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Review article

A critical review of comparative global historical energy consumption and future demand: The story told so far

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ABSTRACT

This review presents a critical combined energy analysis of demand in developed/developing countries, including the load requirements of the various business sectors. It summarizes on-demand time-series, energy supply, overall trade in gas, oil, electricity, coal, and renewable energy (e.g., wind, solar, geothermal, tidal, etc.) as well as global carbon dioxide (CO2) emissions. The duration of the review is selected between the energy supply and demand forecast from 1990 to 2040. Multi-energy approaches include primary energy generation, consumption, gross domestic product (GDP) energy intensity, the total trade balance of crude oil production, production of natural gas, trade balance and use of natural gas, production of lignite and coal, demand for trade in lignite and coal, generation and use of electricity, the share of renewables in power generation, total percentage of solar energy. Geographic coverage covered the global energy demand of the Organization for Economic Co-operation and Development (OECD), the group of seven (G7), Brazil, Russia, India, China, and South Africa (BRICS), European Union, Europe, North America, Commonwealth of Independent States (CIS), Asia, Latin America, Pacific, Middle-East and Africa. Market individuals and cooperative policymakers communicate in a variety of ways: our review and its impact on energy trade, social development, economic and climate change, which is then presented in a deeper way, in the future energy outlook. The findings of the review make it clear that there is a great deal of future global energy demand until 2040 in different situations: new aspects of policymaking, the requirement is about 15% lower in the 450-scenario, and 10% higher in the current energy policy scenario.

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Nomenclature

Bcm	Billion cubic meters (10^9 cubic meters)
BRICS	Brazil, Russia, India, China, and South Africa
CIS	Commonwealth of Independent States
CO_2	Carbon dioxide
EU	European Union
G7	The Group of Seven
gCO_2/kWh	Gram carbon dioxide equivalent/ kilowatt-hour
GDP	Gross domestic product
GHGE	Greenhouse gases emissions
GW	Gigawatt
IAE	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
kCO_2	Kilogram of carbon dioxide ($10^{-3}tCO_2$)
Koe	Kilo of oil equivalent (10^{-3}toe)
LA	Latin America
LNG	Liquefied natural gas
LT	Long term
mb/d	Millions of barrels per day
ME	Middle east
Mt	Million tonne
Mtoe	Tonne of oil equivalent
NA	North America
NG	Natural gas
NGL	Natural gas liquids
NPS	New policies scenario
OECD	The Organization for Economic Co-operation and Development
OPEC	Organization of the petroleum exporting countries
RE	Renewable energy
RES	Renewable energy sources
SDG	Sustainable development goals
SE4ALL	Sustainable energy for all
tCO_2	Tonne of carbon dioxide
toe	Tonne of oil equivalent
TWh	Terawatt hour
UK	United Kingdom
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
WEC	World Energy Council
$2015p	Dollars at the constant exchange rate, price and purchasing power parities of the year 2015

1. Introduction

World energy demand in a large number of contexts, including the current state-of-the-art, allowing the devastating impact of global warming on the different situations where countries and people work together to reach the Paris agreement target well below temperature 2.0 °C (Kona et al., 2018; IEA, 2017). In recent decades, the worldwide use of energy has risen exponentially, ranging from 8,588.9 million tonnes (Mtoe) in 1995 to 13,147.3 Mtoe in 2015 (Dong et al., 2020). Energy performance is one of the key pillars of every policy to ensure inclusive and sustainable economic growth across the globe. Cost-effective measures to improve the energy security of supply, reduce the climate footprint of energy networks, and enhance the welfare and competitiveness of the International Energy Agency (IEA) remain in place. In the recent era, total primary energy consumption (approximately 80%) from fossil fuels (Zhang et al., 2017; Zerta et al., 2008; Jamshidi and Askarzadeh, 2019). Various government institutions, such as the World Energy Council (WEC), the Organization of Petroleum Exporting Countries (OPEC), and world mega-oil organizations have investigated a large number of future global energy forecasting studies (Cooperation, 2015).

One hundred ninety-three countries signed the Sustainable Development Goals (SDGs) in September 2015, including both developed and developing countries officially known as the 2030 Agenda for Global Development of SDGs and Corporations (Omer and Noguchi, 2020; Alawneh et al., 2019; Akuraju et al., 2020; United Nations, 2015a). As a result, significant sustainability attention is paid to air pollution and is directly identified in two primary SDG objectives: SDG 11.6 (mitigation of air pollution impacts of large cities affecting people) and SDG 3.9 (significant reduction in health effects due to hazardous elements) (Mannion, 2014).

On the contrary, energy and power are the essential requirements that are important to every nation. This significance has arisen in the energy sector and is being further used in the transport sector, and the energy industry has received considerable attention over the last few decades. The energy sector plays an important role in the increase in wealth and, therefore, in the growth of the country, as well as in environmental and social sustainability (Bouzguenda et al., 2019; Jefferson, 2006; Rackliffe, 2014). Energy is a key factor in meeting the global sustainable agenda and should be the primary challenge for developing

and developed countries (Iddrisu and Bhattacharyya, 2015; Pietrosemoli and Rodríguez-Monroy, 2019). Non-OECD countries are forecast to account for 64.0% of 739 quadrillion Btu of total world energy requirements by 2040 (IEA, 2017). Asia is projected to be the largest shift in energy use in non-OECD countries (IEA, 2017). The global demand for energy increases the demand for fossil fuels rather than for coal. The shift in the share of production of the entire gross domestic output parameter results in more significant variations in energy requirements and consumption. China's growth is leading to an increase in the proportion of energy-intensive commodities produced in the world. India's per capita income and energy requirements continue to lag in the various larger economies (Rosenstein et al., 1992; IEA, 2017; U.S. Energy Information Administration, 2019; USEIA, 2030, 2008; IEA, 2013). In addition, electricity is a key parameter of social and economic development. It covers different types of energy resources and economic levels, the energy development plan, and the energy consumption policy of a particular country. By examining these characteristics and trends of global energy reviews, progress and shifts in clean energy growth, a different perception of the future of energy development, this review provides an overall perspective and review of global energy growth, history, and future developments. We cover details on energy transformation, primary and final world energy demand, geographic coverage and the past with high-quality publications and future energy demand analysis.

1.1. Scope of this study

This study covers a comprehensive analysis of historical energy consumption (from 1990 to 2017) and future energy requirements (from 2020 to 2040) based on geographical coverage. The forecasting studies provide an in-depth analysis of rapid changes in energy demand and future requirements (Ahmad and Chen, 2020; Ahmad et al., 2020b,a; Tanveer Ahmad, 2020). The geographical coverage is based on OECD, G7, BRICS, Europe, the European Union (EU), the Commonwealth of Independent States (CIS), North America (NA), Latin America (LA), the United States of America (USA), Asia, the Pacific and the Middle East (ME). Table 1 provides a brief overview of the different countries with geographical coverage. In addition, this study analyzes time-series on demand and supply, requirements for trade in coal, oil, electricity, and gas, as well as information on renewable energy and CO2 emissions. With a wide range of geographic coverage as well as a multi-energy demand analysis, the data for the review analysis and future energy forecasted demand was taken from a closed data source (EnerData, 2018).

There are different scenarios for the future energy outlook in the world. The aim of this review study is to give an outlook of past, present, and future energy and price forecast of OECD, G7, BRICS, Europe, EU, CIS, NA, LA, Asia, Pacific, Africa, and ME. This study aims to provide a leading source of strategic insight into energy and future emissions, detailed scenarios that map the consequences of various energy policies and investment choices. In order to reflect developing countries, a more progressive future energy outlook is needed to reflect the growth and local resource use priorities and ways to address these priorities by energy efficiency measures and technologies.

1.2. Related literature

The basic objective of the global energy transformation is to reduce CO2 emissions significantly. Germany is expected to reduce its CO2 emissions by 80% by 2050 and to be around 95% lower since 1990 (Henning and Palzer, 2015); (Sterchele et al., 2017). Climate prevention is a vital issue and gives priority not only to the national level, but also to many citizens (Åkerfeldt and Hammar, 2016). Chemical industries have a significant role to play in the pollution of the current environment (Bazzanella et al., 2017). New real-time modern, environmentally friendly technologies are producing good results to reduce CO2 emissions (Bazzanella and Ausfelder, 2017). Fig. 1 visualizing the energy transition will require access to cheap and carbon-free (Bazzanella and Ausfelder, 2017). The reduction in CO2 emissions is still a major challenge for the European chemical industry. Low carbon demand, alternative feedstock demand, and huge investment are challenging and need opportunities for a number of non-fuel applications to explore and implement environmentally friendly scenarios by 2050. The basic reason to overcome this obstacle is higher generation costs for low-carbon technologies. Sustainable materials, industrial symbiosis, and recycling options need to be investigated in order to increase resource efficiency and improve the energy sector.

A comprehensive review of existing potential biomass technologies and their use in energy planning and decision-making has been conducted in reference (Brosowski et al., 2016). The European Union Emissions Trading System (EUETS) covers manufacturing plants and 11,000 power stations to reduce emissions, including 28 EU member states (Brandt and Svendsen, 2016). North Rhine-Westphalia, a German state, is building projects to achieve its green and clean energy goals for sustainable development (Emonts et al., 2017). The Canadian government, along with most provinces, has planned a climate change and clean growth framework to reduce CO2 emissions (Canada and Canada, 2017). There is a clear consensus in German society that it is vital to achieve a reduction in CO2 emissions and to encourage renewable energy sources to play a dominant role in future energy chain systems in Germany (Palzer and Henning, 2014). Over the last few years, the evolution of renewable energy has exceeded all expectations (Ren21, 2014). There has been a significant shift in the world's installed renewable capacity and a significant increase in renewable technologies. A large number of renewable energy sources are increasing, as shown in Fig. 2, the bulk employment ratio is also increasing in countries such as the United States, China, India, Brazil, Germany and the Member States of the European Union (Ren21, 2014). Solar, biomass, and biofuels are renewable energy sources that generate a large number of energy and energy jobs. The SBC Energy Institute is set up to promote and generate an understanding of future and current energy technologies that will be needed to ensure a secure, safe and reliable global energy mix and shift supply from carbon-intensive to carbon-restricted (Decout et al., 2014).

The building sector is a major energy-consuming sector and is estimated to account for more than a third of the world's energy consumption (Kim et al., 2019; Transition to sustainable buildings: Strategies and opportunities to 2050, 2013). In 1950, total energy use in the industrial sector was 48%, but gradually decreased to 31% in early 2010 (Azari and Abbasabadi, 2018; Annual Energy Review, 2010a). However, there is a small increase in commercial energy consumption from 11% in 1949 to 19% in 2010 (Annual Energy Review, 2010b). Data from the US Department of Energy show that commercial and residential buildings contributed 41.10% to energy consumption and 40% to greenhouse gas emissions in 2010 (DOE, 2012). The demand for the Chinese building energy sector has increased 1.7-times, and the energy consumption ratio of the total energy demand has remained relatively stable between 17.70% and 20.30% (Tian et al., 2019; Huo et al., 2018). Hisham Khatib reviewed nuclear energy demand in the immediate aftermath of the Fukushima incident with the strategic energy challenges of energy poverty (Khatib, 2012). Farah et al. (Ahmed et al., 2019), examined the most advanced developments in solar thermal technology in terms of

Table 1
Geographical coverage of the global energy outlook.

Sr. No.	Geographical coverage	Countries
1	OECD	Australia, Austria, Belgium, Canada, Czech Republic, Chile, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Iceland, Italy, Japan, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, South Korea, Switzerland, Turkey, United States, United Kingdom
2	G7	United States, Canada, Japan, Germany, France, UK, Italy
3	BRICS	Brazil, Russia, India, China, South Africa.
4	Europe	European Union, Norway, Switzerland, Turkey, Iceland, Bosnia-Herzegovina, Serbia, Montenegro, FYROM, Albania.
5	EU	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, Bulgaria, Romania.
6	CIS	Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kirghizstan, Moldavia, Uzbekistan, Russia, Tajikistan, Turkmenistan, Ukraine.
7	NA	Canada, United States
8	LA	Argentina, Bahamas, Belize, Bermuda, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, Grenada, Guatemala, Guyana, Honduras, Haiti, Jamaica, Saint Lucia, Mexico, Nicaragua, Netherlands Antilles and Aruba, Panama, Paraguay, Peru, El Salvador, Suriname, Trinidad and Tobago, Uruguay, Venezuela, St. Vincent and Grenadines
9	Asia	Afghanistan, Bangladesh, Bhutan, Brunei, Cambodia, China, Hong-Kong, India, Indonesia, Japan, North Korea, South Korea, Lao, Macau, Malaysia, Maldives, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam
10	Pacific	Australia, Fiji Islands, Kiribati, Papua New Guinea, Samoa, Solomon Islands, Tonga, Vanuatu, New Zealand
11	Africa	Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Central African Republic, Cameroon, Cape Verde, Chad, Congo, Congo Democratic Republic, Comoros, Côte d'Ivoire, Djibouti, Egypt, Eritrea, Ethiopia, Gabon, Ghana, Guinea, Gambia, Guinea-Bissau, Equatorial Guinea, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sierra Leone, Somalia, Sao Tome and Principe, Sudan, Swaziland, South Africa, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe
12	ME	Bahrain, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, United Arab Emirates, Yemen.

