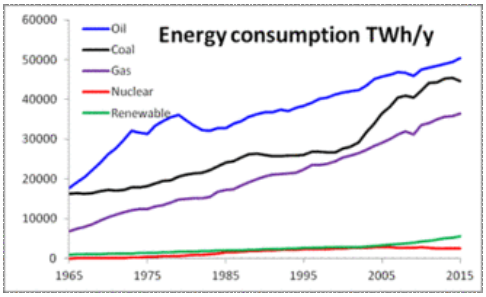
WIKIPEDIA

World energy consumption

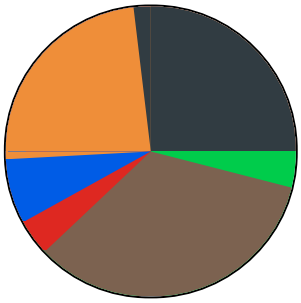
World energy consumption is the total energy produced and used by the entire human civilization. Typically measured per year, it involves all energy harnessed from every energy source applied towards humanity's endeavors across every single industrial and technological sector, across every country. It does not include energy from food, and the extent to which direct biomass burning has been accounted for is poorly documented. Being the power source metric of civilization, world energy consumption has deep implications for humanity's socio-economic-political sphere.



The world's energy consumption (2015 data)[1]
Each 10,000 TWh/y corresponds to an average value of about 1.14 TW.

Institutions such as the International Energy Agency (IEA), the U.S. Energy Information Administration (EIA), and the European Environment Agency (EEA) record and publish energy data periodically. Improved data and understanding of world energy consumption may reveal systemic trends and patterns, which could help frame current energy issues and encourage movement towards collectively useful solutions.

Closely related to energy consumption is the concept of total primary energy supply (TPES), which – on a global level – is the sum of energy production minus storage changes. Since changes of energy storage over the year are minor, TPES values can be used as an estimator for energy consumption. However, TPES ignores conversion efficiency, overstating forms of energy with poor conversion efficiency (e.g. coal, gas and nuclear) and understating forms already accounted for in converted forms (e.g. photovoltaics or hydroelectricity). The IEA estimates that, in 2013, total primary energy supply (TPES) was 157.5 petawatt hours or 1.575×10^{17} Wh (157.5 thousand TWh; 5.67×10^{20} J; 13.54 billion toe) or about 18 TW-year.[3] From 2000–2012 coal was the source of energy with the total largest growth. The use of oil and natural gas also had considerable growth, followed by hydropower and renewable energy. Renewable energy grew at a rate faster than any other time in history during this period. The demand for nuclear energy decreased, in part due to nuclear disasters (Three Mile Island in 1979, Chernobyl in 1986, and Fukushima in 2011).[1][4] More recently, consumption of coal has declined relative to renewable energy. Coal dropped from about 29% of the global total primary energy consumption in 2015 to 27% in 2017, and non-hydro renewables were up to about 4% from 2%.[5]



World total primary energy consumption by fuel in 2018[2]

- Coal (27%)
- Natural Gas (24%)
- Hydro (renewables) (7%)
- Nuclear (4%)
- Oil (34%)
- Others (renewables) (4%)

In 2011, expenditures on energy totaled over US$6 trillion, or about 10% of the world gross domestic product (GDP). Europe spends close to one-quarter of the world's energy expenditures, North America close to 20%, and Japan 6%.[6]

Contents

External links

Overview

Energy supply, consumption and electricity

World total primary energy supply (TPES), or "primary energy" differs from the world final energy consumption because much of the energy that is acquired by humans is lost as other forms of energy during the process of its refinement into usable forms of energy and its transport from its initial place of supply to consumers. For instance, when oil is extracted from the ground it must be refined into gasoline, so that it can be used in a car, and transported over long distances to gas stations where it can be used by consumers. World final energy consumption refers to the fraction of the world's primary energy that is used in its final form by humanity.

Also one needs to bear in mind that there are different qualities of energy. Heat, especially at a relatively low temperature, is low-quality energy, whereas electricity is high-quality energy. It takes around 3 kWh of heat to produce 1 kWh of electricity. But by the same token, a kilowatt-hour of this high-quality electricity can be used to pump several kilowatt-hours of heat into a building using a heat pump. And electricity can be used in many ways in which heat cannot. So the "loss" of energy incurred when generating electricity is not the same as a loss due to, say, resistance in power lines.

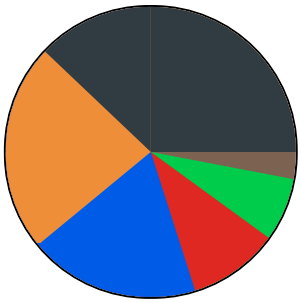
In 2014, world primary energy supply amounted to 155,481 terawatt-hour (TWh) or 13,541 million tonne of oil equivalent (Mtoe), while the world final energy consumption was 109,613 TWh or about 29.5% less than the total supply.[11] World final energy consumption includes products as lubricants, asphalt and petrochemicals which have chemical energy content but are not used as fuel. This non-energy use amounted to 9,723 TWh (836 Mtoe) in 2015.[12]

Key figures (TWh)

Year	Primary energy supply (TPES)[1]	Final energy consumption[1]	Electricity generation	Ref
1973	71,013 (Mtoe 6,106)	54,335 (Mtoe 4,672)	6,129	[3]
1990	102,569	–	11,821	–
2000	117,687	–	15,395	–
2010	147,899 (Mtoe 12,717)	100,914 (Mtoe 8,677)	21,431	[7]
2011	152,504 (Mtoe 13,113)	103,716 (Mtoe 8,918)	22,126	[8]
2012	155,505 (Mtoe 13,371)	104,426 (Mtoe 8,979)	22,668	[9]
2013	157,482 (Mtoe 13,541)	108,171 (Mtoe 9,301)	23,322	[10]
2014	155,481 (Mtoe 13,369)	109,613 (Mtoe 9,425)	23,816	[11]
2015	158,715 (Mtoe 13,647)	109,136 (Mtoe 9,384)		[12][13]
2017	162,494 (Mtoe 13,972)	113,009 (Mtoe 9,717)	25,606	[14]

[1] converted from Mtoe into TWh (1 Mtoe = 11.63 TWh) and from Quad BTU into TWh (1 Quad BTU = 293.07 TWh)

The United States Energy Information Administration (EIA) regularly publishes a report on world consumption for most types of primary energy resources. For 2013, estimated world energy consumption was 5.67×10^{20} joules, or 157,481 TWh. According to the IEA the total world energy consumption in past years was 143,851 TWh in 2008, 133,602 TWh in 2005, 117,687 TWh in 2000, and 102,569 TWh in 1990.[3] In 2012 approximately 22% of world energy was consumed in North America, 5% was consumed in South and Central America, 23% was consumed in Europe and Eurasia, 3% was consumed in Africa, and 40% was consumed in the Asia Pacific region.[1]



2018 World electricity generation (26,700 TWh) by source (IEA, 2019)[15]

- Coal (38%)
- Gas (23%)
- Hydro and other (19%)
- Nuclear (10%)
- Solar PV and wind (7%)
- Oil (3%)

Electricity generation

The total amount of electricity consumed worldwide was 19,504 TWh in 2013, 16,503 TWh in 2008, 15,105 TWh in 2005, and 12,116 TWh in 2000. By the end of 2014, the total installed electricity generating capacity worldwide was nearly 6.14 TW (million MW) which only includes generation connected to local electricity grids.[16] In addition there is an unknown amount of heat and electricity consumed off-grid by isolated villages and industries. In 2014, the share of world energy consumption for electricity generation by source was coal at 41%, natural gas at 22%, nuclear at 11%, hydro at 16%, other sources (solar, wind, geothermal, biomass, etc.) at 6% and oil at 4%. Coal and natural gas were the most used energy fuels for generating electricity. The world's electricity consumption was 18,608 TWh in 2012. This figure is about 18% smaller than the generated electricity, due to grid losses, storage losses, and self-consumption from power plants (gross generation). Cogeneration (CHP) power stations use some of the heat that is otherwise wasted for use in buildings or in industrial processes.

In 2016 the total world energy came from 80% fossil fuels, 10% biofuels, 5% nuclear and 5% renewable (hydro, wind, solar, geothermal). Only 18% of that total world energy was in the form of electricity.[17] Most of the other 82% was used for heat and transportation.

