has been advances in horizontal drilling and hydraulic fracturing technologies, which have made it possible to exploit the country's vast shale gas resources. Rising estimates of shale gas resources have helped to increase total U.S. natural gas reserves by almost 50 percent over the past decade, and shale gas rises to 26 percent of U.S. natural gas production in 2035 in the *IEO2010* Reference case. Tight gas, shale gas, and coal-bed methane resources are even more important for the future of domestic natural gas supplies in Canada and China, where they account for 63 percent and 56 percent of total domestic production, respectively, in 2035 in the Reference case.

World natural gas trade, both by pipeline and by shipment in the form of liquefied natural gas (LNG), is poised to increase in the future. Most of the projected increase in LNG supply comes from the Middle East and Australia, where a number of new liquefaction projects are expected to become operational within the next decade. In the *IEO2010* Reference case, world liquefaction capacity increases 2.4-fold, from about 8 trillion cubic feet in 2007 to 19 trillion cubic feet in 2035. In addition, new pipelines currently under construction or planned will increase natural gas exports from Africa to European markets and from Eurasia to China.

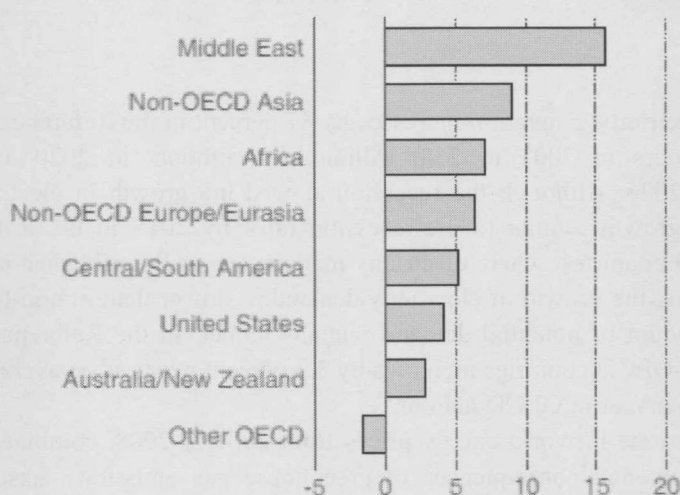


Figure 4. Net change in world natural gas production by region, 2007-2035 (trillion cubic feet).

Coal

In the absence of national policies and/or binding international agreements that would limit or reduce greenhouse gas emissions, world coal consumption is projected to increase from 132 quadrillion Btu in 2007 to 206 quadrillion Btu in 2035, at an average annual rate of 1.6 percent. Much of the projected increase in coal use occurs in non-OECD Asia, which accounts for 95 percent of the total net increase in world coal use from 2007 to 2035 (Figure 5). Increasing demand for energy to fuel electricity generation and industrial production in the region is expected to be met in large part by coal. For example, installed coal-fired generating capacity in China more than doubles in the Reference case from 2007 to 2035, and coal use in China's industrial sector grows by 55 percent. The development of China's electric power and

industrial sectors will require not only large-scale infrastructure investments but also substantial investment in both coal mining and coal transportation infrastructure.

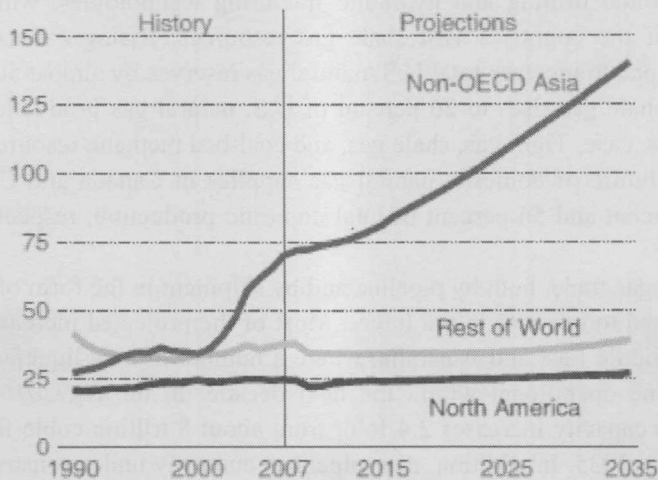


Figure 5. World coal consumption by region, 1990-2035 (quadrillion Btu).