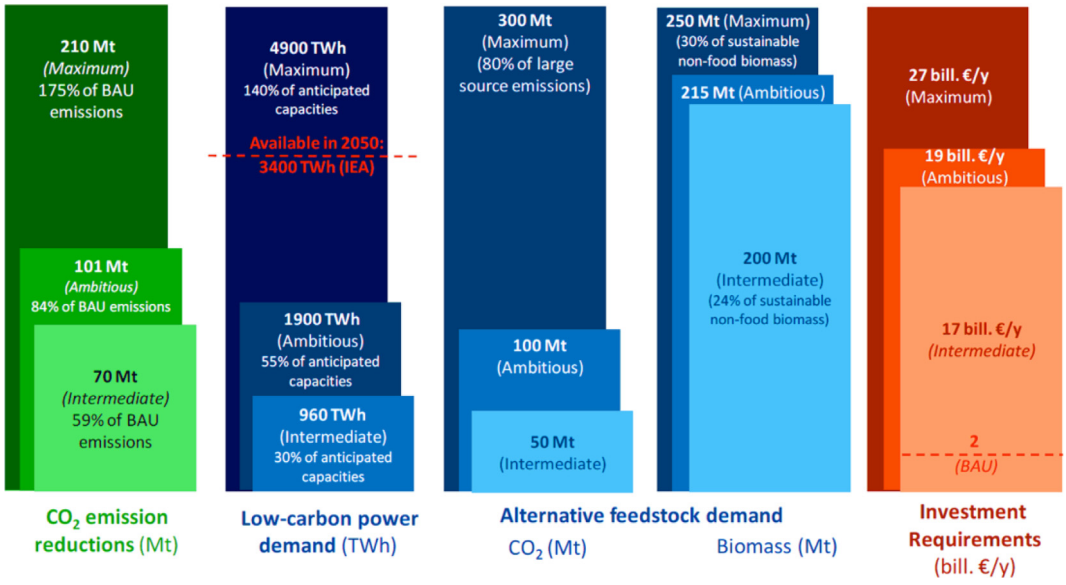

Fig. 1. Challenges and opportunities for a number of non-fuel application scenarios by 2050 (Bazzanella et al., 2017).

process configuration, membrane materials, energy storage, and energy recovery devices.

Study shows that two out of ten people in the world still live without electricity (Panos et al., 2016). According to the IEA report, 1267 million people worldwide did not have access to electricity in 2010 (IEA, 2011; OCDE/IEA, 2012). This statistic, which increased to 1285 million in 2012, shows that the outpaced population growth without access to electricity is alive in developing countries in particular, such as Latin America, Asia and Africa (IEA: Directorate of Global Energy Economics, 2014). A large number of studies have been conducted, in particular in developing countries, on the impact on greenhouse gas emissions, the greenhouse effect of the agriculture-economic growth (Qiao et al., 2019), supply and demand to identify different types of policies and drivers that make a significant contribution to energy access. Necessary policies and reforms, as set out in the reference (Charles Moonga, 2006), and case studies at the regional and national level are presented in reference (Nouni et al., 2009; Wang et al., 2006; Davidson and Mwakasonda, 2004; Musiliu, 2012; Bastakoti, 2003). This study is comprehensive and useful in establishing global access to energy by 2040; energy planners need significant but attainable investment in energy production infrastructure, resulting in lower impacts on primary CO2 emissions and energy demand.

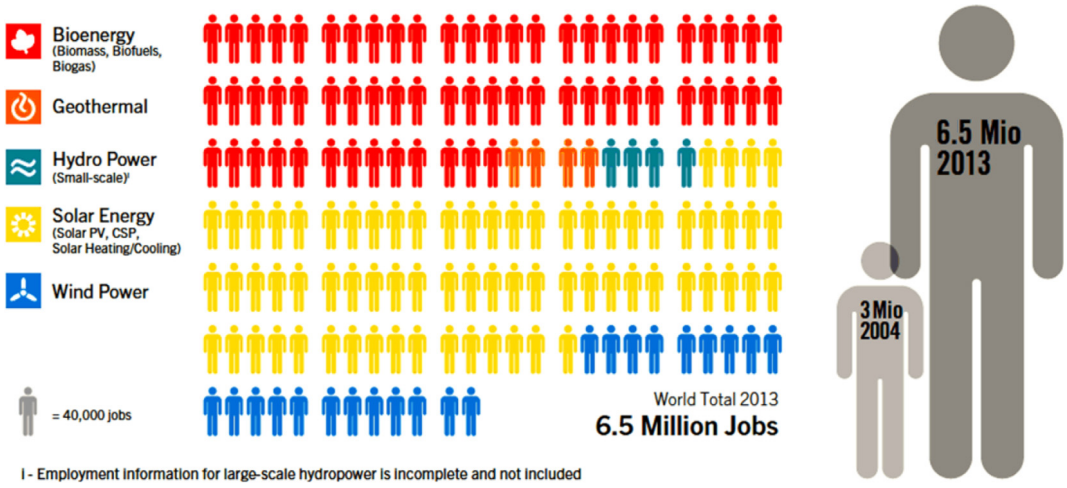

Fig. 2. Job ratio with an increase in renewable energy sources (Ren21, 2014).

1.3. Review methods

The proposed review structure of the Global Energy Outlook Method used recursive dynamic modeling on a year-by-year basis, including international energy rates, lagged demand adjustments, as well as supply from other parts of the world. Well-picked to determine the impacts of various energy-related issues (e.g., RES promotion, energy policy, energy security and energy efficiency issues, etc.) and weather-related issues (e.g., CO2 emission constraints, effort sharing between different countries), this review study focuses on the energy system, future forecasting and adaptation of fuel prices to the global environment. Long-term forecasts of global energy projections and their impact on international energy markets are reviewed on the basis of existing data. The outlook for energy rates at national, international, and sectoral levels is analyzed. In addition, detailed regional/national energy emissions and balances, primary energy demand, integration of primary generation, power and transformation, final energy demand, and energy losses are reviewed. Fig. 3 gives a clear outline of the proposed review including: (i) energy; (ii) oil; (iii) gas; (iv) coal; (v) CO2 emissions; (vi) oil products; (vii) electricity; and (viii) share of renewable energy. In addition, all parameters are classified into different subclassifications, such as primary production, trade balance, and primary generation.

The total share of renewable energy is divided into two parts. The first part shows the total share of renewables in electricity generation, and the second part shows the total share of solar and wind power generation. Geographically, the global energy demand, OECD, G7, BRICS, Europe, EU, CIS, NA, LA, Asia, Pacific, and ME have been used for the review analysis. Energy sources consisting of nuclear, hydro, biomass, fossil fuels, wind, solar and other energy sources are considered. The net energy supply, net import, net export, and domestic supply parameters were also analyzed for energy costs in real time in the past and in the near future. Energy transformation is shown by technologies for coal liquids, gas liquids, hydrogen, biofuels, and production. Three sectors, including refineries, the energy sector and electricity generation are considered in this scenario. Final energy demand comprised of final energy consumers, such as buildings and industry, agriculture, transport, and other types of consumers. The marginal CO2 emission reduction cost curve and analysis of the trading system by sector/region under different trading rules and market configuration are considered. There are different types of models used to measure data, such as the POLES model (Criqui, 2001), MedPro model (France, 2019), EnerNEO model (EnerNEO model (National Energy Outlook), 2019), and CO_2 emissions reduction toolbox like (EVALUATE, Carbon Market Tool, AERO) (Analysis, 2019). The MedPro model is a bottom-up approach used to predict long-term energy demand, greenhouse gas forecasts, and the load curve. EnerNEO software is proposed by Enerdata to measure long-term national supply and demand for energy under a number of climate and energy policies, including the INDC agreement at COP21 (United Nations, 2015b). It provides a detailed analysis and assessment of energy requirements by fuel, sub-sectors, and industry, as well as the development of energy production and capacity. The leveraged marginal cost reduction curves are a globally recognized POLE model used to measure CO2 emissions as well as CO2 mitigation strategies. The CMT (Carbon Market Tool) measures economic constraints for analysis of trade (Lubowski, 2019).

The rest of the paper is structured with the following parts: Section 2 divided into seven different sections for illustration, energy, oil, natural gas generation, the balance of trade in natural gas and domestic gas consumption, electricity, the share of renewable energy in total energy production and CO2 emissions. Section 3 reviews the future energy forecast requirement until 2040. The future perceptive price of oil, gas, and coal is fully analyzed in Section 4. Section 5 concludes this research.

2. World energy trends

The trends in world energy consumption are discussed in this section.

2.1. Energy

This is a global era of energy transformation, including low-carbon approaches and an increase in energy requirements set to begin with a double-speed demand for load across the globe. The critical question is, what are the trends in technology, the latest data, policy shifts and how will the impact on the energy sector be up to 2040? This part of the review explains that total energy production, trade in the energy balance, total energy consumption and gross domestic product (GDP) energy intensity. Russia is one of the most important countries in the world's energy markets (Proskuryakova and Filippov, 2015). The country is investing heavily in innovation and research in the energy sector to show and understand the major impact of the global energy outlook. The historical demand for US oil is briefly analyzed and in reference (Greene et al., 1998). B. Ang (Ang, 1989), presented and analyzed the trends in commercial energy consumption, the relationship between energy economic growth

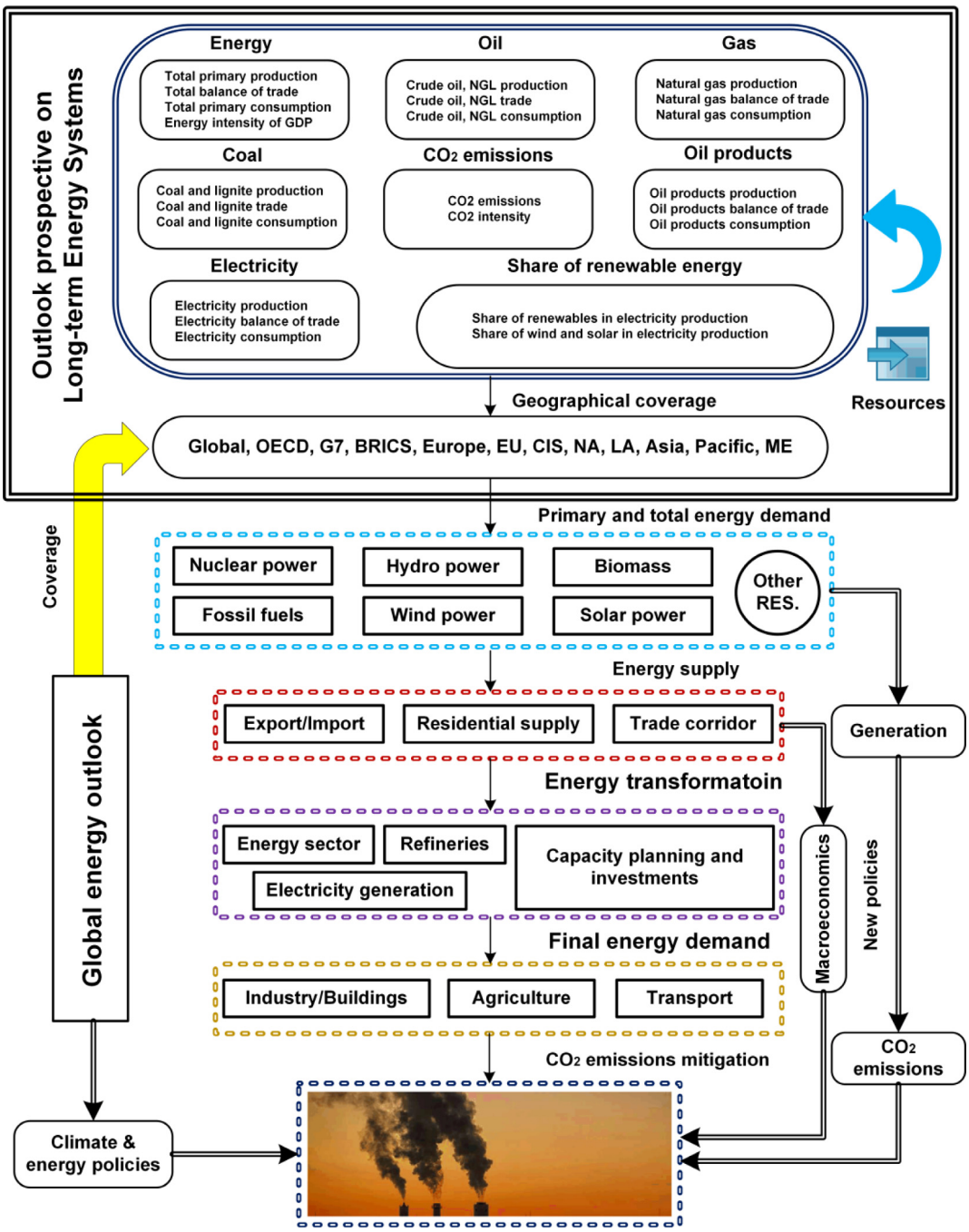

Fig. 3. Methods of review for the global energy outlook.

and energy consumption in the Association of Southeast Asian Nations (ASEAN) from 1960 to 1986. Various efforts have been made to reduce energy use globally (Csereklyei and Stern, 2015; Bithas and Kalimeris, 2013) and to reduce energy consumption at sub-national (Dong et al., 2016; Zhang and Bai, 2018) and national (Román-Collado et al., 2018; Champion et al., 2010) levels. These efforts are still underway, and a lot of work has been done to achieve meaningful results. Details are given step by step below:

2.1.1. Total energy generation and consumption

The number of primary energy resources produced or extracted is estimated by primary energy generation. It covers oil, coal, electricity, gas, biomass, and heat generation. The generation of geothermal, hydro, and nuclear power is considered to be a fundamental generation. For specific energy products, it is the aggregate of external trade, primary production, marine containers (fuel used by aircraft and ships for international transport) and stock exchanges. Fig. 4 shows total energy production and consumption in different regions from 1990 to 2017. It is worth mentioning that overall energy production in the USA is gradually increasing, but there is a rapid change in energy production in Asia. Global total energy demand was 8795 Mtoe in 1990 and 14080 Mtoe in 2017, respectively. There has been a major shift in energy production since the last decades. There is a slight change in the overall energy production of the OECD. The BRICS countries show a large variation in the demand for energy production after the year 2000. Global future energy demand examines a variety of alternative trends to explore different perspectives for energy transformation and development. The outlines have certain general characteristics, such as a significant increase in