Recently there has been a large increase in international agreements and national Energy Action Plans, such as the EU 2009

Renewable Energy Directive, to increase the use of renewable energy due to the growing concerns about pollution from energy sources that come from fossil fuels such as oil, coal, and natural gas.[4][18] One such initiative was the United Nations Development Programme's World Energy Assessment in 2000 that highlighted many challenges humanity would have to overcome in order to shift from fossil fuels to renewable energy sources.[4] From 2000–2012 renewable energy grew at a rate higher than any other point in history, with a consumption increase of 176.5 million tonnes of oil. During this period, oil, coal, and natural gas continued to grow and had increases that were much higher than the increase in renewable energy. The following figures illustrate the growth in consumption of fossil fuels such as oil, coal, and natural gas as well as renewable sources of energy during this period.[1]

Trends

The energy consumption growth in the G20 slowed down to 2% in 2011, after the strong increase of 2010. The economic crisis is largely responsible for this slow growth. For several years now, the world energy demand is characterized by the bullish Chinese and Indian markets, while developed countries struggle with stagnant economies, high oil prices, resulting in stable or decreasing energy consumption.[22]

According to IEA data from 1990 to 2008, the average energy use per person increased 10% while world population increased 27%. Regional energy use also grew from 1990 to 2008: the Middle East increased by 170%, China by 146%, India by 91%, Africa by 70%, Latin America by 66%, the United States by 20%, the European Union by 7%, and world overall grew by 39%.

In 2008, total worldwide primary energy consumption was 132,000 terawatt-hours (TWh) or 474 exajoules (EJ).[23] In 2012, primary energy demand increased to 158,000 TWh (567 EJ).[24]

Energy consumption in the G20 increased by more than 5% in 2010 after a slight decline of 2009. In 2009, world energy consumption decreased for the first time in 30 years by 1.1%, or about 130 million tonnes of oil equivalent (Mtoe), as a result of the financial and economic crisis, which reduced world GDP by 0.6% in 2009.[25]

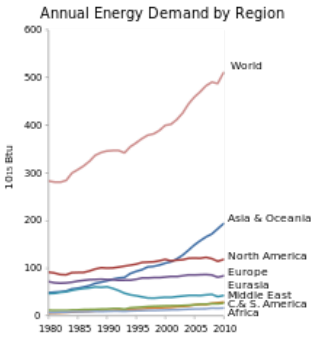
This evolution is the result of two contrasting trends: Energy consumption growth remained vigorous in several developing countries, specifically in Asia (+4%). Conversely, in OECD, consumption was severely cut by 4.7% in 2009 and was thus almost down to its 2000 levels. In North America, Europe and the CIS, consumption shrank by 4.5%, 5% and 8.5% respectively due to the slowdown in economic activity. China became the world's largest energy consumer (18% of the total) since its consumption surged by 8% during 2009 (up from 4% in 2008). Oil remained the largest energy source (33%) despite the fact that its share has been decreasing over time. Coal posted a growing role in the world's energy consumption: in 2009, it accounted for 27% of the total.

Most energy is used in the country of origin, since it is cheaper to transport final products than raw materials. In 2008, the share export of the total energy production by fuel was: oil 50% (1,952/3,941 Mt), gas 25% (800/3,149 bcm) and hard coal 14% (793/5,845 Mt).[26]

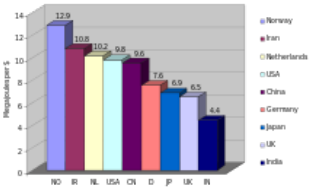
Most of the world's high energy resources are from the conversion of the sun's rays to other energy forms after being incident upon the planet. Some of that energy has been preserved as fossil energy, some is directly or indirectly usable; for example, via solar PV/thermal, wind, hydro- or wave power. The total solar irradiance is measured by satellite to be roughly 1361 watts per square meter *(see solar constant)*, though it fluctuates by about 6.9% during the year due to the Earth's varying distance from the sun. This value, after multiplication by the cross-sectional area intercepted by the Earth, is the total rate of solar energy received by the planet; about half, 89,000 TW, reaches the Earth's surface.[27]

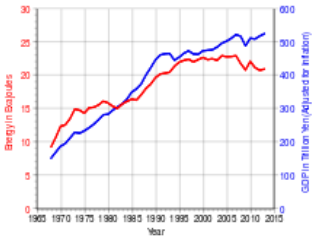
The estimates of remaining non-renewable worldwide energy resources vary, with the remaining fossil fuels totaling an estimated 0.4 yottajoule (YJ) or 4×10^{23} joules, and the available nuclear fuel such as uranium exceeding 2.5 YJ. Fossil fuels range from 0.6 to 3 YJ if estimates of reserves of methane clathrates are accurate and become technically extractable. The total power flux from the sun intercepting the Earth is 5.5 YJ per year, though not all of this is available for human consumption. The IEA estimates for the world to meet global energy demand for the two decades from 2015 to 2035 it will require investment of $48 trillion and "credible policy frameworks."[28]

According to IEA (2012) the goal of limiting warming to 2 °C is becoming more difficult and costly with each year that passes. If action is not taken before 2017, CO_2 emissions would be locked-in by energy infrastructure existing in 2017. Fossil fuels are dominant in the global energy mix, supported by $523 billion subsidies in 2011, up almost 30% on 2010 and six times



World primary energy consumption in quadrillion Btu[19]


Energy intensity of different economies: The graph shows the ratio between energy usage and GDP for selected countries. GDP is based on 2004 purchasing power parity and 2000 dollars adjusted for inflation.[20]


GDP and energy consumption in Japan, 1958–2000: The data shows the correlation between GDP and energy use; however, it also shows that this link can be broken. After the oil shocks of 1973 and 1979 the energy use stagnated while Japan's GDP continued to grow, after 1985, under the influence of the then much cheaper oil, energy use resumed its historical relation to GDP.[21]

more than subsidies to renewables.[29]

Regional energy use (kWh/capita & TWh) and growth 1990–2008 (%)[30][31]

	kWh/capita			Population (million)			Energy use (1,000 TWh)		
Region	**1990**	**2008**	**Growth**	**1990**	**2008**	**Growth**	**1990**	**2008**	**Growth**
United States	89,021	87,216	–2%	250	305	22%	22.3	26.6	20%
European Union	40,240	40,821	1%	473	499	5%	19.0	20.4	7%
Middle East	19,422	34,774	79%	132	199	51%	2.6	6.9	170%
China	8,839	18,608	111%	1,141	1,333	17%	10.1	24.8	146%
Latin America	11,281	14,421	28%	355	462	30%	4.0	6.7	66%
Africa	7,094	7,792	10%	634	984	55%	4.5	7.7	70%
India	4,419	6,280	42%	850	1,140	34%	3.8	7.2	91%
Others*	25,217	23,871	nd	1,430	1,766	23%	36.1	42.2	17%
World	**19,422**	**21,283**	**10%**	**5,265**	**6,688**	**27%**	**102.3**	**142.3**	**39%**

Source: IEA/OECD, Population OECD/World Bank

- Energy use = kWh/capita * billion capita (population) = 1 TWh
- Others: Mathematically calculated, includes e.g. countries in Asia and Australia. The use of energy varies between the "other countries": E.g. in Australia, Japan, or Canada, more energy is used per capita than in Bangladesh or Burma.

Emissions

Global warming emissions resulting from energy production are an environmental problem. Efforts to resolve this include the Kyoto Protocol (1997) and the Paris Agreement (2015), international governmental agreements aiming to reduce harmful climate impacts, which a number of nations have signed. Limiting global temperature increase to 2 degrees Celsius, thought to be a risk by the SEI, is now doubtful.

To limit global temperature to a hypothetical 2 degrees Celsius rise would demand a 75% decline in carbon emissions in industrial countries by 2050, if the population is 10 billion in 2050.[32] Across 40 years, this averages to a 2% decrease every year. In 2011, the emissions of energy production continued rising regardless of the consensus of the basic problem. Hypothetically, according to Robert Engelman (Worldwatch Institute), in order to prevent collapse, human civilization would have to stop increasing emissions within a decade regardless of the economy or population (2009).[33]

Greenhouse gases are not the only emissions of energy production and consumption. Large amounts of pollutants such as sulphurous oxides (SO_x), nitrous oxides (NO_x), and particulate matter (PM) are produced from the combustion of fossil fuels and biomass; the World Health Organization estimates that 7 million premature deaths are caused each year by air pollution.[34] Biomass combustion is a major contributor.[34][35][36] In addition to producing air pollution like fossil fuel combustion, most biomass has high CO_2 emissions.[37]

By source

Fossil fuels

The twentieth century saw a rapid twenty-fold increase in the use of fossil fuels. Between 1980 and 2006, the worldwide annual growth rate was 2%.[23] According to the US Energy Information Administration's 2006 estimate, the estimated 471.8 EJ total consumption in 2004, was divided as given in the table above, with fossil fuels supplying 86% of the world's energy:

Coal

In 2000, China accounted for 28% of world coal consumption, other Asia consumed 19%, North America 25% and the EU 14%. The single greatest coal-consuming country is China. Its share of the world coal production was 28% in 2000 and rose to 48% in 2009. In contrast to China's ~70% increase in coal consumption, world coal use increased 48% from 2000 to 2009. In practice, the majority of this growth occurred in China and the rest in other Asia.[38] China's energy consumption is mostly driven by the industry sector, the majority of which comes from coal consumption.[39]