Electricity

World net electricity generation increases by 87 percent in the Reference case, from 18.8 trillion kilowatthours in 2007 to 25.0 trillion kilowatthours in 2020 and 35.2 trillion kilowatthours in 2035. Although the recession slowed the growth in electricity demand in 2008 and 2009, growth returns to pre-recession rates by 2015 in the Reference case. In general, in OECD countries, where electricity markets are well established and consumption patterns are mature, the growth of electricity demand is slower than in non-OECD countries, where a large amount of potential demand remains unmet. In the Reference case, total net generation in non-OECD countries increases by 3.3 percent per year on average, as compared with 1.1 percent per year in OECD nations.

The rapid increase in world energy prices from 2003 to 2008, combined with concerns about the environmental consequences of greenhouse gas emissions, has led to renewed interest in alternatives to fossil fuels—particularly, nuclear power and renewable resources. As a result, long-term prospects continue to improve for generation from both nuclear and renewable energy sources—supported by government incentives and by higher fossil fuel prices.

From 2007 to 2035, world renewable energy use for electricity generation grows by an average of 3.0 percent per year (Figure 6), and the renewable share of world electricity generation increases from 18 percent in 2007 to 23 percent in 2035. Coal-fired generation increases by an annual average of 2.3 percent in the Reference case, making coal the second fastest-growing source for electricity generation in the projection. The outlook for coal could be altered substantially, however, by any future legislation that would reduce or limit the growth of greenhouse gas emissions. Generation from natural gas and nuclear power—which produce relatively low levels of greenhouse gas emissions (natural gas) or none (nuclear)—increase by 2.1 and 2.0 percent per year, respectively, in the Reference case.

Much of the world increase in renewable electricity supply is fueled by hydropower and wind power. Of the 4.5 trillion kilowatthours of increased renewable generation over the projection period, 2.4 trillion kilowatthours (54 percent) is attributed to hydroelectric power and 1.2 trillion kilowatthours (26 percent) to wind. Except for those two sources, most renewable generation technologies are not economically competitive with fossil fuels over the projection period, outside a limited number of niche markets. Typically, government incentives or policies provide the primary support for construction of renewable generation facilities. Although they remain a small part of total renewable generation, renewables other than hydroelectricity and wind—including solar, geothermal, biomass, waste, and tidal/wave/oceanic energy—do increase at a rapid rate over the projection period (Figure 7).

Electricity generation from nuclear power increases from about 2.6 trillion kilowatthours in 2007 to a projected 3.6 trillion kilowatthours in 2020 and then to 4.5 trillion kilowatthours in 2035. Higher future prices for fossil fuels make nuclear power economically competitive with generation from coal, natural gas, and liquid fuels, despite the relatively high capital costs of nuclear power plants. Moreover, higher capacity utilization rates have been reported for many existing nuclear facilities, and the projection anticipates that most of the older nuclear power plants in OECD countries and non-OECD Eurasia will be granted extensions to their operating lives.

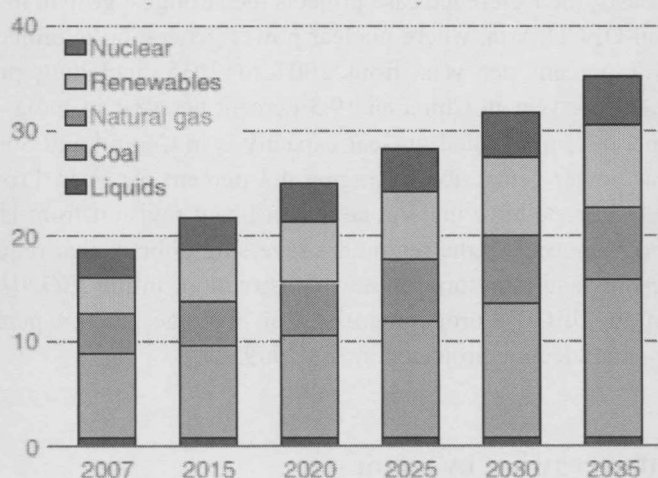


Figure 6. World net electricity generation by fuel, 2007-2035 (trillion kilowatthours).