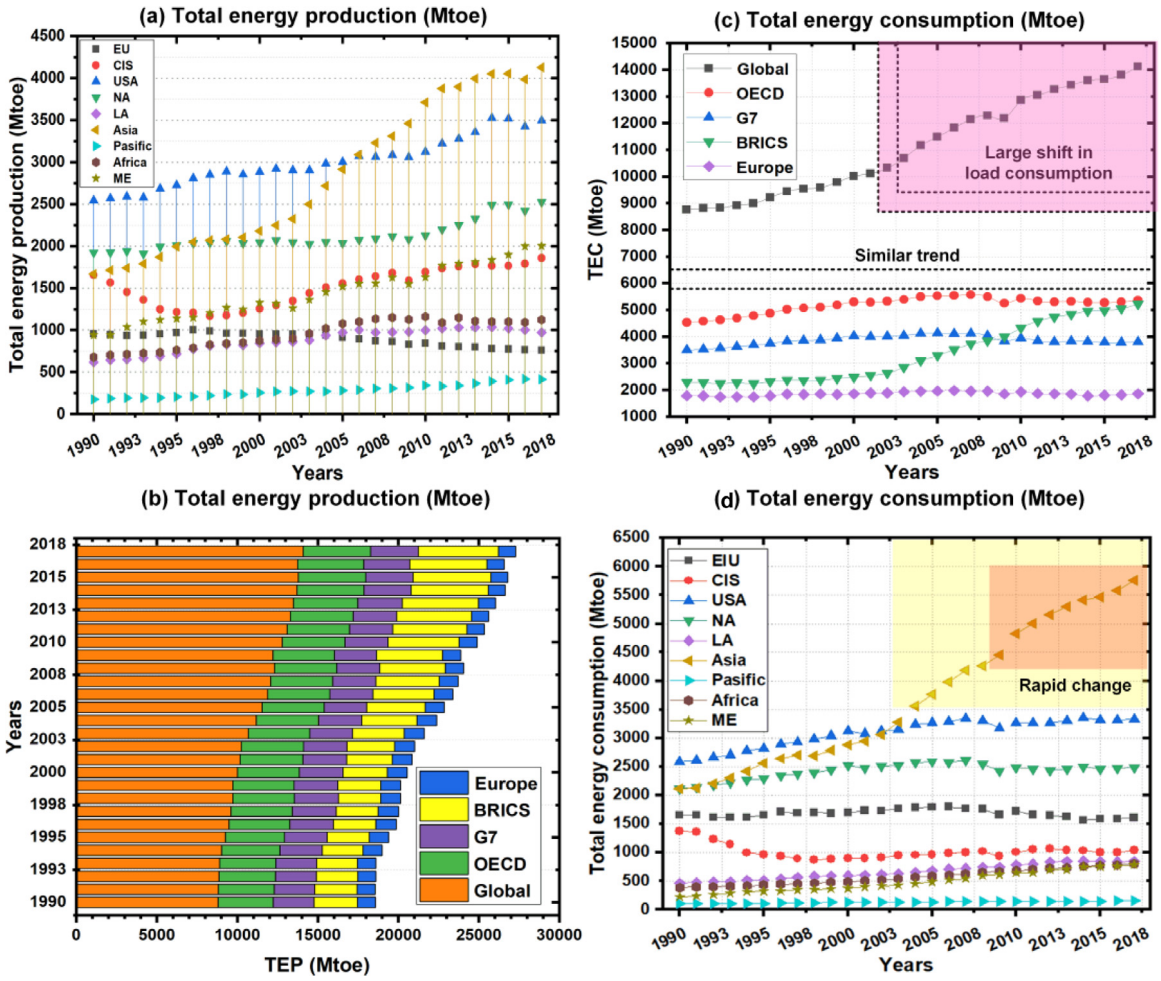

Fig. 4. (a) The total energy production of the EU, CIS, USA, NA, LA, Asia, Pacific, Africa and ME; (b) the total energy production of Europe, BRICS, G7, OECD and global demand; (c) the overall energy consumption of Europe, BRICS, G7, OECD and (d) the total energy consumption of the EU, CIS, USA, NA, LA, Asia, Pacific, Africa and ME.

energy requirements and a transformation towards a low-carbon mixture of fossil fuels, but also a change in technological assumptions or a specific policy. Fig. 4(c) & (d) explains the overall energy consumption of Europe, BRICS, G7, OECD, EU, CIS, USA, NA, LA, Asia, Pacific Africa and ME. Similar trends have been observed in energy consumption compared to energy production. In 2017, the total energy consumption of the OECD, G7, BRICS and Europe were 14126 Mtoe, 5363 Mtoe, 3804 Mtoe, 5214 Mtoe and 1857 Mtoe, respectively. It is about a 40% increase from 1990 to 2017. In Asia, China, India, and Japan, the three major players in future energy consumption requirements are estimated to be 3105 Mtoe, 934 Mtoe and 429 Mtoe, respectively. After 2000, there is a major shift in energy generation and consumption. This is due to the global era of industrialization, technological advancement, and the rapid evolution of the world's leading countries, such as the USA, the European Union, China, Japan, India and so on. CIS countries show variations between supply and demand, such as 1993 to 1998, the demand for energy generation has decreased, but there is a change between supply and demand after 2000 and 2015. The LA and Africa have almost shown a similar trend, but three are rapid changes in US energy supply and demand.

2.1.2. Energy balance of trade and energy intensity of GDP

The trade balance shows the difference between imports and exports. The surplus amount of net-export is shown to be negative (−). The remaining geopolitical and geographic regions are the aggregates of the trade balance of all regions. Fig. 5(a) & (b) shows the total energy balance of trade and the energy intensity of the gross domestic product at constant energy supply levels. Various colors show an increase and decrease in energy intensity and trade balance. Energy intensity is measured by dividing the cumulative energy consumption requirement of a particular region by GDP. It estimates the absolute amount of energy needed to generate a single unit of gross domestic product. GDP is shown at a consistent exchange rate and an increasing parity of power to exclude inflation, which influences and indicates the diversity of energy consumption and general energy price levels in the real economic project. It has been noted that there is a slight shift in energy intensity in the CIS and BRICS countries from 1990 to 2017. Low parity rates of 0.079 koe/$2015p and 0.078 koe/$2015p perceived by the EU and Europe in 2017, respectively. Asia is leading the trade in energy balances. The Group of Seven (G7) and OCED countries ranked second in Asia to boost trade in the energy balance. Energy intensity at constant purchasing power parities is declining significantly in the EU, the G7 and OECD countries. But the contrary is happening for ME and Africa with a 0.131 and 0.133 increase in energy intensity in 2017. Overall, the global energy intensity at constant purchasing power parities varies from 0.174 (1990) to 0.116 (2017).

2.2. Oil

This section is divided into five different parts, including the balance of trade in crude oil, the input of crude oil to refineries,

(a) Energy balance of trade (Mtoe)

Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OECD	1257	1216	1266	1296	1328	1318	1382	1428	1465	1507	1576	1610	1601	1701	1799	1865	1909	1874	1830	1656	1690	1642	1549	1448	1318	1320	1329	1289
G7	1084	1070	1113	1140	1150	1133	1194	1231	1263	1291	1359	1403	1387	1454	1541	1588	1591	1541	1473	1336	1346	1275	1192	1118	1007	977	979	881
BRICS	399	323	296	232	262	254	257	240	241	234	218	271	301	325	308	323	273	231	172	62	23	61	151	188	252	198	239	283
Europe	716	706	690	655	619	637	657	664	704	676	704	730	732	784	829	882	933	908	934	855	889	889	875	868	837	861	864	905
European Union	757	765	764	734	714	740	775	786	816	793	830	859	863	906	943	984	1018	989	1017	939	957	947	928	912	884	907	911	946
CIS	275	200	205	213	235	237	273	282	293	318	349	377	424	474	537	580	589	622	621	635	679	670	673	721	704	736	765	795
America	144	88	130	157	176	128	138	156	188	234	251	287	263	303	317	331	318	346	296	216	205	122	42	21	75	88	71	147
North America	283	246	273	324	342	314	345	383	414	446	476	514	493	532	579	606	590	565	493	425	393	313	214	132	74	60	63	46
Latin America	139	158	143	167	166	186	208	228	226	212	225	227	230	229	262	275	272	219	197	209	188	191	172	154	149	148	134	101
Asia	464	469	523	577	603	633	668	721	682	732	797	763	806	848	944	922	956	1026	1055	1125	1264	1308	1407	1469	1518	1544	1668	1761
Pacific	65	81	84	86	84	88	90	101	110	109	126	132	137	135	137	144	142	150	153	159	181	174	181	205	233	251	260	258
Africa	289	304	310	309	309	320	335	358	347	355	378	375	375	406	444	480	486	499	482	449	467	374	411	359	320	316	294	297
Middle-East	700	683	750	791	786	792	799	832	894	868	935	899	821	908	974	1006	1000	972	999	902	950	1078	1064	1073	1050	1099	1195	1191

(b) Energy intensity of GDP at constant purchasing power parities (koe/$2015p)

Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
World	0.174	0.173	0.171	0.170	0.166	0.165	0.163	0.158	0.155	0.153	0.149	0.147	0.147	0.146	0.145	0.142	0.139	0.136	0.133	0.133	0.133	0.130	0.128	0.125	0.123	0.119	0.117	0.116
OECD	0.147	0.147	0.145	0.145	0.143	0.142	0.142	0.138	0.135	0.133	0.131	0.129	0.127	0.126	0.125	0.122	0.119	0.116	0.114	0.113	0.114	0.109	0.107	0.106	0.103	0.101	0.100	0.098
G7	0.152	0.152	0.150	0.150	0.149	0.147	0.147	0.143	0.140	0.138	0.136	0.133	0.132	0.131	0.129	0.127	0.123	0.121	0.118	0.117	0.117	0.112	0.110	0.109	0.107	0.104	0.102	0.101
BRICS	0.269	0.266	0.263	0.258	0.247	0.243	0.236	0.224	0.217	0.210	0.201	0.195	0.190	0.192	0.192	0.188	0.182	0.174	0.168	0.166	0.165	0.162	0.158	0.152	0.148	0.141	0.137	0.133
Europe	0.124	0.123	0.120	0.120	0.117	0.116	0.118	0.113	0.111	0.107	0.104	0.104	0.103	0.103	0.101	0.099	0.096	0.092	0.091	0.090	0.092	0.087	0.086	0.085	0.080	0.080	0.079	0.078
European Union	0.127	0.126	0.122	0.123	0.119	0.119	0.120	0.116	0.113	0.109	0.106	0.106	0.104	0.105	0.103	0.101	0.098	0.093	0.092	0.091	0.092	0.087	0.087	0.086	0.081	0.080	0.079	0.078
CIS	0.328	0.345	0.363	0.371	0.378	0.386	0.389	0.367	0.374	0.360	0.333	0.316	0.303	0.293	0.275	0.259	0.245	0.226	0.219	0.216	0.221	0.220	0.216	0.206	0.203	0.201	0.200	0.202
America	0.167	0.167	0.165	0.162	0.160	0.158	0.157	0.152	0.149	0.148	0.145	0.142	0.142	0.141	0.138	0.134	0.130	0.128	0.125	0.123	0.123	0.120	0.117	0.116	0.115	0.112	0.112	0.111
North America	0.197	0.199	0.197	0.195	0.191	0.189	0.186	0.180	0.174	0.170	0.168	0.163	0.162	0.159	0.157	0.152	0.147	0.147	0.144	0.141	0.140	0.137	0.132	0.131	0.131	0.126	0.124	0.122
Asia	0.191	0.184	0.180	0.179	0.176	0.175	0.170	0.166	0.164	0.162	0.159	0.156	0.155	0.156	0.159	0.156	0.154	0.148	0.144	0.144	0.144	0.140	0.137	0.133	0.128	0.122	0.119	0.116
Pacific	0.167	0.167	0.168	0.168	0.163	0.160	0.163	0.160	0.157	0.153	0.151	0.145	0.144	0.140	0.137	0.134	0.134	0.134	0.134	0.133	0.131	0.129	0.124	0.121	0.117	0.115	0.113	0.111
Africa	0.168	0.171	0.172	0.177	0.175	0.179	0.175	0.174	0.171	0.172	0.167	0.167	0.166	0.164	0.159	0.156	0.151	0.147	0.145	0.142	0.139	0.141	0.139	0.137	0.137	0.134	0.133	0.133
Middle-East	0.101	0.105	0.110	0.117	0.125	0.125	0.122	0.125	0.119	0.122	0.117	0.125	0.129	0.125	0.122	0.124	0.125	0.124	0.129	0.134	0.133	0.125	0.132	0.129	0.134	0.133	0.128	0.131

Fig. 5. (a) Shows the total energy balance of trade and (b) shows the intensity of the energy gross domestic product at constant energy supply levels.

the generation of refined oil products, oil products and the balance of trade in oil products. Further details of each sub-section are provided below:

2.2.1. Crude oil balance of trade

Crude oil consists of all kinds of liquid hydrocarbons to be purified: NG liquids, crude oil and semi-purified products. Fig. 6(a) indicate the domestic consumption of oil products. The blue bar shows higher and lower demand for domestic consumption. OECD, G7 and US oil products have higher domestic consumption compared to the rest of the world. An overview of the worldwide use of crude oil through a variety of inter-regional trade activities is given in reference (Wu and Chen, 2019; Ji and Fan, 2016). The Chinese economy is undergoing an embodied crude oil analysis from 2011 to 2014 (An et al., 2019). It shows that China has placed the second-largest crude oil customer in the world. There is a significant shift in demand in Asia, the USA, the OECD, and the G7. But there is nothing sudden about domestic demand for oil consumption from all countries. There are almost constant growth and demand in the supply of oil demand. Global total domestic demand for oil was 4256 Mt in 2017 and 1.64% higher than in the previous year in 2016.

2.2.2. Crude oil input to refineries

Fig. 6(b) describes the input of crude oil to the refineries. The OECD's overall recovery of oil demand is higher than Asia, the Pacific, Africa and the ME. Some data points show a zero number, and this is due to missing data values. OECD countries are at the forefront of the demand for crude oil consumption. In the near future, however, Asia will be a major competitor to the OECD, G7, BRICS and the EU. There is no significant change in the demand for crude oil in the CIS, Africa, and Pacific regions. The ME is gradually increasing its demand for crude oil to refineries. Astonishingly, LA's demand for crude oil is gradually declining due to the shift from conventional energy sources to renewable resources.