World annual coal production increased 1,905 Mt or 32% in 6 years in 2011 compared to 2005, of which over 70% was in China and 8% in India. Coal production was in 2011 7,783 Mt, and 2009 6,903 Mt, equal to 12.7% production increase in two years.[40]

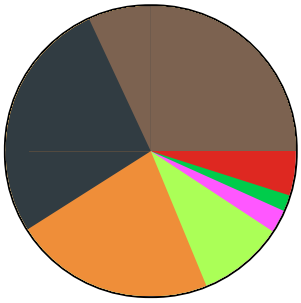
If production and consumption of coal continue at the rate as in 2008, proven and economically recoverable world reserves of coal would last for about 150 years. This is much more than needed for an irreversible climate catastrophe. Coal is the largest source of

carbon dioxide emissions in the world. According to James Hansen the single most important action needed to tackle the climate crisis is to reduce CO_2 emissions from coal.[41] Indonesia and Australia exported together 57.1% of the world coal export in 2011. China, Japan, South Korea, India and Taiwan had 65% share of all the world coal import in 2011.[42]

Regional coal supply (TWh), share 2010 (%) and share of change 2000–2010[38][43]

Region	2000	2008	2009*	2010*	%*	Change 2000–2009*
North America	6,654	6,740	6,375	6,470	16%	–1.2%
Asia excl. China	5,013	7,485	7,370	7,806	19%	18.9%
China	7,318	16,437	18,449	19,928	48%	85.5%
EU	3,700	3,499	3,135	3,137	8%	–3.8%
Africa	1,049	1,213	1,288	1,109	3%	0.4%
Russia	1,387	1,359	994	1,091	3%	–2.0%
Others	1,485	1,763	1,727	1,812	4%	2.2%
Total	**26,607**	**38,497**	**39,340**	**41,354**	**100%**	**47.9%**

Source: IEA, *in 2009, 2010 BP
*Change 2000–2009: Region's share of the world change +12,733 TWh from 2000 to 2009



Total primary energy supply of 13,972 Mtoe by source in 2017 (IEA, 2019)[14]

- Oil (32.0%)
- Coal/peat/shale (27.1%)
- Natural gas (22.2%)
- Biofuels and waste (9.5%)
- Hydro electricity (2.5%)
- Others (renewables) (1.8%)
- Nuclear (4.9%)

Oil

Coal fueled the industrial revolution in the 18th and 19th century. With the advent of the automobile, aeroplanes and the spreading use of electricity, oil became the dominant fuel during the twentieth century. The growth of oil as the largest fossil fuel was further enabled by steadily dropping prices from 1920 until 1973. After the oil shocks of 1973 and 1979, during which the price of oil increased from 5 to 45 US dollars per barrel, there was a shift away from oil.[45] Coal, natural gas, and nuclear became the fuels of choice for electricity generation and conservation measures increased energy efficiency. In the U.S. the average car more than doubled the number of miles per gallon. Japan, which bore the brunt of the oil shocks, made spectacular improvements and now has the highest energy efficiency in the world.[46] From 1965 to 2008, the use of fossil fuels has continued to grow and their share of the energy supply has increased. From 2003 to 2008, coal was the fastest growing fossil fuel.[47]

It is estimated that between 100 and 135 billion tonnes of oil has been consumed between 1850 and the present.[48]

Top 10 coal exporters (Mt)[44]

Rank	Nation	2010	2011	Share % 2011	2012
1	Indonesia	162	309	29.7%	383
2	Australia	298	285	27.4%	302
3	Russia	89	99	9.5%	103
4	US	57	85	8.2%	106
5	Colombia	68	76	7.3%	82
6	South Africa	68	70	6.7%	72
7	Kazakhstan	33	34	3.3%	32
8	Canada	24	24	2.3%	25
9	Vietnam	21	23	2.2%	18
10	Mongolia	17	22	2.1%	22
x	Others	19	14	1.3%	
Total (Mt)		**856**	**1,041**		**1,168**
Top ten		97.8%	98.7%		

Natural Gas

In 2009, the world use of natural gas grew 31% compared to 2000. 66% of this growth was outside EU, North America, Latin America, and Russia. Others include the Middle East, Asia, and Africa. The gas supply increased also in the previous regions: 8.6% in the EU and 16% in the North America 2000–2009.[49]

Regional gas supply (TWh) and share 2010 (%)[43][49]

Land	2000	2008	2009	2010	%
North America	7,621	7,779	8,839	8,925	27%
Asia excl. China	2,744	4,074	4,348	4,799	14%
China	270	825	1,015	1,141	3%
EU	4,574	5,107	4,967	5,155	16%
Africa	612	974	1,455	1,099	3%
Russia	3,709	4,259	4,209	4,335	13%
Latin America	1,008	1,357	958	nd	nd
Others	3,774	5,745	6,047	7,785	23%
Total	**24,312**	**30,134**	**31,837**	**33,240**	**100%**

Source: IEA, in 2009, 2010 BP

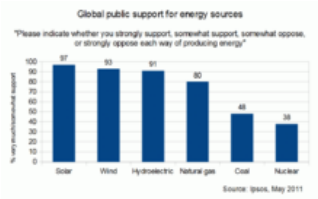
Nuclear power

As of 1 July 2016, the world had 444 operable grid-electric nuclear fission power reactors with 62 others under construction.[50]

Annual generation of nuclear power has been on a slight downward trend since 2007, decreasing 1.8% in 2009 to 2558 TWh, and another 1.6% in 2011 to 2518 TWh, despite increases in production from most countries worldwide, because those increases were more than offset by decreases in Germany and Japan. Nuclear power met 11.7% of the world's electricity demand in 2011. Source: IEA/OECD.[8]

While all the commercial reactors today use nuclear fission energy, there are plans to use nuclear fusion energy for future power plants. Several international nuclear fusion reactor experiments exists or are being constructed, including ITER.

Renewable energy



Strong public support for renewables worldwide in 2011[51]

Renewable energy is generally defined as energy that comes from resources that are not significantly depleted by their use, such as sunlight, wind, rain, tides, waves and geothermal heat.[52] Renewable energy is gradually replacing conventional fuels in four distinct areas: electricity generation, hot water/space heating, motor fuels, and rural (off-grid) energy services.[53]

Based on REN21's 2019 report, renewables contributed 18.1 percent to the world's energy consumption and 26 percent to its electricity generation in 2017 and 2018, respectively. This energy consumption is divided as 7.5% coming from traditional biomass, 4.2% as heat energy (non-biomass), 1% biofuels for transport, 3.6% hydro electricity and 2% electricity from wind, solar, biomass, geothermal, and ocean power. Worldwide investments in renewable technologies amounted to more than US$289 billion in 2018, with countries like China and the United States heavily investing in wind, hydro, solar and biofuels.[54] Renewable energy resources exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency is resulting in significant energy security, climate change mitigation, and economic benefits.[55] In international public opinion surveys there is strong support for promoting renewable sources such as solar power and wind power.[56] At the national level, at least 30 nations around the world already have renewable energy contributing more than 20 percent of energy supply. National renewable energy markets are projected to continue to grow strongly in the coming decade and beyond.[57]

The following table shows increasing nameplate capacity, and has capacity factors that range from 11% for solar, to 40% for hydropower.[58]

Selected renewable energy global indicators	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Investment in new renewable capacity (annual) (10^9 USD)[59]	182	178	237	279	256	232	270	285	241	279	289
Renewables power capacity (existing) (GWe)	1,140	1,230	1,320	1,360	1,470	1,578	1,712	1,849	2,017	2,195	2,378
Hydropower capacity (existing) (GWe)	885	915	945	970	990	1,018	1,055	1,064	1,096	1,114	1,132
Wind power capacity (existing) (GWe)	121	159	198	238	283	319	370	433	487	539	591
Solar PV capacity (grid-connected) (GWe)	16	23	40	70	100	138	177	227	303	402	505
Solar hot water capacity (existing) (GWth)	130	160	185	232	255	373	406	435	456	472	480
Ethanol production (annual) (10^9 litres)	67	76	86	86	83	87	94	98	98	106	112
Biodiesel production (annual) (10^9 litres)	12	17.8	18.5	21.4	22.5	26	29.7	30	30	31	34
Countries with policy targets for renewable energy use	79	89	98	118	138	144	164	173	176	179	169
Source: The Renewable Energy Policy Network for the 21st Century (REN21)–Global Status Report[60][61][62][63][64][65][66][67][68]											

Renewable energy 2000-2013 (TWh)[69]

	2000	2010	2013
North-America	1,973	2,237	2,443
EU	1,204	2,093	2,428
Russia	245	239	271
China	2,613	3,374	3,847
Asia (-China)	4,147	4,996	5,361
Africa	2,966	3,930	4,304
Latin America	1 502	2,127	2,242
Other	567	670	738
Total renewable	15,237	19,711	21,685
Total energy	116,958	148,736	157,485
Share	13.0%	13.3%	13.8%
Total nonrenewable	101,721	129,025	135,800

From 2000 to 2013 the total renewable energy use has increased by 6,450 TWh and total energy use by 40,500 TWh.