Around the world, nuclear generation is attracting new interest as countries seek to increase the diversity of their energy supplies, improve energy security, and provide a low-carbon alternative to fossil fuels. Still, there is considerable uncertainty associated with nuclear power projections. Issues that could slow the expansion of nuclear power in the future include plant safety, radioactive waste disposal, rising construction costs and investment risk, and nuclear material proliferation concerns. Those issues continue to raise public concern in many countries and may hinder the development of new nuclear power reactors. Nevertheless, the *IEO2010* Reference case incorporates improved prospects for world nuclear power. The projection for nuclear electricity generation in 2030 is 9 percent higher than the projection published in last year's *IEO*.

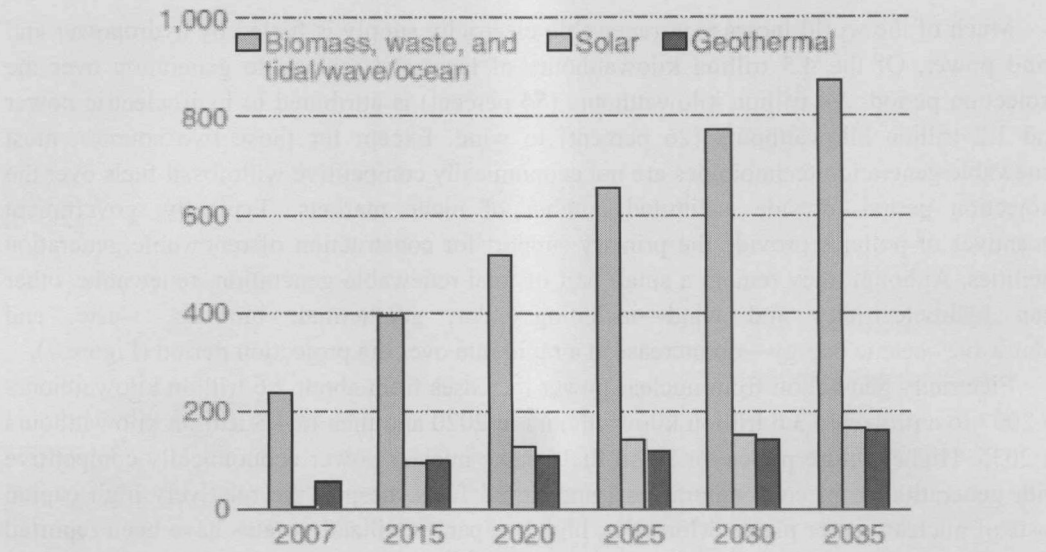


Figure 7. World renewable electricity generation by energy source, excluding wind and hydropower, 2007-2035 (billion kilowatthours).

On a regional basis, the Reference case projects the strongest growth in nuclear power for the countries of non-OECD Asia, where nuclear power generation is projected to grow at an average rate of 7.7 percent per year from 2007 to 2035, including projected increases averaging 8.4 percent per year in China and 9.5 percent per year in India. Outside Asia, the largest projected increase in installed nuclear capacity is in Central and South America, with increases in nuclear power generation averaging 4.3 percent per year. Prospects for nuclear generation in OECD Europe have undergone a significant revision from last year’s outlook, because a number of countries in the region are reversing policies that require the retirement of nuclear power plants and moratoria on new construction. In the *IEO2010* Reference case, nuclear generation in OECD Europe increases on average by 0.8 percent per year, as compared with the small decline projected in *IEO2009*.

World delivered energy use by sector

This section discusses delivered energy use, which does not include losses associated with electricity generation and transmission.

Industry

The industrial sector uses more energy globally than any other end-use sector, currently consuming about 50 percent of the world’s total delivered energy. Energy is consumed in the industrial sector by a diverse group of industries—including manufacturing, agriculture, mining, and construction—and for a wide range of activities, such as processing and assembly, space conditioning, and lighting. Worldwide, projected industrial energy consumption grows from 184 quadrillion Btu in 2007 to 262 quadrillion Btu in 2035. The industrial sector accounted for most of the reduction in energy use during the recession, primarily as a result of substantial cutbacks in manufacturing that had more pronounced