2.2.3. Refined oil products production

The production of crude oil is similar to gross output. All petroleum products based on liquid hydrocarbons are used to purify NGL and crude oil as well as to process the production of natural gas. Fig. 6(c) shows statistics on the production of crude oil worldwide and Fig. 6(d) presents the trade in the crude oil balance. Domestic supply or consumption is the net balance of energy generation, stock change and external trade. Energy utilization is mainly distributed between industry, power plants, tertiary sectors, domestic and transport sectors and one portion of the total energy transformation in the world. The ME and the USA are leading the way in the production of crude oil. But there is a large deficit of crude production in Asian, African, EU and European countries. Mostly, the crude requirements of global energy demand are met by the ME, the USA and OECD countries. Compared to the production of crude oil in 1990, ME's production of crude oil almost doubled in 2017. The gross balance of trade and oil products is the balance of trade, as presented in Fig. 6 (e & f). Asia is a major importer of crude oil, among other countries such as the OECD, the USA, the G7 and the BRICS. There is a slight difference that can be seen in the trade balance of crude oil in OECD countries. The balance of trade in oil products, Asia, Africa, LA and the Pacific, is leading fast-growing countries. However, the results are in the negative numbers of OECD, G7, BRICS and ME. World production of refined oil products in 2017 was 4292 Mt and 26.42% higher than in 1990. The OECD, BRICS, G7 and the USA are among the top producers of refined oil products.

2.3. Natural gas generation, trade balance and domestic consumption

Fig. 7 shows the domestic consumption of natural gas (NG), the trade balance of NG and the production balance of NG on the global market. NG consumption in the OECD countries' domestic sector is higher than in other regions and the G7 countries are second in this list. The CIS countries are making a slight shift in domestic NG demand. The Asia, Pacific, BRICS counters show a small change in domestic gas consumption. But the situation in the NG trade balance is different. Asia is expanding its NG trade balance rapidly compared to the Pacific, CIS, BRICS and LA countries. There is a slight change in the NG trade balance between the OECD and EU countries between 2014 and 2017. However, OECD countries are at the top of the NG production

(a) Oil products domestic consumption (Mt)

Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
World	3890	3116	3132	3132	3164	3226	3317	3395	3426	3496	3587	3558	3587	3651	3808	3853	3892	3942	3898	3808	3908	3938	3979	4007	4050	4124	4188	4258
OECD	1789	1800	1840	1855	1905	1919	1966	1992	2001	2030	2030	2042	2033	2064	2097	2095	2066	2047	1959	1866	1893	1861	1834	1817	1800	1822	1844	1864
G7	1387	1381	1403	1409	1435	1439	1472	1485	1498	1519	1512	1523	1514	1535	1560	1554	1527	1498	1420	1343	1365	1344	1320	1309	1300	1308	1312	1323
BRICS	486	506	494	489	460	487	495	517	526	551	573	577	589	614	670	677	712	745	765	766	802	847	884	912	950	992	1018	1058
Europe	649	655	653	648	651	662	680	680	689	679	667	678	674	681	682	680	678	659	650	616	612	586	569	556	549	564	574	587
European Union	598	606	606	598	602	610	624	624	634	626	613	624	618	624	625	623	618	600	591	557	553	530	511	497	491	500	507	516
CIS	371	374	308	259	204	199	179	174	170	166	164	163	162	165	164	164	169	171	175	168	172	187	191	187	199	198	204	203
America	1023	1009	1029	1046	1085	1083	1123	1156	1185	1204	1216	1229	1214	1234	1280	1292	1281	1286	1237	1179	1219	1215	1210	1207	1218	1215	1215	1220
North America	809	789	804	814	836	832	860	878	895	916	924	936	930	955	987	990	974	967	907	855	879	867	848	845	852	862	869	878
Latin America	215	220	225	232	248	252	263	278	291	287	293	292	284	278	293	302	307	319	329	324	340	348	362	362	366	353	346	341
Asia	595	622	657	692	719	773	798	831	814	856	878	879	904	930	994	992	1009	1044	1026	1040	1076	1110	1148	1182	1195	1247	1290	1335
Pacific	36	36	36	36	38	39	40	41	41	42	43	43	43	46	47	47	48	48	50	48	50	52	53	55	55	54	53	56
Africa	82	83	86	85	83	88	91	96	97	100	100	104	107	109	116	121	122	128	138	144	151	150	160	166	168	174	172	171
Middle-East	133	134	149	154	163	163	172	174	178	186	192	201	209	211	223	239	252	257	271	275	271	275	294	304	306	293	289	295

(b) Crude oil input to refineries (Mt)

Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
World	0	0	0	0	0	0	0	0	0	0	3510	3534	3556	3641	3770	3813	3851	3862	3900	3818	3898	3925	3991	3992	4048	4118	4183	4249
OECD	1808	1831	1884	1925	1959	1968	2023	2082	2112	2081	2100	2084	2071	2104	2132	2130	2126	2120	2093	1981	1985	1978	1971	1954	1961	2000	2000	2029
G7	1359	1363	1389	1422	1437	1435	1462	1497	1516	1493	1513	1502	1494	1518	1541	1538	1526	1524	1500	1409	1409	1398	1374	1362	1365	1377	1383	1399
BRICS	542	537	511	491	458	467	476	503	496	539	589	606	634	668	716	749	792	823	865	917	989	1024	1086	1120	1164	1184	1218	1250
Europe	0	0	0	0	0	0	0	0	0	0	754	754	750	762	778	777	778	769	763	709	703	693	689	660	655	693	689	704
European Union	660	657	660	672	682	682	700	711	732	696	707	705	701	711	726	725	724	716	714	665	659	646	643	611	609	639	637	645
CIS	454	435	359	306	256	246	235	232	222	223	231	244	259	269	272	283	294	297	304	304	311	323	333	337	353	342	336	336
America	1087	1075	1085	1104	1119	1121	1148	1176	1206	1209	1221	1225	1212	1225	1261	1249	1259	1251	1256	1211	1209	1218	1216	1229	1250	1232	1221	1214
North America	816	803	812	828	835	840	861	881	894	895	909	909	904	920	936	927	930	928	921	875	889	891	885	895	915	916	923	943
Latin America	271	272	273	276	284	281	287	295	311	314	312	317	308	304	325	322	330	323	335	336	320	327	331	334	336	316	298	272
Asia	525	562	606	634	664	699	744	793	779	814	861	862	875	924	989	1013	1040	1072	1082	1112	1177	1202	1256	1274	1291	1340	1400	1451
Pacific	34	35	36	38	38	38	40	41	42	41	41	40	42	42	40	39	37	38	37	38	37	39	38	37	35	31	29	28
Africa	107	108	108	108	107	112	116	123	112	116	109	124	124	116	119	129	118	118	122	116	122	110	110	112	112	104	104	102
Middle-East	204	198	226	237	265	268	279	284	289	294	292	285	294	304	312	323	326	317	336	328	339	338	347	343	351	376	405	413

(c) Crude oil production (Mt)

Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
World	3176	3175	3215	3242	3272	3324	3415	3511	3572	3502	3629	3631	3604	3741	3909	3954	3988	3963	3992	3906	3992	4038	4129	4143	4230	4332	4358	4364
OECD	895	914	929	936	971	982	1008	1020	1017	991	1009	1005	1009	1003	974	924	907	898	862	863	865	868	916	972	1057	1097	1077	1111
G7	611	610	612	611	633	637	639	641	640	623	616	604	610	598	580	548	550	554	541	557	571	584	642	707	797	844	831	878
BRICS	734	680	608	568	540	537	547	554	557	565	594	619	663	709	754	774	795	810	815	826	862	876	886	889	907	928	929	928
Europe	220	231	247	260	302	314	332	330	327	332	336	326	325	311	290	268	247	241	229	218	202	184	169	161	161	169	173	170
European Union	132	131	134	139	168	170	170	169	173	178	171	160	164	154	143	131	120	119	111	104	98	85	77	72	71	76	77	76
CIS	577	524	450	401	363	352	355	359	360	369	392	423	463	511	557	573	595	620	624	640	656	660	663	669	671	676	688	692
America	885	905	911	918	925	947	987	1016	1021	987	1002	1005	1007	996	1028	1016	1029	994	980	1002	1031	1062	1123	1188	1283	1322	1282	1304
North America	505	505	504	497	492	494	496	500	494	474	478	476	481	479	471	450	460	463	456	478	496	520	586	655	746	788	772	820
Latin America	381	401	408	420	433	454	491	516	527	513	524	529	527	517	557	567	570	531	524	525	534	542	537	533	537	534	510	484
Asia	294	305	303	307	319	330	336	342	342	340	340	341	345	346	353	357	357	355	360	358	376	371	377	375	375	382	363	358
Africa	320	334	338	337	339	348	366	382	381	374	386	388	385	418	458	478	488	499	500	483	497	422	455	418	397	393	377	387
Middle-East	845	841	931	985	991	1000	1005	1050	1104	1069	1135	1111	1042	1126	1193	1234	1245	1225	1269	1178	1204	1314	1318	1310	1323	1369	1457	1436

(d) Crude oil balance of trade (Mt)

Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OECD	949.2	938.0	998.1	1039.2	1044.6	1025.3	1053.6	1110.4	1131.2	1110.3	1124.3	1129.6	1093.9	1153.6	1218.3	1263.2	1272.5	1263.4	1268.0	1153.0	1163.7	1146.4	1107.3	1028.4	953.7	984.9	981.0	948.6
G7	774.9	772.6	812.0	851.2	856.3	832.0	861.3	904.6	915.7	893.2	928.7	947.0	924.7	973.3	1022.4	1046.9	1026.7	1015.9	996.8	895.1	889.5	860.7	792.3	713.1	630.2	628.9	631.4	577.1
BRICS	-162.4	-110.8	-73.7	-52.8	-58.9	-46.5	-38.4	-22.6	-33.5	-2.1	34.2	7.5	-13.0	-22.9	-10.2	-8.3	19.9	43.8	85.3	122.3	156.4	182.0	224.6	254.4	287.2	290.8	320.7	350.2
Europe	470.1	451.7	447.1	441.1	411.0	398.5	401.6	409.6	436.6	390.1	393.0	404.8	399.5	432.4	471.7	494.0	512.0	502.7	516.7	465.3	477.5	479.4	496.1	480.4	470.2	502.7	489.8	510.9
European Union	506.4	504.8	513.4	512.2	497.4	493.0	510.7	520.6	540.5	495.3	510.4	524.3	511.0	536.4	566.9	577.2	583.7	573.5	581.6	534.5	534.7	529.9	540.7	518.9	514.2	542.6	534.2	551.6
CIS	-107.1	-68.4	-81.2	-88.0	-100.0	-98.5	-112.3	-120.9	-132.6	-143.2	-156.8	-174.0	-198.6	-239.5	-274.2	-285.1	-291.1	-313.7	-310.5	-329.1	-332.5	-328.1	-321.0	-317.2	-303.7	-322.6	-341.8	-348.4
America	233.3	204.5	224.0	239.1	249.4	219.8	221.2	230.2	247.6	272.5	281.2	307.1	278.2	309.0	320.6	316.6	307.4	338.2	341.6	289.2	258.8	234.0	174.6	118.8	57.9	26.5	40.5	-14.4
North America	329.3	316.5	331.5	371.0	384.5	379.0	399.8	434.0	447.0	457.0	475.1	493.9	475.2	502.9	531.8	539.9	531.2	521.8	510.0	457.0	454.5	427.6	360.5	298.0	239.8	231.1	243.5	188.1
Latin America	-96.0	-111.9	-107.4	-131.9	-135.1	-159.2	-178.6	-203.8	-199.4	-184.5	-193.9	-186.8	-197.0	-194.0	-211.2	-223.3	-223.8	-183.6	-168.4	-167.9	-195.7	-193.7	-185.9	-179.1	-182.0	-204.7	-203.1	-202.5
Asia	276.5	289.5	340.5	372.8	385.6	405.2	445.0	487.3	462.3	494.7	562.0	544.1	550.0	599.3	662.2	677.0	710.6	742.6	756.3	775.2	828.4	857.1	901.3	910.6	927.1	972.7	1039.0	1094.9
Pacific	2.1	0.7	2.1	4.9	5.8	5.5	7.9	7.6	6.4	9.7	3.3	0.7	4.5	7.8	7.3	11.1	11.5	10.0	9.5	7.6	10.5	13.9	14.4	14.7	14.1	11.6	9.9	10.4
Africa	-201.5	-214.8	-216.3	-215.4	-216.4	-219.8	-232.4	-240.0	-241.4	-236.1	-255.7	-248.1	-248.4	-282.4	-322.4	-337.1	-351.7	-364.9	-360.2	-352.0	-361.9	-293.1	-331.7	-294.4	-266.1	-274.8	-249.1	-243.1
Middle-East	-599.8	-606.1	-656.9	-691.2	-664.0	-666.0	-663.6	-689.9	-752.3	-712.8	-778.4	-756.7	-676.3	-747.1	-811.0	-841.8	-846.7	-832.2	-854.7	-748.4	-757.1	-867.9	-856.3	-862.7	-835.4	-868.8	-936.2	-923.8

(e) Oil products balance of trade (Mt)

Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OECD	121	92	78	59	75	74	85	60	55	91	105	105	114	116	116	136	124	97	67	60	58	21	-8	-15	-23	-50	-39	-50
G7	115	95	86	63	67	70	80	60	71	88	90	89	80	80	76	89	82	43	11	6	5	-17	-31	-34	-31	-58	-68	-76
BRICS	-55	-42	-31	-13	-20	-9	-13	-7	3	-11	-35	-41	-55	-54	-52	-74	-72	-81	-81	-109	-113	-100	-108	-128	-125	-115	-121	-117
Europe	37	40	34	23	19	29	29	24	26	36	39	43	48	43	28	37	41	30	34	47	47	35	15	26	26	16	23	15
European Union	29	34	27	16	12	20	19	14	15	26	24	31	34	30	14	21	25	13	16	22	23	15	-9	1	2	-10	-6	-13
CIS	53	-32	-29	-28	-38	-38	-53	-52	-49	-53	-57	-68	-86	-87	-93	-107	-106	-112	-112	-118	-126	-115	-114	-129	-128	-127	-113	-112
America	-19	-36	-27	-28	-20	-27	-18	-11	-3	3	8	4	-3	9	12	35	31	33	7	-22	1	-28	-36	-46	-43	-52	-46	-31
North America	18	2	5	-3	3	-7	1	-1	10	14	18	21	14	21	34	52	39	26	6	-25	-37	-64	-84	-93	-97	-112	-121	-132
Latin America	-37	-39	-31	-25	-23	-20	-19	-10	-13	-11	-11	-18	-17	-12	-22	-17	-8	-7	13	3	38	36	48	47	53	60	75	80
Asia	73	63	70	82	91	100	98	96	90	100	86	82	102	94	105	72	72	72	63	67	82	85	85	90	96	96	85	87
Pacific	2	1	0	1	2	3	2	2	1	3	3	3	3	4	9	9	12	12	15	16	16	15	18	20	22	24	29	31
Africa	-22	-22	-22	-22	-23	-23	-23	-29	-16	-19	-14	-22	-21	-10	-6	-7	-4	8	17	27	31	42	51	55	59	69	66	66
Middle-East	-84	-61	-80	-85	-106	-108	-118	-123	-121	-130	-124	-107	-109	-119	-117	-111	-97	-82	-82	-84	-97	-102	-95	-84	-95	-116	-142	-145

(f) Refined oil products production (Mt)

Category	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
World	3158	3175	3177	3209	3234	3273	3383	3484	3509	3519	3596	3625	3634	3715	3860	3904	3934	3951	3984	3880	3953	3988	4020	4035	4084	4181	4231	4292
OECD	1830	1859	1910	1953	1984	1991	2046	2107	2132	2100	2123	2110	2093	2128	2166	2161	2151	2140	2116	1993	2017	2016	1986	1978	1972	2035	2033	2055
G7	1381	1387	1412	1446	1461	1457	1488	1522	1539	1517	1537	1527	1518	1543	1573	1569	1552	1547	1526	1426	1446	1441	1395	1392	1384	1421	1429	1441
BRICS	541	557	535	517	488	497	508	532	528	569	618	637	657	688	743	771	814	849	880	924	965	996	1046	1088	1134	1158	1189	1219
Europe	702	698	702	717	724	722	744	757	779	739	746	747	742	755	771	769	770	761	756	702	696	686	681	654	648	686	683	696
European Union	654	651	656	669	677	675	693	706	727	690	699	698	692	703	720	717	715	707	706	658	651	639	635	604	602	632	631	638
CIS	417	417	347	293	248	238	229	227	218	218	227	239	253	258	265	277	285	292	295	292	308	313	314	325	343	338	331	332
America	1107	1103	1108	1132	1147	1148	1186	1214	1241	1241	1262	1269	1253	1267	1313	1298	1302	1297	1301	1244	1257	1273	1250	1269	1281	1282	1274	1265
North America	840	831	839	856	863	866	891	911	923	926	943	942	937	956	977	968	966	962	957	900	931	939	911	928	941	964	974	990
Latin America	268	272	269	276	284	282	295	304	318	314	319	327	316	311	336	330	336	335	344	344	326	334	340	341	341	318	301	275
Asia	565	601	639	668	690	732	772	815	805	840	884	884	889	935	1001	1032	1060	1092	1097	1118	1148	1174	1225	1242	1255	1308	1359	1408
Pacific	38	38	38	39	40	41	42	42	43	42	44	42	43	42	42	41	39	39	39	39	39	40	39	39	36	33	29	29
Africa	108	110	110	110	109	113	118	126	116	122	117	133	133	127	126	135	123	126	129	123	129	117	116	118	119	112	111	109
Middle-East	220	207	234	249	275	279	293	302	307	317	317	311	322	332	342	352	355	346	366	363	377	384	395	389	401	424	443	452

Fig. 6. (a) Domestic consumption of oil products; (b) input of crude oil to refineries; (c) trade balance of crude oil; (d) trade balance of crude oil; (e) trade balance of total oil products; and (f) production of refined oil products.

list. They are produced by about 1400 bcm of NG in 2017. The USA is leading the way compared to the NA, G7 and CIS countries. However, the Pacific and the EU regions lack the NG balance of production on the world market.

2.4. Lignite and coal production, balance of trade and domestic consumption

Lignite and coal account for all solid mineral fuels. Their total calorific value is very significant from hard lignite to coal

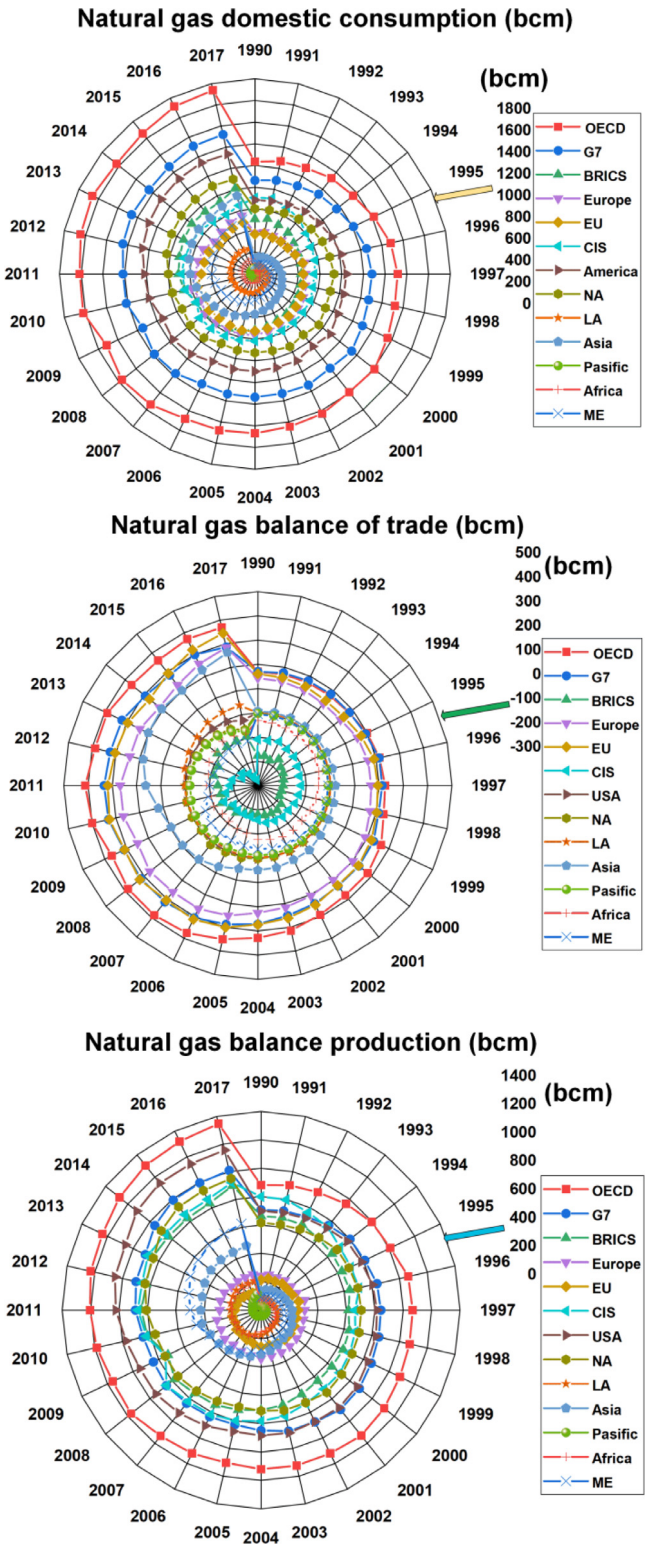

Fig. 7. (a) Domestic NG consumption; (b) trade balance of NG; (c) generation balance of NG.

(the average coefficients of the entire country are used). China is the world's largest producer of lignite and coal (45%). The production of coal increased in India with the support of the government to reduce its dependence on imports. Fig. 8 view a brief historical overview of domestic coal consumption, and trade balance. Asia and the BRICS countries are at the top of the

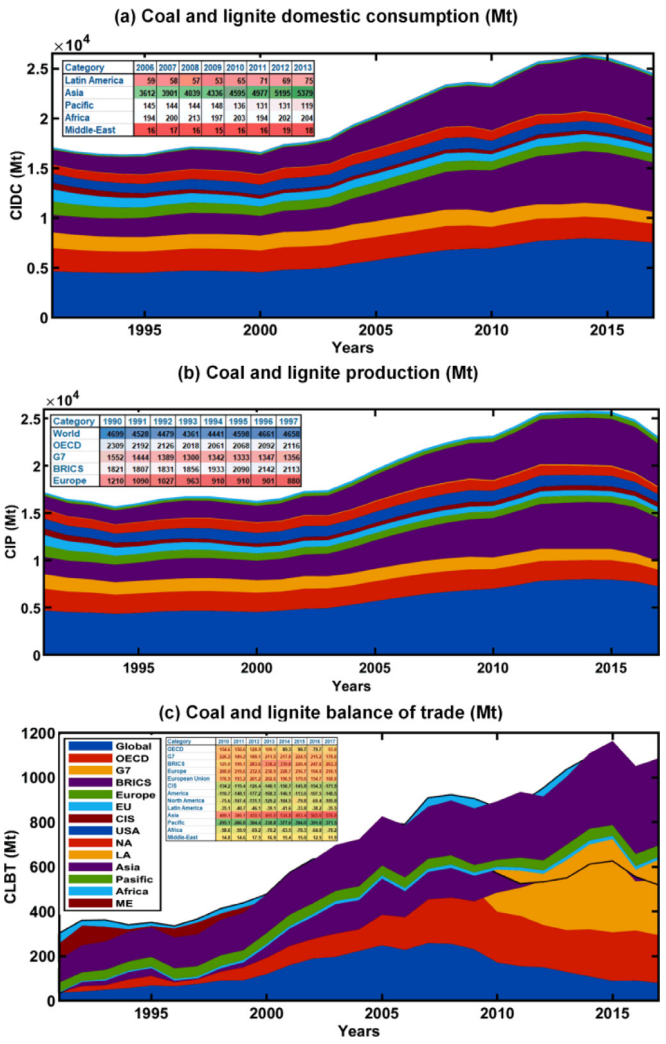

Fig. 8. (a) The domestic consumption of coal and lignite; (b) the production of coal and lignite; and (c) the trade balance of coal and lignite.

list for coal and lignite consumption and domestic use. There is a 0.9% increase in lignite and coal consumption between 2016 and 2017 and a 2.17% increase in total global demand between 2000 and 2017. A decrease of −1.4%, −0.7%, −1.7% and 1.0% in lignite and coal consumption can be observed in the EU, Europe, the G7 and the OECD, respectively. Asia plays a leading role in the production of lignite and coal. The increase in production amounted to about 4.6% compared to the last two decades. There is a significant increase in the production of lignite and coal from BRICS, LA, Pacific and African countries. The OECD, G7, EU, USA, and CIS countries lag at −0.8%, −1.8%, −1.79%, −1.4% and 1.9% respectively, compared to 2000–2017. The trade balance of coal and lignite is negative for CIS, USA, NA, LA, Pacific and African countries. Asia is leading with a total of 576.9 Mt in 2017 and is higher than the EU, BRICS, OECD and G7 countries.

2.5. Electricity

In this section, the total production of electricity and the domestic electricity requirements are briefly analyzed.

2.5.1. Electricity generation

Generations of electricity include public and private utilities and independent power producers. The statistics of the world's

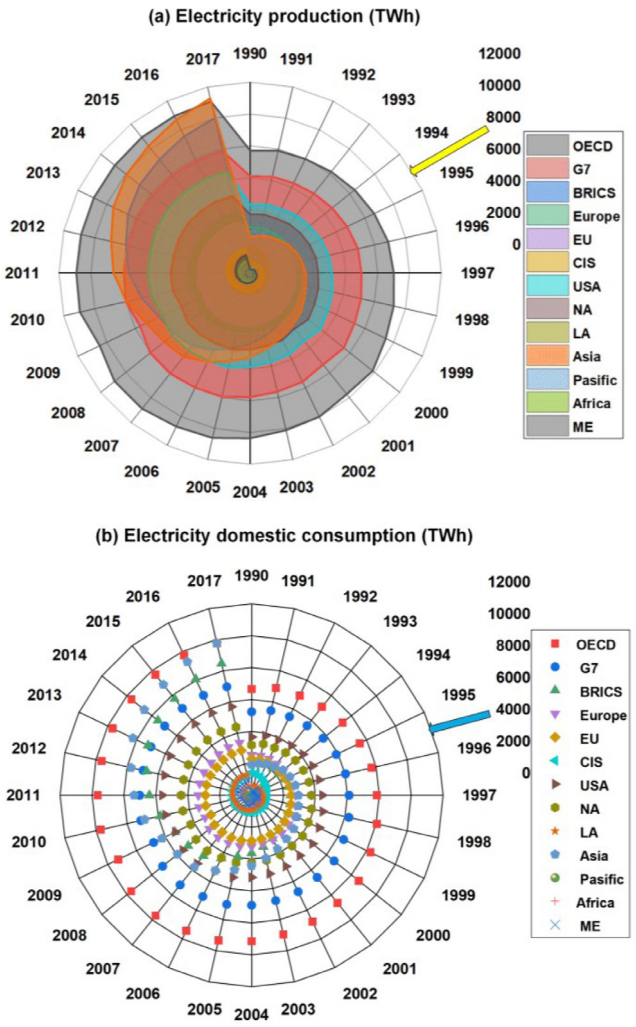

Fig. 9. (a) Represents the production of electricity; (b) shows the world's domestic consumption of electricity.

total electricity generation are shown in Fig. 9(a), the consumption of electricity is shown in Fig. 9(b). The significant change in electricity generation in 2017 comes from Asia, with China contributing almost half of the increase due to the high demand for electricity combined with the accelerated development of production capacity, followed by Japan and India. The demand for electricity generation in the USA is declining, but there is a significant increase in demand in the EU and Canada to a smaller extent. Overall, the world's total generation of electricity increased by 2.7% in 2016–2017 and by 3.0% between 2000 and 2017. Asia is a leader in electricity generation with a 5.5% increase in total demand in 2016–2017. The demand for electricity generation in BRICS, Europe, Africa, and ME increased gradually with a slow pace of 4.7%, 1.2%, 2.2% and 3.9%, respectively, in 2016–2017. Decreased demand for electricity generation can be seen in the NA and Pacific regions. Total electricity generation in the world was recorded at 25591.639 TWh in 2017.