Hydro

Hydroelectricity is the term referring to electricity generated by hydropower; the production of electrical power through the use of the kinetic energy of falling or flowing water. In 2015 hydropower generated 16.6% of the world's total electricity and 70% of all renewable electricity,[70] which continues the rapid rate of increase experienced between 2003 and 2009.[71] Hydropower is produced in 150 countries, with the Asia-Pacific region generating 32 percent of global hydropower in 2010. China is the largest hydroelectricity producer, with 2,600 PJ (721 TWh) of production in 2010, representing around 17% of domestic electricity use. There are now three hydroelectricity plants larger than 10 GW: the Three Gorges Dam in China, Itaipu Dam in Brazil, and Guri Dam in Venezuela.[71] Nine of the worlds top 10 renewable electricity producers are primarily hydroelectric, one is wind.

Marine energy

Marine energy, also known as *ocean energy* and *marine and hydrokinetic energy* (MHK) includes tidal and wave power and is a relatively new sector of renewable energy, with most projects still in the pilot phase, but the theoretical potential is equivalent to 4–18 Mtoe. MHK development in U.S. and international waters includes projects using devices such as, wave energy converters in open coastal areas with significant waves, tidal turbines placed in coastal and estuarine areas, in-stream turbines in fast-moving rivers, ocean current turbines in areas of strong marine currents, and ocean thermal energy converters in deep tropical waters.[72]

Wind

Wind power is growing at the rate of 17% annually, with a worldwide installed capacity of 432,883 megawatts (MW) at the end of 2015,[73][74][75] and is widely used in Europe, Asia, and the United States.[76][77] Several countries have achieved relatively high levels of wind power penetration, such as 21% of stationary electricity production in Denmark,[78] 18% in Portugal,[78] 16% in Spain,[78] 14% in Ireland[79] and 9% in Germany in 2010.[78][80] As of 2011, 83 countries around the world are using wind power

on a commercial basis.[80] Continuing strong growth, by 2016 wind generated 3% of global power annually.[81]

Solar

Solar energy, radiant light and heat from the sun, has been harnessed by humans since ancient times using a range of ever-evolving technologies. Solar energy technologies include solar heating, solar photovoltaics, concentrated solar power and solar architecture, which can make considerable contributions to solving some of the most urgent problems the world now faces. The International Energy Agency projected that solar power could provide "a third of the global final energy demand after 2060, while CO_2 emissions would be reduced to very low levels."[82] Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Active solar techniques include the use of photovoltaic systems and solar thermal collectors to harness the energy. Passive solar techniques include orienting a building to the Sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. From 2012 to 2016 solar capacity tripled and now provides 1.3% of global energy.[83]

Geothermal

Geothermal energy is used commercially in over 70 countries.[84] In 2004, 200 petajoules (56 TWh) of electricity was generated from geothermal resources, and an additional 270 petajoules (75 TWh) of geothermal energy was used directly, mostly for space heating. In 2007, the world had a global capacity for 10 GW of electricity generation and an additional 28 GW of direct heating, including extraction by geothermal heat pumps.[85][86] Heat pumps are small and widely distributed, so estimates of their total capacity are uncertain and range up to 100 GW.[84]. It was estimated that geothermal heat pumps had, in 2015, a total capacity of about 50 GW producing about 455 petajoules (126 TWh) per year [87].

Bio energy

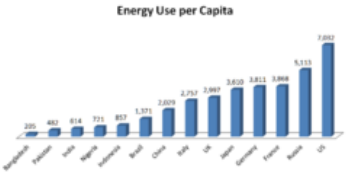
Until the beginning of the nineteenth century biomass was the predominant fuel, today it has only a small share of the overall energy supply. Electricity produced from biomass sources was estimated at 44 GW for 2005. Biomass electricity generation increased by over 100% in Germany, Hungary, the Netherlands, Poland, and Spain. A further 220 GW was used for heating (in 2004), bringing the total energy consumed from biomass to around 264 GW. The use of biomass fires for cooking is excluded.[85] World production of bioethanol increased by 8% in 2005 to reach 33 gigalitres (8.7×10^9 US gal), with most of the increase in the United States, bringing it level to the levels of consumption in Brazil.[85] Biodiesel increased by 85% to 3.9 gigalitres (1.0×10^9 US gal), making it the fastest growing renewable energy source in 2005. Over 50% is produced in Germany.[85]

By country

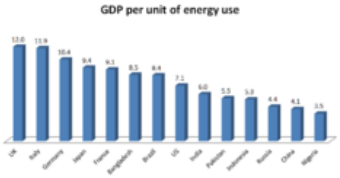
Energy consumption is loosely correlated with gross national product and climate, but there is a large difference even between the most highly developed countries, such as Japan and Germany with an energy consumption rate of 6 kW per person and the United States with an energy consumption rate of 11.4 kW per person. In developing countries, particularly those that are sub-tropical or tropical such as India, the per person energy use rate is closer to 0.7 kW. Bangladesh has the lowest consumption rate with 0.2 kW per person.

The US consumes 25% of the world's energy with a share of global GDP at 22% and a share of the world population at 4.6%.[88] The most significant growth of energy consumption is currently taking place in China, which has been growing at 5.5% per year over the last 25 years. Its population of 1.3 billion people (19.6% of the world population[88]) is consuming energy at a rate of 1.6 kW per person.

One measurement of efficiency is energy intensity. This is a measure of the amount of energy it takes a country to produce a dollar of gross domestic product.



The World Bank: Kilograms of oil equivalent (2011)



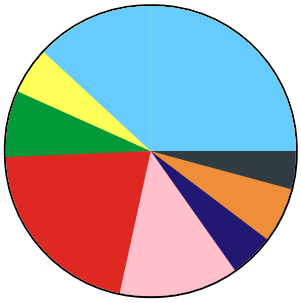
The World Bank: PPP $ per kg of oil equivalent (2011)

Oil

Saudi Arabia, Russia and the United States accounted for 34% of oil production in 2011. Saudi Arabia, Russia and Nigeria accounted for 36% of oil export in 2011.

Top 10 oil exporters (Mt)[89]

Rank	Nation	2011	Share % 2011	2012
1	Saudi Arabia	333	17.0%	
2	Russia	246	12.5%	
3	Nigeria	129	6.6%	
4	Iran	126	6.4%	
5	UAE	105	5.4%	
6	Iraq	94	4.8%	
7	Venezuela	87	4.4%	
8	Angola	84	4.3%	
9	Norway	78	4.0%	
10	Mexico	71	3.6%	
x	Others	609	31.0%	
Total (Mt)		**1,962**		

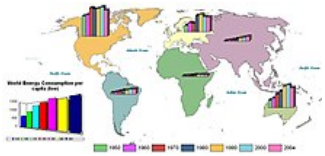


World total final consumption of 9,717 Mtoe by region in 2017 (IEA, 2019)[14]

- OECD (38.2%)
- Middle East (5.1%)
- Non-OECD Eurasia (7.5%)
- China (20.6%)
- Rest of Asia (13.5%)
- Non-OECD Americas (4.8%)
- Africa (6.1%)
- International aviation and marine bunkers (4.2%)

Top 10 oil producers (Mt)[44]

Rank	Nation	2005	2008	2009	2010	2011	Share % 2011	2012
1	Saudi Arabia	519	509	452	471	517	12.9%	544
2	Russia	470	485	494	502	510	12.7%	520
3	United States	307	300	320	336	346	8.6%	387
4	Iran	205	214	206	227	215	5.4%	186
5	China	183	190	194	200	203	5.1%	206
6	Canada	143	155	152	159	169	4.2%	182
7	UAE	nd	136	120	129	149	3.7%	163
8	Venezuela	162	137	126	149	148	3.7%	162
9	Mexico	188	159	146	144	144	3.6%	nd
10	Nigeria	133	nd	nd	130	139	3.5%	nd
x	Kuwait	nd	145	124	nd	nd	nd	152
x	Iraq	nd	nd	114	140	nd	nd	148
x	Norway	139	nd	nd	nd	nd	nd	nd
Total		**3,923**	**3,941**	**3,843**	**3,973**	**4,011**	**100%**	
Top ten		62%	62%	61%	62%	63%		



World energy consumption per capita, 1950–2004

Coal

Coal was 27% of world energy consumption in 2019 but is being displaced by natural gas and renewables.[90]