2.5.2. Domestic electricity consumption

Electricity or household supply is the balance of external trade and generation. It is mainly distributed among industry, power plants, tertiary sectors, the domestic sector, and the transport sector in the transformation of power. Fig. 9(b) shows the world consumption of electricity in the domestic sector. Domestic energy consumption in the US has remained mostly stable since

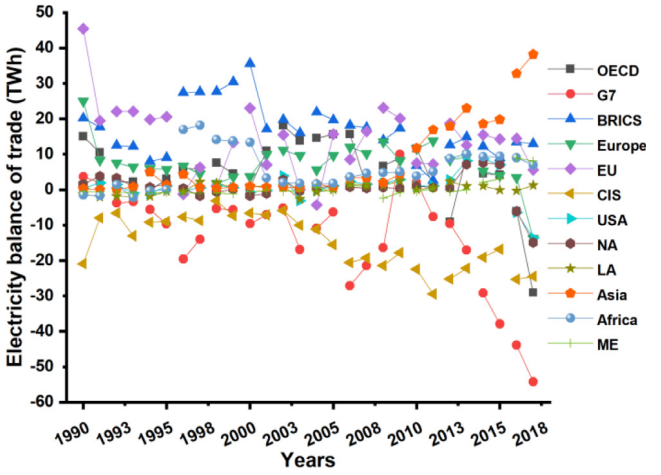

Fig. 10. Electricity balance of trade.

2011 due to improved energy performance, while demand in Canada has increased. It has continued steadily in the EU (increase in demand for electricity in Poland, Spain, Italy, and Germany, drop in the United Kingdom) and has increased in Turkey. Domestic electricity consumption is also expanding considerably in Egypt and Iran. In the EU countries, Poland and Portugal, the increase in electricity consumption in 2016–2017 were marked by a significant increase of 2.6% and 3.3%. There is a 1.4% increase in CIS countries between 2000 and 2017. The Asian countries are leading the way in this regard. There is a 5.5% increase in 2016–2017 and a 6.5% increase in total domestic energy consumption in 2000–2017. China and India are at the top of the list, with a 5.9% and 5.3% increase in household energy consumption between 2016 and 2017. In the ME countries, Iran and Kuwait are paying great attention to the large increase in electricity required for domestic consumption. In Fig. 10, the electricity balance of trade of all countries are briefly analyzed. The OECD, G7 and EU total trade balances in 2017 were −29.1 TWh, −54.2 TWh and −5.6 TWh, respectively. A slight shift can be observed in CIS and LA countries. The total trade balance in Asian countries was 38.1 TWh in 2017.

2.6. Renewable energy

2.6.1. Share of RES in total electricity generation

The ratio of renewable energy in the generation of electricity is the ratio between renewable energy and renewable energy generation (RES) such as (hydro, wind, solar and geothermal) and total energy generation. It is in Fig. 11(a), the total share of RES, including hydropower generation in the mix of world power generation, which has been growing rapidly since the end of the 2000s, increased by approximately 1.0% in 2017 to around 25%. Solar and wind production has gained momentum, supported by aggressive environmental strategies in the EU, the USA, India, China, Australia and Japan, and by the turbulent decline in wind and solar development prices in the recent era, enabling emerging nations to develop their RES capabilities. RES now accounts for one-third of the total energy mix in the EU, one-sixth in the USA, India, Japan, and one-fourth in China. In the EU, renewable energy has remained stable in 2017 as a robust development of REG in the UK and Germany, which has been negated by conflicting hydraulic conditions in the southern part of Europe (Italy, France, and Spain). The proportion of renewables in total electricity generation by OECD, G7 and EU countries has increased significantly. The CIS countries show an increase of 0.3 points in

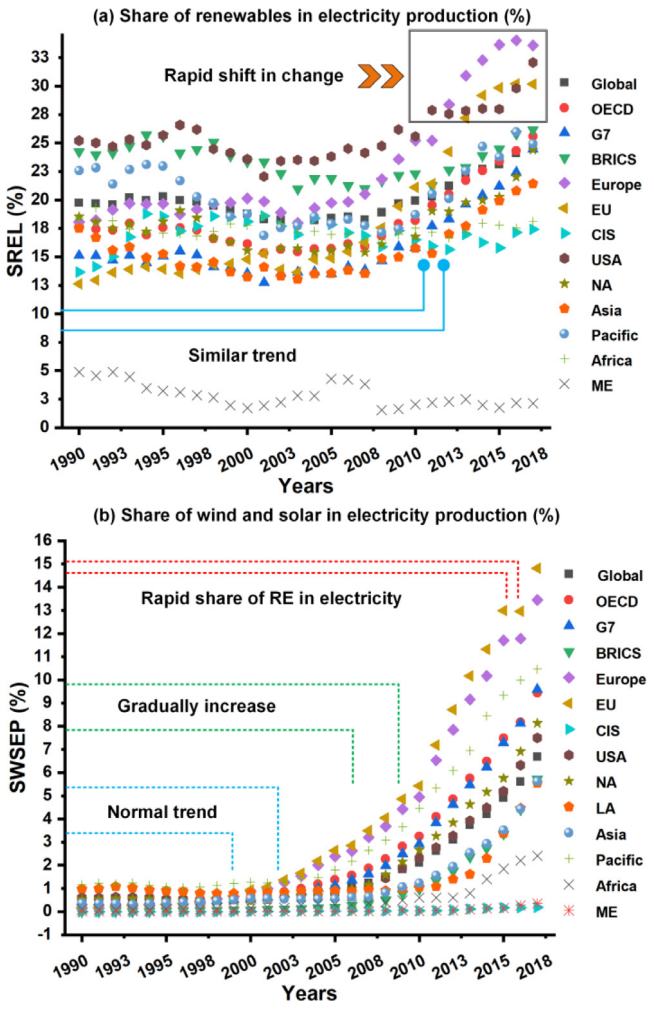

Fig. 11. (a) shows the share of RES in the generation of electricity; (b) explains the share of solar and wind energy in the generation of electricity.

the entire generation of electricity. The USA, NA and Asia share 8.5 points, 8.9 points and 8.2 points in total electricity generation between 2000 and 2017. Overall, the share of renewable energy in the entire generation of electricity is gradually increasing day by day.

2.6.2. Share of solar and wind power generation

Solar and wind-generated a significant increase in 2017 and their overall percentage of global energy mix increased by 1% of total demand. The generation of solar power was responsible for 20% of the additional energy generation in 2017 and 30% of the generation of wind power. Decreasing prices in the recent era linked to ambitious plans – especially in Asia – have supported the integration of more than 600.0 GW of wind and solar power since 2010, expanding RE production. In addition to the rapid change in the EU (in the UK and Germany), supported by Brazil, China, India, the USA and Japan, the entire solar and wind energy mix was extended to process in all countries in 2017 (Fig. 11(b)). The energy generated from the solar and wind forms is aggregated for analysis. Between 1990 and 2001, there has been a small increase in the generation of solar and wind power, but it has gradually grown to 2010. After 2010, a rapid and significant change in solar and wind power generation can be observed. This is due to a large number of countries; in particular, the developed countries are investing a lot in the generation of renewable energy in order to save the environment and generate clean energy. Significant increases can be seen in the USA, LA, Asia, OECD, G7, EU and BRICS countries.

2.7. CO_2 emissions

2.7.1. GHGE from the combustion of fuel

The GHGE includes emissions from gas, coal, and fossil fuel combustion by different sectors. They are determined to follow up on the methodology of the United Nations Framework Convention on Climate Change (UNFCCC) ('2006 IPCC Guidelines for National Greenhouse Gas Inventory'). In Fig. 12(a), It can be observed that CO2 emissions have continued steadily in the US, in line with their use of power; however, a sound economic increase has accelerated China's coal waste as well as CO2 emissions — upward, despite the shift in gas-to-coal policy that has sustained stable emissions since 2014. The global economic shift is a sustained increase in CO2 emissions and power consumption in most countries, such as Russia, India, South Korea, Japan, Iran, and Canada. Opposing hydropower status also resulted in an increase in Europe and Brazil (notably an increase of 1.90% in 2017 analyzed with an average decrease of −1.90% in the previous decade; CO2 emissions increased notably in Turkey due to higher coal use), in Spain, Germany, France, and Poland, but decreased in the United Kingdom compared to more renewable energy sources. Conversely, total CO2 radiation has decreased in Ukraine and Mexico, where a large number of nuclear power plants have been used to generate coal. The ratio of CO2 emissions from combustion fuel has doubled since the early 1970s, accelerating environmental change and climate degradation (Kan et al., 2019; IPCC, 2014; CO2 Emissions from Fuel Combustion, 2018). At present, almost all countries are seriously focusing on reducing GHGE and on promoting renewable energy sources for sustainable energy and development.

2.7.2. CO2 intensity at constant energy supply parities

The CO2 intensity can be described as the total greenhouse gas emission (GHGE) ratio of fuel combustion to the gross domestic product. The CO2 released is estimated to produce one unit of GDP. Gross domestic product is shown at a fixed exchange price and a parity of power to eliminate inflation and to indicate abnormalities in related energy use and general cost levels in existing levels of financial activity. Applying energy parity measures to the gross domestic product rather than exchange prices increases the amount of gross domestic product in countries with economical living costs and, as a result, reduces their energy intensity. Kangyin et al. (Dong et al., 2019), determine the impact of regional and global CO_2emissions. The aim of this analysis was to investigate and evaluate the utility of non-renewable and renewables in terms of the main impact factors of regional or global CO_2. In Fig. 12(b), CO2 intensity has decreased in entire countries since 1990, with the exception of the ME, but higher concentrations of fossil fuel are still recorded by developed nations. CO2 emissions increased in Russia in 2017, despite a mean 2.20%/year decrease since 1990, and in the ME (Iran and Saudi Arabia). The intensity of CO2 emissions is increasing mainly in emerging countries such as China and India. In the EU – the lowest CO2 intensity in the world – it remained constant, with higher emissions in Germany and France offsetting increases in the UK.

3. Future global energy and demand outlook

In this section, we reviewed the future energy forecast requirement until 2040. Section 1.3 sets out the future energy outlook method and algorithms used for analysis. Primary energy

Table 2
Total primary energy consumption requirement.

Category	Unit	2020	2021	2022	2023	2024	2025	2030	2035	2040
World	Mtoe	14,243	14,455	14,666	14,863	15,034	15,165	15,867	16,623	17,487
Europe	Mtoe	1,858	1,852	1,842	1,831	1,818	1,800	1,712	1,658	1,650
Asia	Mtoe	6,318	6,504	6,692	6,870	7,031	7,162	7,772	8,294	8,770
Africa	Mtoe	749	765	783	802	821	840	957	1,106	1,301
ME	Mtoe	777	777	774	767	757	746	727	725	742
NA	Mtoe	2,562	2,556	2,549	2,538	2,522	2,500	2,406	2,359	2,347
LA	Mtoe	874	889	904	920	936	953	1,047	1,150	1,258
CIS	Mtoe	955	962	970	981	994	1,007	1,082	1,162	1,246
Pacific	Mtoe	149	150	152	154	156	157	163	169	172

Table 3
Total final energy consumption requirements.

Category	Unit	2020	2021	2022	2023	2024	2025	2030	2035	2040
World	Mtoe	9,970	10,134	10,289	10,425	10,529	10,599	10,925	11,308	11,775
Europe	Mtoe	1,354	1,357	1,357	1,354	1,346	1,334	1,261	1,211	1,193
Asia	Mtoe	4,372	4,500	4,627	4,745	4,843	4,918	5,237	5,517	5,776
Africa	Mtoe	590	602	615	628	641	653	730	832	970
ME	Mtoe	504	507	507	504	498	492	481	480	491
NA	Mtoe	1,764	1,761	1,756	1,747	1,734	1,715	1,635	1,591	1,568
LA	Mtoe	638	651	663	675	687	697	748	802	853
CIS	Mtoe	642	650	657	664	671	679	719	759	805
Pacific	Mtoe	105	106	108	109	110	111	114	117	120

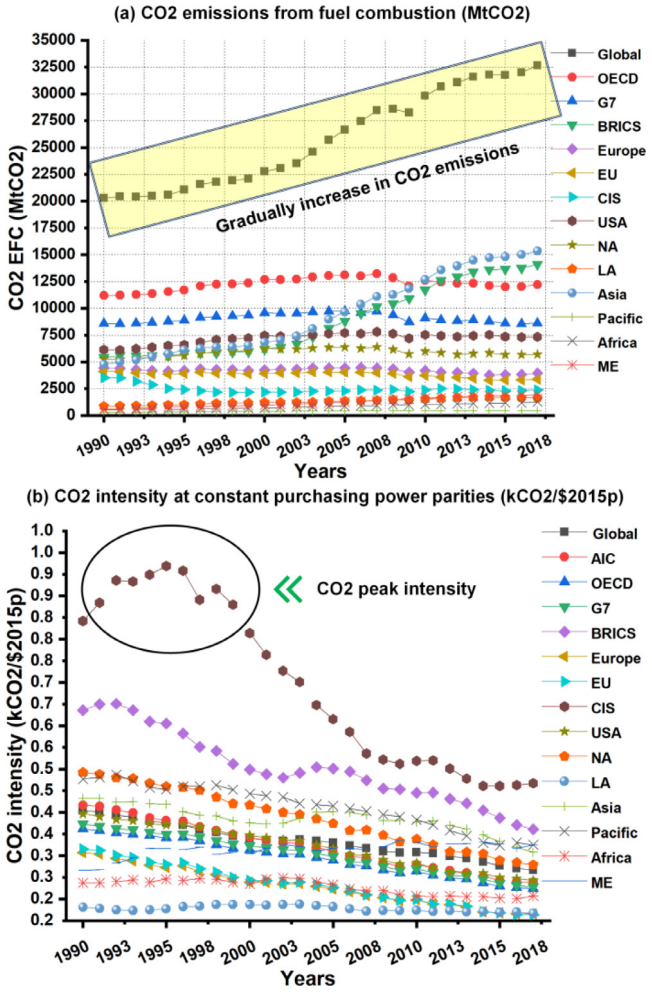

Fig. 12. (a) CO2 emissions from fuel combustion; (b) GHG intensity at constant energy supply parities.

consumption measures the overall use of energy, including total energy consumption and losses during the energy transformation

Table 4
Final demand for electricity consumption.

Category	Unit	2020	2025	2030	2035	2040
World	TWh	22,536	25,307	28,513	31,907	35,407
Europe	TWh	3,398	3,528	3,648	3,793	3,985
Asia	TWh	10,410	12,488	14,826	17,120	19,254
Africa	TWh	709	867	1,095	1,392	1,789
ME	TWh	994	1,059	1,138	1,254	1,404
NA	TWh	4,335	4,383	4,413	4,491	4,614
LA	TWh	1,334	1,489	1,692	1,919	2,170
CIS	TWh	1,101	1,223	1,407	1,617	1,843
Pacific	TWh	257	270	294	320	348

process. Total final energy consumption estimates the energy demand requirements of final customers, with the exception of losses and inputs associated with changes in the energy sector. The total primary and final energy consumption is shown in Tables 2 and 3. It is a forecast from 2020 to 2040. Total world demand for primary energy is expected to be 17,487 Mtoe in 2040, with 1.1% between 2015 and 2040. Africa is at the top of the list with a 2.7% increase and Asia was second in terms of a 1.9% increase in demand for primary energy consumption. The final energy consumption in the world, the EU, Asia, Africa, ME, NA, LA, CIS and Pacific countries, will be 11,775 Mtoe, 1,193 Mtoe, 5,776 Mtoe, 970 Mtoe, 491 Mtoe, 1,568 Mtoe, 853 Mtoe, 805 Mtoe and 120 Mtoe respectively. The significant increase in total final energy consumption comes from Asia, Europe, and the Netherlands. The demand for CIS, Pacific and LA final energy consumption is gradually increasing.

Tables 4 and 5 shows the total installed capacity and final consumption of electricity. The share of final energy consumption from Asia, NA, Europe, LA, CIS, Africa, ME, and Pacific will be 54.4%, 13.0%, 11.3%, 6.1%, 5.2%, 5.1%, 4.0% and 1.0% respectively. The share of total installed capacity from Asia, NA, Europe, LA, CIS, Africa, ME, and Pacific will be 54.4%, 13.0%, 12.5%, 6.0%, 5.1%, 4.8%, 3.5% and 1.2%, respectively. The final electricity consumption of African countries will be higher compared to the Pacific, CIS, LA, NA, ME, and Asia. However, Asia is ranked second in this list in terms of final energy consumption.

The percentage of RES in energy generation refers to the ratio between total power generation and electricity produced from RES (solar, wind, large and large hydro, geothermal, biomass or

Table 5
Total electrical capacity installed.

Category	Unit	2020	2025	2030	2035	2040
World	GW	8,027	9,005	10,087	11,297	12,420
Europe	GW	1,331	1,430	1,488	1,556	1,617
Asia	GW	3,710	4,370	5,146	5,989	6,709
Africa	GW	246	295	363	463	591
ME	GW	339	353	365	394	435
NA	GW	1,392	1,463	1,517	1,536	1,550
LA	GW	467	518	584	666	740
CIS	GW	439	465	503	561	631
Pacific	GW	102	111	120	133	146

Table 6
Share of renewables in the generation of electricity.

Category	Unit	2020	2025	2030	2035	2040
World	%	27.8	30.2	32.8	35.4	37.1
Europe	%	39.9	45.6	49.0	51.9	53.8
Asia	%	24.6	25.9	28.5	31.3	33.1
Africa	%	22.0	24.2	26.1	28.3	29.8
ME	%	3.5	6.5	10.9	17.9	25.1
NA	%	24.5	28.9	33.2	36.3	38.7
LA	%	60.7	62.4	62.7	63.8	62.6
CIS	%	19.3	20.3	21.1	22.1	23.2
Pacific	%	32.3	36.7	41.1	47.9	53.8

other) and total electricity generation. It is a (percent) value. Renewable energy use means a significant reduction in CO2 emissions and leaves a critically direct impact on climate change (Aleixandre-Tudó et al., 2019; Charters, 2000; Cansino et al., 2010; Jagoda et al., 2011; Sims et al., 2003). The solar and wind industry would be the best option for future energy planning and management, but it is superior in terms of different perceptions, including accessibility, cost-effectiveness and efficiency, as opposed to the various conventional energy sources (Kannan and Vakeesan, 2016). Table 6 shows the proportion of RES in the generation of electricity. Europe, the Pacific, and America will be at the top of the world's average electricity generation renewables (37% in 2040).

The consumption of final NG estimates the requirements of final customers for natural gas with the exception of losses and inputs associated with the transformation of energy sectors. The primary use of natural gas for power generation is the total information or data used by private and public power generation units (including fuel cells and cogeneration plants). According to Tables 7 and 8, compared to trends suspected by 2040, which included a significant boom in Asia and decreased by (1/4) in Europe and ME. The share of total natural gas consumption in Asia, NA, Europe, LA, CIS, Africa, ME and Pacific will be 39.7%, 18.2%, 11.3%, 10.7%, 7.7%, 6.9%, 4.4% and 1.1% respectively in 2040. The share of total natural gas inputs for power plants in Asia, NA, Europe, LA, CIS, Africa, ME and the Pacific will be 36.3%, 59.9%, 12.6%, 10.1%, 8.8%, 8.7%, 6.5% and 1.1%, respectively in 2040. One of the most dominant future power-producing fuels in the African and Asian countries will double by 2040. Between 2006 and 2016, CO2 emissions increased rapidly by 6753.2 Mt, especially in developing countries (Jiang et al., 2019; Le Quéré et al., 2017; Boyd and Green, 2015). It is concluded that overall activity and scenario analysis has increased due to rapid population growth, but CO2 can be reduced by increasing a large number of cleaner energy technologies (Lin and Raza, 2019).

CO2 gas emissions are global climate change emanations from the process industries and from the combustion of fossil fuels. CO2 emissions from land use, agriculture, animal husbandry and forestry are not covered. Biomass combustion is supposed to be carbon neutral. The CO2 intensity of power generation describes the amount of global Carbon dioxide emissions associated with

Table 7
Final consumption of natural gas.

Category	Unit	2020	2025	2030	2035	2040
World	bcm	1,788	1,915	1,952	2,029	2,142
Europe	bcm	339	328	292	259	241
Asia	bcm	397	537	629	742	850
Africa	bcm	54	63	72	81	95
ME	bcm	216	198	183	170	164
NA	bcm	464	446	415	399	390
LA	bcm	96	111	123	136	148
CIS	bcm	201	210	216	219	230
Pacific	bcm	20	21	22	23	24

Table 8
Inputs for natural gas for power plants.

Category	Unit	2020	2025	2030	2035	2040
World	Mtoe	1,181	1,269	1,321	1,421	1,552
Europe	Mtoe	130	141	142	148	156
Asia	Mtoe	327	371	418	489	564
Africa	Mtoe	67	80	93	111	136
ME	Mtoe	137	151	149	141	136
NA	Mtoe	271	268	251	249	246
LA	Mtoe	64	69	79	87	101
CIS	Mtoe	173	176	176	181	196
Pacific	Mtoe	12	13	14	15	16

Table 9
Total emissions of CO2, including industrial processes.

Category	Unit	2020	2025	2030	2035	2040
World	MtCO2	36,265	37,763	38,177	38,617	39,549
Europe	MtCO2	3,959	3,670	3,313	3,075	2,940
Asia	MtCO2	18,444	20,456	21,399	22,016	22,738
Africa	MtCO2	1,345	1,536	1,780	2,094	2,515
ME	MtCO2	2,081	1,964	1,887	1,825	1,790
NA	MtCO2	5,816	5,323	4,793	4,496	4,285
LA	MtCO2	1,848	1,950	2,028	2,102	2,200
CIS	MtCO2	2,363	2,467	2,591	2,639	2,720
Pacific	MtCO2	408	398	387	372	361

Table 10
CO2 intensity of the generation of electricity.

Category	Unit	2020	2025	2030	2035	2040
World	gCO2/kWh	440	412	382	352	333
Europe	gCO2/kWh	268	230	198	180	168
Asia	gCO2/kWh	534	507	462	419	396
Africa	gCO2/kWh	503	462	435	410	389
ME	gCO2/kWh	599	511	463	405	351
NA	gCO2/kWh	368	327	295	279	260
LA	gCO2/kWh	214	189	178	165	161
CIS	gCO2/kWh	438	417	408	372	342
Pacific	gCO2/kWh	532	478	433	369	316

the production of 1 kilowatt-hour of energy. It is stated in the gram of CO2 per kilowatt-hour (gCO2/kWh). The intensity of CO2 in GDP is similar to the number of anthropogenic CO2 emissions from fossil combustion associated with the production of a single unit of GDP. This parameter is estimated in constant dollars at energy parity (kgCO2/US$15pp). Tables 9 and 10 show the total emission of CO2, including the intensity of CO2 in power generation and industrial processes. The success of the NDCs could be complemented by an absolute increase in emissions in emerging markets. Total CO2 emissions from Asia (57.5%) are projected at 22,738 MtCO2, NA (10.8%) 4,285 MtCO2, Europe (7.4%) 2,940 MtCO2, CIS (6.9%) 2,720 MtCO2, Africa (6.4%) 2,515 MtCO2, LA (5.6%) 2,200 MtCO2, ME (4.5%) 1,790 MtCO2 and Pacific (0.9%) 361 MtCO2. The carbon content of energy production will fall in global regions as a whole, with the world falling by more than 30.0% between 2015 and 2040. Table 11 shows the CO2 intensity of GDP. The overall trend of CO2 intensity to GDP is declining.

Table 11
The CO2 intensity of GDP.

Category	Unit	2020	2025	2030	2035	2040
World	kgCO2/$15ppp	0.267	0.232	0.197	0.167	0.144
Europe	kgCO2/$15ppp	0.158	0.133	0.109	0.092	0.080
Asia	kgCO2/$15ppp	0.316	0.270	0.223	0.182	0.152
Africa	kgCO2/$15ppp	0.199	0.184	0.170	0.158	0.149
ME	kgCO2/$15ppp	0.317	0.265	0.237	0.215	0.199
NA	kgCO2/$15ppp	0.268	0.225	0.185	0.159	0.138
LA	kgCO2/$15ppp	0.176	0.163	0.147	0.134	0.123
CIS	kgCO2/$15ppp	0.434	0.389	0.334	0.278	0.237
Pacific	kgCO2/$15ppp	0.268	0.226	0.188	0.154	0.130

Table 12
Prices for oil, gas, and coal.

Category	Unit	2020	2025	2030	2035	2040
Oil price						
World	US$$_{2015}$/boe	60	73	84	93	100
Gas price						
Asia	US$$_{2015}$/Mbtu	35	41	46	48	51
USA	US$$_{2015}$/Mbtu	19	23	27	31	36
Europe	US$$_{2015}$/Mbtu	30	36	45	49	54
Coal price						
Europe	US$$_{2015}$/tonne	12	12	12	12	12
NA	US$$_{2015}$/tonne	16	16	16	17	17
Asia	US$$_{2015}$/tonne	18	18	18	18	19

4. The price of oil, gas, and coal in the future

The cost of fossil fuels is given as a fixed number of regional/international market rate parameters for gas, oil, and coal. The rate of oil estimated for the world oil exchange and comprised of the man Brent-spot-eprice is set at US$ 15.0/boe. The price of natural gas estimated for the Asian, US and EU markets, including the Asian import rate base, the US-Henry-Hub spot rate and the Zeebrugge-spot rate presented at US$ 15/MBtu. The rate of coal estimated for the Asian, NA and EU markets with past data, based on Japan, the USA, the CIF-ARA, and the EU, is reported at US$ 15.0/tonne. Tables 12 and 13 shows the rates of gas, oil and coal with different continents and the forecast for regional data and Fig. 13 shows a brief history and current overview of the percentage increase/decrease in world energy, oil, gas, coal, CO2 emissions and the share of renewable energy in electricity generation.

The rate of oil is supposed to be higher than US$ 60/barrel. Oil prices are therefore expected to remain between US$ 50.0 and US$ 80.0/barrel until 2030. For short-term perceptions, the rate of oil may rise differently in response to ST financial, economic, political issues, with the exception of primary long-term market facts. The current oil rate of US$ 60.0–70.0/barrel has already consolidated, in our view, a geopolitical uncertainty premium of some US$ 10.0–20.0/barrel. The international crude oil rate is expected to accelerate above the US$ 60.0/barrel in the future, but not to exceed US$ 100.0/b from 2040.