Natural gas

Top 10 natural gas producers (bcm)[89]

Rank	Nation	2005	2008	2009	2010	2011	Share % 2011
1	Russia	627	657	589	637	677	20.0%
2	US	517	583	594	613	651	19.2%
3	Canada	187	175	159	160	160	4.7%
4	Qatar	nd	79	89	121	151	4.5%
5	Iran	84	121	144	145	149	4.4%
6	Norway	90	103	106	107	106	3.1%
7	China	nd	76	90	97	103	3.0%
8	Saudi Arabia	70	nd	nd	82	92	2.7%
9	Indonesia	77	77	76	88	92	2.7%
10	Netherlands	79	85	79	89	81	2.4%
x	Algeria	93	82	81	nd	nd	nd
x	UK	93	nd	nd	nd	nd	nd
Total		**2,872**	**3,149**	**3,101**	**3,282**	**100%**	**3,388**
Top ten		67%	65%	65%	65%	67%	

bcm = billion cubic meters

Top 10 natural gas importers (bcm)[89]

Rank	Nation	2005	2008	2009	2010	2011	Share % 2011
1	Japan	81	95	93	99	116	13.9%
2	Italy	73	77	69	75	70	8.4%
3	Germany	91	79	83	83	68	8.2%
4	US	121	84	76	74	55	6.6%
5	South Korea	29	36	33	43	47	5.6%
6	Ukraine	62	53	38	37	44	5.3%
7	Turkey	27	36	35	37	43	5.2%
8	France	47	44	45	46	41	4.9%
9	UK	nd	26	29	37	37	4.4%
10	Spain	33	39	34	36	34	4.1%
x	Netherlands	23	nd	nd	nd	nd	nd
Total		**838**	**783**	**749**	**820**	**834**	**100%**
Top ten		70%	73%	71%	69%	67%	
Import of production		29%	25%	24%	25%	25%	

bcm = billion cubic meters

Wind power

Top 10 countries
by nameplate windpower capacity
(2011 year-end)[91]

Country	Windpower capacity 2011 (MW) ‡provisional	% world total	Windpower capacity 2019 (MW)	% world total
China	62,733‡	26.3	236,402	36.3
United States	46,919	19.7	105,466	16.2
Germany	29,060	12.2	61,406	9.4
Spain	21,674	9.1	n/a	n/a
India	16,084	6.7	37,506	5.7
France	6,800‡	2.8	16,645	2.6
Italy	6,747	2.8	n/a	n/a
United Kingdom	6,540	2.7	23,340	3.6
Canada	5,265	2.2	13,413	2.1
Portugal	4,083	1.7	n/a	n/a
(rest of world)	32,446	13.8	156,375	24.1
World total	**238,351 MW**	**100%**	**650,557 MW**	**100%**

Top 10 countries
by windpower electricity production
(2010 totals)[92]

Country	Windpower production (TWh)	% world total
United States	95.2	27.6
China	55.5	15.9
Spain	43.7	12.7
Germany	36.5	10.6
India	20.6	6.0
United Kingdom	10.2	3.0
France	9.7	2.8
Portugal	9.1	2.6
Italy	8.4	2.5
Canada	8.0	2.3
(rest of world)	48.5	14.1
World total	**344.8 TWh**	**100%**

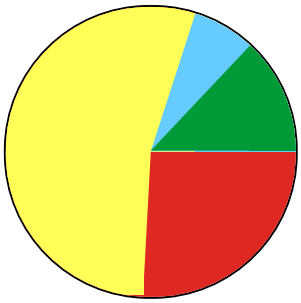
By sector

The table to the right shows the amounts of energy consumed worldwide in 2012 by four sectors, according to the Energy Information Administration of the US Department of Energy:

- Residential (heating, lighting, and appliances)
- Commercial (lighting, heating and cooling of commercial buildings, and provision of water and sewer services)
- Industrial users (agriculture, mining, manufacturing, and construction)
- Transportation (passenger, freight, and pipeline)

Of the total 120 PWh (120×10^{15} Wh) consumed, 19.4 were in the form of electricity, but this electricity required 61.7 PWh to produce. Thus the total energy consumption was around 160 PWh (ca 550×10^{15} Btu).[93] The efficiency of a typical existing power plant is around 38%.[94] The new generation of gas-fired plants reaches a substantially higher efficiency of 55%. Coal is the most common fuel for the world's electricity plants.[95]

Another report gives different values for the sectors, apparently due to different definitions. According to this, total world energy use per sector in 2008 was industry 28%, transport 27% and residential and service 36%. Division was about the same in the year 2000.[96]



World total final consumption of 119.8 PWh by sector in 2012[93]

European Union

The European Environmental Agency (EEA) measures final energy consumption (does not include energy used in production and lost in transportation) and finds that the transport sector is responsible for 32% of final energy consumption, households 26%, industry 26%, services 14% and agriculture 3% in 2012.[97] The use of energy is responsible for the majority of greenhouse gas emissions (79%), with the energy sector representing 31 p.p., transport 19 p.p., industry 13 p.p., households 9 p.p.and others 7 p.p..[98]

World energy use by sector, 2012[93]

Sector	10^{15}Btu	Petawatt-hours	%
Residential	53.0	15.5	13
Commercial	29.3	8.6	7
Industrial	222.3	65.1	54
Transportation	104.2	30.5	26
Total*	**408.9**	**119.8**	**100**

Source: US DOE. PWh from 0.293 times Btu column.
Numbers are the end use of energy
Percentages rounded

While efficient energy use and resource efficiency are growing as public policy issues, more than 70% of coal plants in the European Union are more than 20 years old and operate at an efficiency level of between 32–40%.[99] Technological developments in the 1990s have allowed efficiencies in the range of 40–45% at newer plants.[99] However, according to an impact assessment by the European Commission, this is still below the best available technological (BAT) efficiency levels of 46–49%.[99] With gas-fired power plants the average efficiency is 52% compared to 58–59% with best available technology (BAT), and gas and oil boiler plants operate at average 36% efficiency (BAT delivers 47%).[99] According to that same impact assessment by the European Commission, raising the efficiency of all new plants and the majority of existing plants, through the setting of authorisation and permit conditions, to an average generation efficiency of 52% in 2020 would lead to a reduction in annual consumption of 15 km^3 (3.6 cu mi) of natural gas and 25 Mt (25,000,000 long tons; 28,000,000 short tons) of coal.[99]

See also

- Life-cycle greenhouse-gas emissions of energy sources
- Cubic mile of oil
- Domestic energy consumption
- Earth's energy budget
- Electric energy consumption
- Energy demand management
- Energy development
- Energy intensity
- Energy policy
- Environmental impact of aviation
- Energy security and renewable technology
- Kardashev scale
- Peak oil
- Renewable energy commercialization
- List of renewable energy topics by country
- Sustainable energy
- World Energy Outlook

Lists

- List of countries by carbon dioxide emissions
- List of countries by electricity consumption
- List of countries by electricity production
- List of countries by total primary energy consumption and production
- List of countries by energy consumption per capita
- List of countries by energy intensity
- List of countries by greenhouse gas emissions
- List of countries by renewable electricity production

World energy use per sector[96]

Year	2000	2008	2000	2008
Sector	**TWh**		**%***	
Industry	21,733	27,273	27	28
Transport	22,563	26,742	28	27
Residential and service	30,555	35,319	37	36
Non-energy use	7,119	8,688	9	9
Total*	**81,970**	**98,022**	**100**	**100**

Source: IEA 2010, Total is calculated from the given sectors
Numbers are the end use of energy
Total world energy supply (2008) 143,851 TWh
Percentages rounded

References

1. BP: Statistical Review of World Energy (https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf), Workbook (xlsx), London, 2016
2. "Statistical Review of World Energy (2019)" (https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2019-full-report.pdf) (PDF). Retrieved 27 September 2019.
3. "Key world energy statistics" (ftp://ftp.energia.bme.hu/pub/energetikai_alapismeretek/KeyWorld_Statistics_2015.pdf) (PDF). IEA. 2015. Retrieved 6 April 2017.
4. World Energy Assessment (http://www.undp.org/content/dam/aplaws/publication/en/publications/environment-energy/www-ee-library/sustainable-energy/world-energy-assessment-energy-and-the-challenge-of-sustainability/World%20Energy%20Assessment-2000.pdf) (WEA). UNDP, United Nations Department of Economic and Social Affairs, World Energy Council, New York
5. "Statistical Review of World Energy (June 2018)" (https://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2018/bp-statistical-review-of-world-energy-2018-full-report.pdf) (PDF). Retrieved 27 September 2019.
6. Nathalie Desbrosses, World Energy Expenditures (http://www.leonardo-energy.org/blog/world-energy-expenditures), Leonardo Energy, 28 November 2011 (accessed 30 January 2015)
7. "2012 Key World Energy Statistics" (http://alofatuvalu.tv/FR/12_liens/12_articles_rapports/IEA_rpt_2012_us.pdf) (PDF). *www.iea.org*. IEA. 2012. pp. 6, 24, 28. Archived (https://web.archive.org/web/20150703071922/http://alofatuvalu.tv/FR/12_liens/12_articles_rapports/IEA_rpt_2012_us.pdf) (PDF) from the original on 3 July 2015.
8. "2013 Key World Energy Statistics" (https://web.archive.org/web/20190706111345/http://www.qibebt.cas.cn/xscbw/yjbg/201312/P020131219323434673634.pdf) (PDF). *www.iea.org*. IEA. 2013. pp. 6, 24, 26, 28. Archived from the original (http://proclimweb.scnat.ch/portal/ressources/3108.pdf) (PDF) on 6 July 2019. Retrieved 1 July 2015.
9. "2014 Key World Energy Statistics" (http://www.iea.org/publications/freepublications/publication/KeyWorld2014.pdf) (PDF). *www.iea.org*. IEA. 2014. pp. 6, 38. Archived (https://web.archive.org/web/20150405035039/http://www.iea.org/publications/freepublications/publication/keyworld2014.pdf) (PDF) from the original on 5 April 2015.
10. "Key World Energy Statistics" (ftp://ftp.energia.bme.hu/pub/energetikai_alapismeretek/KeyWorld_Statistics_2015.pdf) (PDF). 28 May 2017. pp. 27, 37.
11. "Key World Energy Statistics" (http://www.iea.org/publications/freepublications/publication/KeyWorld2016.pdf) (PDF). *IEA*. 28 May 2017. p. 38.
12. "Key World Energy Statistics" (https://www.iea.org/publications/freepublications/publication/KeyWorld2017.pdf) (PDF). *IEA*. September 2017. p. 7 (TPES), 36 (TFC, total final consumption). Retrieved 5 September 2018.

13. "International Energy Outlook 2017" (https://www.eia.gov/outlooks/ieo/pdf/0484(2017).pdf) (PDF). *EIA*. 14 September 2017. p. 10.
14. "Key World Energy Statistics 2019" (https://webstore.iea.org/key-world-energy-statistics-2019). International Energy Agency. 26 September 2019. pp. 6, 36. Retrieved 7 December 2019.
15. IEA Website (https://www.iea.org/geco/electricity/)
16. "Electricity - Installed generating capacity, 2014" (https://web.archive.org/web/20170429221541/https://www.cia.gov/library/publications/the-world-factbook/fields/2236.html#xx). Archived from the original (https://www.cia.gov/library/publications/the-world-factbook/fields/2236.html#xx) on 29 April 2017. Retrieved 6 April 2017.
17. "Shell – World Energy Model – A View To 2100" (https://www.shell.com/energy-and-innovation/the-energy-future/scenarios/shell-scenarios-energy-models/world-energy-model/_jcr_content/par/textimage.stream/1510344160326/2ee82a9c68cd84e572c9db09cc43d7ec3e3fafe7/shell-world-energy-model.pdf) (PDF). Shell International BV. 2017. Retrieved 28 October 2019.
18. Nakićenović, Nebojša; Grübler, Arnulf; McDonald, Alan (1998). *Global energy: perspectives*. Cambridge, NY: Cambridge University Press. ISBN 0521642000.
19. "International Energy Statistics" (http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=44&pid=44&aid=2). Energy Information Administration. Retrieved 5 June 2013.
20. "World Energy Intensity: Total Primary Energy Consumption per Dollar of Gross Domestic Product using Purchasing Power Parities, 1980–2004" (https://web.archive.org/web/20070206021602/http://www.eia.doe.gov/pub/international/iealf/tablee1p.xls). Energy Information Administration, U.S. Department of Energy. 23 August 2006. Archived from the original (http://www.eia.doe.gov/pub/international/iealf/tablee1p.xls) (XLS) on 6 February 2007. Retrieved 3 April 2007.
21. "Historical Statistics of Japan" (http://www.stat.go.jp/english/data/chouki/index.htm). Japan Ministry of Internal Affairs and Communications. Retrieved 3 April 2007.
22. "Sluggish growth of World energy demand in 2011" (http://www.enerdata.net/enerdatauk/press-and-publication/energy-press-releases/sluggish-growth-world-energy-demand-in-2011.php).
23. "Consumption by fuel, 1965–2008" (https://web.archive.org/web/20130726202544/http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/2009_downloads/statistical_review_of_world_energy_full_report_2009.xls#'Primary%20Energy%20–%20Consumption'!A1). *Statistical Review of World Energy 2009*. BP. 8 June 2009. Archived from the original (http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/2009_downloads/statistical_review_of_world_energy_full_report_2009.xls#'Primary%20Energy%20–%20Consumption'!A1) (XLS) on 26 July 2013. Retrieved 24 October 2009.
24. International Energy Statistics 2015
25. "World Energy Statistics – Energy Supply & Demand" (http://www.enerdata.net/enerdatauk/press-and-publication/publications/world-energy-statistics-supply-and-demand.php). Enerdata.
26. IEA Key energy statistics 2010 (http://www.iea.org/textbase/nppdf/free/2010/key_stats_2010.pdf) and IEA Key energy statistics 2009 (http://www.iea.org/textbase/nppdf/free/2009/key_stats_2009.pdf) Archived (https://web.archive.org/web/20100331135712/http://www.iea.org/Textbase/nppdf/free/2009/key_stats_2009.pdf) 31 March 2010 at the Wayback Machine oil p. 11, gas p. 13, hard coal (excluding brown coal) p. 15 and electricity p. 27
27. Schreiber, William (May–June 2007). "Solving the Energy Problem" (http://web.mit.edu/fnl/volume/196/schreiber.html). *MIT Faculty Newsletter*. Retrieved 10 September 2016.
28. "IEA estimates $48tn investments till 2035 to meet global energy demands" (https://www.bloomberg.com/news/2014-06-03/energy-supply-requires-40-trillion-investment-to-2035-iea-says.html). Bloomberg News. Retrieved 4 June 2014.
29. "IEA World Energy Outlook 2012 Executive Summary" (http://www.iea.org/publications/freepublications/publication/English.pdf) (PDF). Retrieved 27 September 2019.
30. Table 55, Regional energy use, 1990 and 2008 (p. 48), in "Energy in Sweden – facts and figures 2010" (https://web.archive.org/web/20131014221749/http://webbshop.cm.se/System/DownloadResource.ashx?p=Energimyndigheten&rl=default%3A%2FResources%2FPermanent%2FStatic%2Fe0a2619a83294099a16519a0b5edd26f%2FET2010_46.pdf) (PDF). Swedish Energy Agency. Archived from the original (https://webbshop.cm.se/System/DownloadResource.ashx?p=Energimyndigheten&rl=default:/Resources/Permanent/Static/e0a2619a83294099a16519a0b5edd26f/ET2010_46.pdf) (PDF) on 14 October 2013. (see also Energy in Sweden 2011 (https://energimyndigheten.a-w2m.se/FolderContents.mvc/Download?ResourceId=2609)), data from IEA Energy Balances of Non-OECD countries (https://www.iea.org/statistics/relateddatabases/energybalancesofnon-oecdcountries/) 2010.
31. "IEA Key energy statistics 2010" (https://web.archive.org/web/20120301212427/http://www.iea.org/textbase/nppdf/free/2010/key_stats_2010.pdf) (PDF). IEA. 2010. p. 48. Archived from the original (http://www.iea.org/textbase/nppdf/free/2010/key_stats_2010.pdf) (PDF) on 1 March 2012.
32. Energiläget 2050 by prof. Cristian Azar and Kristian Lindgren Chalmers Göteborg (in Swedish)
33. *State of the world 2009*, Worldwatch Institute
34. "7 million premature deaths annually linked to air pollution" (http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/). WHO.
35. "Ambient (outdoor) air quality and health" (http://www.who.int/mediacentre/factsheets/fs313/en/). WHO.
36. "Household air pollution and health" (http://www.who.int/mediacentre/factsheets/fs292/en/). WHO.
37. http://www.pfpi.net/wp-content/uploads/2011/04/PFPI-biomass-carbon-accounting-overview_April.pdf