The market rate for natural gas in Asian countries is high on the oil rate. Overall, the gas rate in Asian countries could focus on the long-term perceptive level of EU gas prices, although it remains well above the expected NA gas prices. In order to follow up on the oil-rate collapse in 2015, the indexed oil-gas rate decreased in the year (2016) and has been relatively lower since then. In the long term, rates may not rise substantially due to possible surges in supply from US and Australian LNG or expected to invade the EU and compete with Russian gas supplies. However, Russia would want to retain its market shares, which could push the EU gas rate up by about 2025, while the EU's gas rates are expected to rise slightly over the long term. The recent low-level climate condition of the NA is suspected of continuing to include a small recovery time, among others, due to US projects for a significant amount of LNG exports. Despite the widespread/flat nature of the trend in the generation of shale gas in the US, the importance of exports to residential tariffs should remain unsatisfactory in the medium range. Overall, NG rates will converge in Europe and Asia, but will prevail higher than in the NA. Follow the trend of the primary market; the rate of coal may remain constant in the medium term before rising mutely until 2040.

In the context of the New Policy Scenario (NPS), which takes into account planned and existing government strategies, global primary energy requirements increased by 37.0% between 2012 to 2040. Energy demand has increased rapidly in the past era; the increase in the market is due to structural changes and energy efficiency gains on the world market in favor of limited energy-intensive projects. In 2040, natural gas, oil and coal were each forecast to account for about 1/3 of the total requirement; low-carbon ammunition (mainly nuclear and renewable energy sources) made up the balance. However, oil demand will remain the most significant energy resource; therefore, the use of renewable energy will increase the fastest. Most of the growth in energy requirements will come from non-OECD nations. The Asian countries account for 60%, changing the center of gravity of energy companies. China is the dominant power behind world growth demand for the next era, estimated at about 1/3 of the increase. However, after 2026, over the Chinese growth increase, India's catch slows significantly. Per capita energy use in non-OECD regions is increasing the duration of the outlook; however, from 2040, it is still below the required level, which was led by the OECD at the beginning of 1970. Improved energy performance and technological progress, however, provide a higher level of demand for energy services per unit of energy consumption. However, rising energy changes and rates for the global economic structure increase the average consumption of energy and end-use requirements in non-OECD by nearly 50%. Global oil supply is increasing by 14.0 mb/d to 104.0 mb/d by 2040 (IEA: Directorate of Global Energy Economics, 2013), although the drift is specifically related to timely expenditure in the ME, which is the main global supply source of growth once the supply of non-OPEC oil begins to decline by the 2020s.

All large countries, except Europe, have increased the production of natural gas by more than 50%. The re-ordering of energy trade to Asian supermarkets is accelerating and increasing the requirements for imports of crude oil from India and China, the ME and the various countries are increasing the vulnerability of the conceivable deficit to disruption or investment in oil supplies. The share of natural gas in the entire inter-regional business has increased by 1/3 to more than 20% of the total demand since 2040; interest in the conservation of gas has increased due to increased availability of LNG. At the long-term climate summit in Paris in 2015, various governments have announced new steps to control CO2 emissions; however, emissions still increase by 20% of total emissions in the light of the NPC — steady with the LT temperature increase of around 3.6 ° C worldwide. It is worth mentioning that the data used for the analysis were taken from a closed source, and the future forecasted results of the various sources are in an attempt to predict the future energy demand of the world. The forecasting models developed by "Enerdata" are used for future forecasts. Errors and/or variations may be considered. Future trends may also suddenly change due to unexpected changes in the environment, economic crises, and other reasons, such as wars, etc.

Table 13
Regional price of coal and natural gas.

Category	Unit	2020	2025	2030	2035	2040
Regional coal price						
European coal price (constant US$)	US$15/tonne	50.43	49.92	50.17	51.03	52.35
NA coal price (constant US$)	US$15/tonne	70.09	69.31	69.67	70.84	72.41
Asian coal price (constant US$)	US$15/tonne	77.75	77.01	77.42	78.76	80.47
Regional natural gas prices						
European natural gas market price (constant US$)	US$15/MBtu	5.36	6.57	8.17	8.87	9.67
USA natural gas market price (constant US$)	US$15/MBtu	3.43	4.17	4.90	5.64	6.41
Asian natural gas market price (constant US$)	US$15/MBtu	6.38	7.48	8.22	8.72	9.28

Sr. No.	Type	Ratio	Category													
		% Increase/decerase	Global	OECD	G7	BRICS	Europe	EU	CIS	USA	NA	LA	Asia	Pacific	Africa	ME
1	Total energ production	2016 - 2017 (%)	2.4	2.4	3.9	3.5	1	-0.6	3.9	2.1	4.2	-2.9	3.6	-0.3	2.5	0.1
		2000 - 2017 (%/year)	2	0.5	0.5	3.6	-0.9	-1.3	2.3	1.1	1.3	0.8	3.8	2.9	1.5	2.5
2	Energy consumption	2016 - 2017 (%)	2.3	1.1	0.6	3.2	2	1	3.3	0.7	0.6	0.8	3	0.4	3.1	3.4
		2000 - 2017 (%/year)	2	0.1	-0.3	4.5	0	-0.3	0.9	0.4	-0.1	2.1	4.1	1.1	3	4.5
3	Energy intensity	2016 - 2017 (%)	-1.2	-1.1	-1.4	-2.4	-0.6	-1.3	1.1	-1	-1.6	0	-2.5	-2	-0.2	2.2
		2000 - 2017 (%/year)	-1.5	-1.7	-1.7	-2.4	-1.7	-1.8	-2.9	-1.6	-1.9	0	-1.9	-1.8	-1.3	0.6
4	Crude oil production	2016 - 2017 (%)	0.1	3.1	5.7	-0.1	-1.3	-1.7	0.6	1.7	6.2	-5.1	-1.5	0	2.7	-1.4
		2000 - 2017 (%/year)	1.1	0.6	2.1	2.7	-3.9	-4.7	3.4	1.6	3.2	-0.5	0.3	0	0	1.4
5	Crude oil input to refineries	2016 - 2017 (%)	1.6	1.4	1.2	2.6	2.1	1.2	0.2	-0.5	2.1	-8.7	3.7	-1.3	-1.2	1.8
		2000 - 2017 (%/year)	1.1	-0.2	-0.5	4.5	-0.4	-0.5	2.2	0	0.2	-0.8	3.1	-2.2	-0.3	2.1
6	Refined oil products production	2016 - 2017 (%)	1.4	1.1	0.8	2.6	2	1	0.2	-0.7	1.6	-8.5	3.6	-1.9	-1	2
		2000 - 2017 (%/year)	1	-0.2	-0.4	4.1	-0.4	-0.5	2.3	0	0.3	-0.9	2.8	-2.4	-0.4	2.1
8	Oil porducts domestic consumption	2016 - 2017 (%)	1.7	1.1	0.8	3.9	2.2	1.8	-0.4	0.4	1.1	-1.5	3.5	4.3	-0.6	1.8
		2000 - 2017 (%/year)	1.1	-0.5	-0.8	3.7	-0.8	-1	1.3	0	-0.3	0.9	2.5	1.5	3.2	2.5
9	Natural gas production	2016 - 2017 (%)	4	2.2	1.5	7.7	0.5	-5	6.6	1.2	1.7	-0.9	3	16.7	6.3	4.7
		2000 - 2017 (%/year)	2.4	1.2	0.8	2.1	-1.3	-4.2	1.6	1.7	1.6	2.4	3.7	6.6	3.4	7.1
10	Natural gas domestic consumption	2016 - 2017 (%)	0	1.5	0.7	9.5	4.8	4	6.4	-0.4	-0.3	-0.9	7	2.1	7.7	4.8
		2000 - 2017 (%/year)	0	1.2	0.9	3.5	0.5	0	0.8	1.4	1	3.4	5.8	3.1	5.5	6.6
11	Coal and lignite production	2016 - 2017 (%)	3.2	2.2	4.1	3.1	5.3	-0.8	4.9	4.3	5.3	-2.5	3.5	-4.4	1.7	0.4
		2000 - 2017 (%/year)	2.8	-0.8	-1.8	4.7	-1	-1.8	1.9	-1.4	-1.8	3.2	5.6	2.6	1	0.4
12	Coal and lignite domestic consumption	2016 - 2017 (%)	0.9	0.8	-1.7	0.9	3.1	-1.5	0.6	-1.7	-1.8	-1.3	1.2	-3.1	-3	-6.3
		2000 - 2017 (%/year)	2.7	-1	-1.7	5.3	-0.7	-1.4	0.1	-2.1	-2.4	2.8	5.7	-0.4	1.2	0.5
13	Electricity production	2016 - 2017 (%)	2.7	0.9	0.6	4.7	1.2	0.7	0.3	-0.3	-0.6	0.5	5.5	-0.1	2.2	3.9
		2000 - 2017 (%/year)	3	0.7	0.3	6.6	0.7	0.4	1.3	0.9	0.4	2.9	6.2	1.1	3.6	5.6
14	Electricity domestic consumption	2016 - 2017 (%)	0	0.5	0.3	4.8	0.8	0.4	1.1	-0.7	-1	0.4	5.5	-0.2	2	3.4
		2000 - 2017 (%/year)	0	0.8	0.3	6.9	0.8	0.5	1.4	0.9	0.4	3	6.5	1.3	3.3	5.4
15	Share of RE in electricity production	2016 - 2017 (%)	0.7	1.3	2	0.4	-0.4	0	0.3	2.3	2.4	1.6	0.6	-1	0.6	0
		2000 - 2017 (%/year)	6	9.5	10.9	2.8	13.5	15.4	-0.7	8.5	8.9	-5.7	8.2	6.2	0.3	0.4
16	Wind and solar share in electricity production	2016 - 2017 (%)	1.1	1.3	1.5	1.3	1.7	1.9	0	1.2	1.2	1.1	1.2	0.5	0.2	0.1
		2000 - 2017 (%/year)	6.1	8.8	9	5.6	12.6	13.9	0.2	7	7.7	4.7	5.1	9.2	2.3	0.3
17	CO2 emissions from fuel combustion	2016 - 2017 (%)	2.1	1.3	0.7	2.7	2.9	1.9	3	0.2	0.6	-1.1	2.2	0.7	6.3	3.9
		2000 - 2017 (%/year)	2.1	-0.2	-0.6	5	-0.4	-0.9	0.5	-0.1	-0.5	1.8	4.9	1	3.7	4.3
18	CO2 intensity	2016 - 2017 (%)	-1.3	-0.9	-1.3	-2.8	0.4	-0.4	0.9	-1.4	-1.6	-1.6	-3.3	-1.7	2.9	2.7
		2000 - 2017 (%/year)	-1.4	-1.9	-2	-1.9	-2.1	-2.3	-3.2	-2.1	-2.3	-0.6	-1.2	-1.8	-0.7	0.4

Fig. 13. Historical overview of the percentage increase/decrease in world energy, oil, gas, coal, CO2 emissions, and the share of renewable energy in electricity generation.

5. Conclusion

In this review, the following aspects are reviewed, including: emissions and energy (gas, oil, electricity, coal, CO2 emissions and biomass), power: (energy capacity and generation: nuclear, fossil and renewable energy sources (solar and wind, etc.)), demand (sectoral demand and total market) and sectors (industry, power generation, buildings and transport) (which combines agriculture and energy). It provides a collection of charts, databases, and interactive statistics, including the most widely used energy statistics for future forecasting. In addition, the historical overview and perception of the following key areas are analyzed:

1. Total demand for energy consumption:
   - The primary use of energy by end-use and industry.
   - Energy performance parameters (intensity-both climate-corrected and observed), GHG emissions per capita.
   - Drivers of total energy demand.
   - The ratio of renewable energy to electricity generation.
   - The ratio of generation of solar and wind power.
2. Data on the residential sector by end-users, drivers and fuel:
   - Detailed total data on primary and final energy use by end-use consumers.
   - Consumption drivers.
   - Indicators of energy performance.
   - Emission of CO2.
   - CO2 intensity with constant purchasing power parities.
3. Data on the service sector by end-use consumers, drivers, and fuel.
   - Energy efficiency and indicators of accuracy.
4. Detailed data on the transport sector by type of transport and fuel.
   - Primary energy use and total energy requirements.
   - Final electrical consumption and total installed capacity.
   - The share of RES in the generation of electricity demand.

- Consumption and demand for natural gas.

Energy demand growth and CO2 emissions will be significantly reduced by increasing energy performance and reducing energy consumption in the world, including in large regional economies. The overall global demand for fossil energy sources will be extended for decades to come. A large number of energy sources (non-conventional or conventional renewables) are needed to meet this growing demand. Total CO2 emissions from the Asian region will be slightly or even deteriorating in the near future. A specific cause of this is the migration of heavy industries to the Asian region, where the price of energy consumption is still low. Electricity generation efficiency is currently smaller and will increase slowly.

India and China will have approximately 45.0% of the global total energy increase by 2020; however, global energy use is expected to increase by 30%, while EU energy use is expected to increase by 12.0% between 2006 and 2021. Natural Gas will account for approximately 31.0% of global energy and demand growth between 2006 and 2021 (22% of oil and 25% of coal). EU natural gas use is expected to increase by 40.0% by 2021. The energy area is the primary indicator of this increase, taking 53.0% of this increase. European oil consumption will be reduced by 3.0% over the next 15 years. As a result, China has identified a less energy-intensive phase as a result of development progress; by far, it continues to be the largest consumer and producer of coal by 2040. China's total energy requirement will double in 2040. In the future, India is projected to increase by about 25.0% of the world's energy requirements by 2040. The IEA forecasts a rapid increase in energy use as a result of a rapid change in the demand for coal for electricity generation and industry, as there continues to be a change in the pace at which new nuclear plants or large dams can be built in the country.

RES is set to become the leading energy resource for new ways of generating energy from now to 2040. Their worldwide deployment has increased with great attention in the energy sector, where RES has been overhauling coal as one of the most significant sources of electricity production since the early 2030s. RES-based production leads by 2040 to 50% in the European Union, by approximately 30% in Japan and China, and by more than 25% in India and the USA. In 2040, the global energy mix should be classified into four equal sectors, including low-carbon, gas, oil, and coal. The total global demand for gas will increase by more than 50% in 2040, while the demand for oil and coal will "only" increase by 15% from that date. Overall, energy-saving, and energy efficiency are key components for minimizing energy interruptions and providing a sustainable energy supply to the LT. In addition, new technology sectors, such as hydrogen, are needed to complete the transformation of the energy system.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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