38. Table 52 Global supply of coal, 1990–2009 (pp. 44-45), in "Energy in Sweden — facts and figures 2010" (https://web.archive.org/web/20131014221749/http://webbshop.cm.se/System/DownloadResource.ashx?p=Energimyndigheten&rl=default%3A%2FResources%2FPermanent%2FStatic%2Fe0a2619a83294099a16519a0b5edd26f%2FET2010_46.pdf) (PDF). Swedish Energy Agency. Archived from the original (https://webbshop.cm.se/System/DownloadResource.ashx?p=Energimyndigheten&rl=default:/Resources/Permanent/Static/e0a2619a83294099a16519a0b5edd26f/ET2010_46.pdf) (PDF) on 14 October 2013. (see also Energy in Sweden 2011 (https://energimyndigheten.a-w2m.se/FolderContents.mvc/Download?ResourceId=2609)), data from IEA Energy Balances of Non-OECD countries (https://www.iea.org/statistics/relateddatabases/energybalancesofnon-oecdcountries/) 2010.
39. Ma, Damien. "China's Coming Decade of Natural Gas". *Asia's Uncertain LNG Future, NBR Special Report*. November 2013. Retrieved 8 August 2014.
40. Key statistics 2012, 2010 and 2006 IEA
41. The True Cost of Coal (http://www.greenpeace.org/raw/content/international/press/reports/true-cost-coal.pdf) 27 November 2008 pp. 66–69
42. Key statistics 2012 IEA
43. Energiläget 2011 (http://energimyndigheten.se/Global/Statistik/Energil%C3%A4get/Energil%C3%A4get%20i%20siffror%202011.pdf) Archived (https://web.archive.org/web/20120401205225/http://www.energimyndigheten.se/Global/Statistik/Energil%C3%A4get/Energil%C3%A4get%20i%20siffror%202011.pdf) 1 April 2012 at the Wayback Machine
44. IEA Key World Energy Statistics 2013 (http://www.iea.org/publications/freepublications/publication/name,31287,en.html), 2012 (http://www.iea.org/publications/freepublications/publication/kwes.pdf), 2011 (http://www.iea.org/textbase/nppdf/free/2011/key_world_energy_stats.pdf), 2010 (http://www.iea.org/textbase/nppdf/free/2010/key_stats_2010.pdf), 2009 (http://www.iea.org/textbase/nppdf/free/2009/key2009.pdf) Archived (https://web.archive.org/web/20131007042901/http://www.iea.org/textbase/nppdf/free/2009/key2009.pdf) 7 October 2013 at the Wayback Machine, 2006 (http://www.iea.org/textbase/nppdf/free/2006/key2006.pdf) Archived (https://web.archive.org/web/20091012043312/http://www.iea.org/textbase/nppdf/free/2006/key2006.pdf) 12 October 2009 at the Wayback Machine IEA October, crude oil p. 11, coal p. 13, gas p. 15
45. Yergin, p. 792
46. "Key World Energy Statistics" (https://web.archive.org/web/20091012043312/http://www.iea.org/textbase/nppdf/free/2006/key2006.pdf) (PDF). International Energy Agency. 2006. Archived from the original (http://www.iea.org/textbase/nppdf/free/2006/key2006.pdf) (PDF) on 12 October 2009. Retrieved 3 April 2007. pp. 48–57
47. Yergin, p. ?
48. How Much Oil Have We Used? (https://www.sciencedaily.com/releases/2009/05/090507072830.htm), Science Daily, 8 May 2009. Retrieved March 2014.
49. Table 50 Global supply of gas 1990–2009 (p. 44), in "Energy in Sweden — facts and figures 2010" (https://web.archive.org/web/20131014221749/http://webbshop.cm.se/System/DownloadResource.ashx?p=Energimyndigheten&rl=default%3A%2FResources%2FPermanent%2FStatic%2Fe0a2619a83294099a16519a0b5edd26f%2FET2010_46.pdf) (PDF). Swedish Energy Agency. Archived from the original (https://webbshop.cm.se/System/DownloadResource.ashx?p=Energimyndigheten&rl=default:/Resources/Permanent/Static/e0a2619a83294099a16519a0b5edd26f/ET2010_46.pdf) (PDF) on 14 October 2013. (see also Energy in Sweden 2011 (https://energimyndigheten.a-w2m.se/FolderContents.mvc/Download?ResourceId=2609)), data from IEA Energy Balances of Non-OECD countries (https://www.iea.org/statistics/relateddatabases/energybalancesofnon-oecdcountries/) 2010.
50. World Nuclear Association, (1 July 2016) [1] (http://www.world-nuclear.org/information-library/facts-and-figures/world-nuclear-power-reactors-and-uranium-requireme.aspx), www.world-nuclear.org
51. Ipsos 2011, p. 3
52. "The myth of renewable energy" (http://thebulletin.org/myth-renewable-energy). *Bulletin of the Atomic Scientists*. 22 November 2011. Retrieved 3 October 2013.
53. REN21 (2010). Renewables 2010 Global Status Report (http://www.harbortaxgroup.com/wp-content/uploads/2014/07/REN21_GSR_2010_full_revised-Sept2010.pdf) p. 15.
54. REN21 (2019). "Renewables 2019: Global Status Report" (https://www.ren21.net/wp-content/uploads/2019/05/gsr_2019_full_report_en.pdf) (PDF).
55. International Energy Agency (2012). "Energy Technology Perspectives 2012" (http://www.iea.org/Textbase/npsum/ETP2012SUM.pdf) (PDF).
56. "Global Trends in Sustainable Energy Investment 2007: Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency in OECD and Developing Countries" (http://www.unep.org/pdf/72_Glob_Sust_Energy_Inv_Report_(2007).pdf) (PDF). *www.unep.org*. United Nations Environment Programme. 2007. p. 3. Archived (https://web.archive.org/web/20160304114134/http://www.unep.org/pdf/72_Glob_Sust_Energy_Inv_Report_(2007).pdf) (PDF) from the original on 4 March 2016. Retrieved 13 October 2014.
57. REN21 (2013). "Renewables global futures report 2013" (http://new.ren21.net/Portals/0/REN21_GFR_2013_print.pdf) (PDF).
58. "Electricity generation: very different capacity factors!" (https://meteolcd.wordpress.com/2015/09/21/electricity-generation-very-different-capacity-factors/). 21 September 2015.
59. http://www.ren21.net/wp-content/uploads/2015/06/GSR2015_Figure25.jpg
60. "Renewables 2011: Global Status Report" (https://www.ren21.net/wp-content/uploads/2019/05/GSR2011_Full-Report_English.pdf) (PDF).

61. "Renewables 2012: Global Status Report" (https://www.ren21.net/wp-content/uploads/2019/05/GSR2012_Full-Report_English.pdf) (PDF).
62. "Renewables 2013: Global Status Report" (https://www.ren21.net/wp-content/uploads/2019/05/GSR2013_Full-Report_English.pdf) (PDF).
63. "Renewables 2014: Global Status Report" (https://www.ren21.net/wp-content/uploads/2019/05/GSR2014_Key-Findings_English.pdf) (PDF).
64. "Renewables 2015: Global Status Report" (https://www.ren21.net/wp-content/uploads/2019/05/GSR2015_Full-Report_English.pdf) (PDF).
65. "Renewables 2016: Global Status Report" (https://www.ren21.net/wp-content/uploads/2019/05/REN21_GSR2016_FullReport_en_11.pdf) (PDF).
66. "Renewables 2017: Global Status Report" (https://www.ren21.net/wp-content/uploads/2019/05/GSR2017_Full-Report_English.pdf) (PDF).
67. "Renewables 2018: Global Status Report" (https://www.ren21.net/wp-content/uploads/2019/08/Full-Report-2018.pdf) (PDF).
68. "Renewables 2019: Global Status Report" (https://www.ren21.net/wp-content/uploads/2019/05/gsr_2019_full_report_en.pdf) (PDF).
69. Energiläget i siffror 2016 (http://www.energimyndigheten.se/nyhetsarkiv/2016/nu-finns-energilaget-i-siffror-2016/) Energimyndigheten Sweden (See Renewable energy 12.3 Total energy 12.1)
70. http://www.ren21.net/wp-content/uploads/2016/06/GSR_2016_Full_Report_REN21.pdf
71. "Use and Capacity of Global Hydropower Increases" (http://www.worldwatch.org/node/9527). Worldwatch Institute. January 2012.
72. "Tethys | Environmental Effects of Wind and Marine Renewable Energy" (https://tethys.pnnl.gov/). *tethys.pnnl.gov*. Retrieved 27 September 2019.
73. Global Wind Energy Council. "GWEC Global Statistics" (http://www.gwec.net/global-figures/graphs/).
74. Lars Kroldrup. Gains in Global Wind Capacity Reported (http://greeninc.blogs.nytimes.com/2010/02/15/gains-in-global-wind-capacity-reported/) *Green Inc.*, 15 February 2010.
75. REN21 (2011). "Renewables 2011: Global Status Report" (http://www.ren21.net/Portals/97/documents/GSR/GSR2011_Master18.pdf) (PDF). p. 15.
76. Global wind energy markets continue to boom – 2006 another record year (http://www.gwec.net/uploads/media/07-02_PR_Global_Statistics_2006.pdf) Archived (https://web.archive.org/web/20110407175732/http://www.gwec.net/uploads/media/07-02_PR_Global_Statistics_2006.pdf) 7 April 2011 at the Wayback Machine (PDF).
77. Beattie, David (18 March 2011). "Wind Power: China Picks Up Pace" (http://www.renewableenergyworld.com/rea/news/article/2011/03/wind-power-china-picks-up-paceeu-and-us-fall-but-global-market-grows). *Renewable Energy World*.
78. "World Wind Energy Report 2010" (https://web.archive.org/web/20110904232058/http://www.wwindea.org/home/images/stories/pdfs/worldwindenergyreport2010_s.pdf) (PDF). *Report*. World Wind Energy Association. February 2011. Archived from the original (http://www.wwindea.org/home/images/stories/pdfs/worldwindenergyreport2010_s.pdf) (PDF) on 4 September 2011. Retrieved 30 April 2011.
79. "Renewables" (https://web.archive.org/web/20110810081403/http://www.eirgrid.com/renewables/). eirgrid.com. Archived from the original (http://www.eirgrid.com/renewables/) on 10 August 2011. Retrieved 22 November 2010.
80. REN21 (2011). "Renewables 2011: Global Status Report" (http://www.ren21.net/Portals/97/documents/GSR/GSR2011_Master18.pdf) (PDF). p. 11.
81. http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/renewable-energy/wind-energy.html
82. http://www.iea.org/Textbase/npsum/solar2011SUM.pdf
83. http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/renewable-energy/solar-energy.html
84. "The Future of Geothermal Energy" (https://wayback.archive-it.org/all/20110310030646/http://geothermal.inel.gov/publications/future_of_geothermal_energy.pdf) (PDF). MIT. Archived from the original (http://geothermal.inel.gov/publications/future_of_geothermal_energy.pdf) (PDF) on 10 March 2011. Retrieved 7 February 2007.
85. "Renewables, Global Status Report 2006" (https://web.archive.org/web/20110718181410/http://www.ren21.net/globalstatusreport/download/RE_GSR_2006_Update.pdf) (PDF). Renewable Energy Policy Network for the 21st century. 2006. Archived from the original (http://www.ren21.net/globalstatusreport/download/RE_GSR_2006_Update.pdf) (PDF) on 18 July 2011. Retrieved 3 April 2007.
86. Fridleifsson, Ingvar B.; Bertani, Ruggero; Huenges, Ernst; Lund, John W.; Ragnarsson, Arni; Rybach, Ladislaus (11 February 2008). O. Hohmeyer and T. Trittin (ed.). "The possible role and contribution of geothermal energy to the mitigation of climate change" (https://web.archive.org/web/20110722030340/http://iga.igg.cnr.it/documenti/IGA/Fridleifsson_et_al_IPCC_Geothermal_paper_2008.pdf) (PDF). Luebeck, Germany: 59–80. Archived from the original (http://iga.igg.cnr.it/documenti/IGA/Fridleifsson_et_al_IPCC_Geothermal_paper_2008.pdf) (PDF) on 22 July 2011. Retrieved 6 April 2009.
87. Lund, John W.; Boyd, Tonya L. (March 2016). "Direct utilization of geothermal energy 2015 worldwide review". *Geothermics*. **60**: 66–93. doi:10.1016/j.geothermics.2015.11.004 (https://doi.org/10.1016%2Fj.geothermics.2015.11.004).
88. "World Population Prospects" (https://web.archive.org/web/20070321013235/http://esa.un.org/unpp/). United Nations. Archived from the original (http://esa.un.org/UNPP/) on 21 March 2007. Retrieved 7 February 2011.

89. IEA Key World Energy Statistics 2012 (http://www.iea.org/publications/freepublications/publication/kwes.pdf), 2011 (http://www.iea.org/textbase/nppdf/free/2011/key_world_energy_stats.pdf), 2010 (http://www.iea.org/textbase/nppdf/free/2010/key_stats_2010.pdf), 2009 (http://www.iea.org/textbase/nppdf/free/2009/key2009.pdf) Archived (https://web.archive.org/web/20131007042901/http://www.iea.org/textbase/nppdf/free/2009/key2009.pdf) 7 October 2013 at the Wayback Machine, 2006 (http://www.iea.org/textbase/nppdf/free/2006/key2006.pdf) Archived (https://web.archive.org/web/20091012043312/http://www.iea.org/textbase/nppdf/free/2006/key2006.pdf) 12 October 2009 at the Wayback Machine IEA October, crude oil p. 11, coal p. 13 gas p. 15
90. "Coal | Energy economics | Home" (https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/coal.html). *bp global*. Retrieved 19 July 2020.
91. "GWEC Global Wind Statistics 2011" (http://gwec.net/wp-content/uploads/2012/06/GWEC_-_Global_Wind_Statistics_2011.pdf) (PDF). Global Wind Energy Commission. Retrieved 15 March 2012.
92. "Worldwide Electricity Production From Renewable Energy Sources: Stats and Figures Series: Thirteenth Inventory – Edition 2011" (http://www.energies-renouvelables.org/observ-er/html/inventaire/pdf/13e-inventaire-Chap02.pdf) (PDF). 2.2 Electricity Production From Wind Sources: Main Wind Power Producing Countries – 2010 (text & table): Observ'ER. Retrieved 29 March 2012.
93. Table F1 (https://www.eia.gov/outlooks/ieo/pdf/ieorefenusetab_1.pdf) of "International Energy Outlook 2016" (https://web.archive.org/web/20170727110053/https://www.eia.gov/outlooks/ieo/pdf/0484(2016).pdf) (PDF). Washington, DC: United States Department of Energy. Archived from the original (http://www.eia.doe.gov/oiaf/ieo/index.html) on 27 July 2017.
94. "Energy efficiency measures and technological improvements" (https://web.archive.org/web/20070204112155/http://www.e8.org/index.jsp?numPage=138). e8.org. Archived from the original (http://www.e8.org/index.jsp?numPage=138) on 4 February 2007. Retrieved 21 January 2007. Article by group of ten leading electricity companies
95. "Coal Facts 2006 Edition" (http://arquivo.pt/wayback/20160517000455/http://www.worldcoal.org/assets_cm/files/PDF/coal_fact_card_2006.pdf) (PDF). World Coal Institute. September 2006. Archived from the original (http://www.worldcoal.org/assets_cm/files/PDF/coal_fact_card_2006.pdf) (PDF) on 17 May 2016. Retrieved 8 April 2007.
96. Table 56, Total world energy use per sector 1990–2008 (pp. 48–49), in "Energy in Sweden – facts and figures 2010" (https://web.archive.org/web/20131014221749/http://webbshop.cm.se/System/DownloadResource.ashx?p=Energimyndigheten&rl=default%3A%2FResources%2FPermanent%2FStatic%2Fe0a2619a83294099a16519a0b5edd26f%2FET2010_46.pdf) (PDF). Swedish Energy Agency. Archived from the original (https://webbshop.cm.se/System/DownloadResource.ashx?p=Energimyndigheten&rl=default:/Resources/Permanent/Static/e0a2619a83294099a16519a0b5edd26f/ET2010_46.pdf) (PDF) on 14 October 2013. (see also Energy in Sweden 2011 (https://energimyndigheten.a-w2m.se/FolderContents.mvc/Download?ResourceId=2609)), data from IEA Energy Balances of Non-OECD countries (https://www.iea.org/statistics/relateddatabases/energybalancesofnon-oecdcountries/) 2010.
97. European Environmental Agency. "Final energy consumption by sector and fuel (CSI 027/ENER 016) – Assessment" (http://www.eea.europa.eu/data-and-maps/indicators/final-energy-consumption-by-sector-8/assessment-2). January 2015. Retrieved 21 June 2015.
98. Eva Hoos European Commission 2011. A new Directive on Energy Efficiency (http://eme2.eu/cust/documentrequest.aspx?DocID=148). Retrieved 11 October 2011.
99. European Commission 2011. Impact Assessment Accompanying the document Directive of the European Parliament and of the Council on energy efficiency and amending and subsequently repealing Directives 2004/8/EC and 2006/32/EC (http://eme2.eu/cust/documentrequest.aspx?DocID=152). p. 106. Retrieved 11 October 2011.

External links

- World Energy Outlook (https://www.iea.org/weo)
- BP global energy outlook to 2035 (http://www.bp.com/en/global/corporate/energy-economics/energy-outlook-2035.html)
- BP Statistical Review of World Energy June 2017 (http://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf)
- Energy Statistics and News from the European Union (http://www.energy.eu/)
- Official Energy Statistics from the US government (http://www.eia.doe.gov/)
- Annual Energy Review (http://www.eia.doe.gov/emeu/aer/pdf/aer.pdf), by the U.S. Department of Energy's Energy Information Administration (PDF)
- International Energy Outlook 2019 (https://www.eia.gov/outlooks/ieo/), by the U.S. Energy Information Administration