

REVIEW ARTICLE

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Up-date: Renewable energy and climate change

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Abstract. The Climate Change crisis is worsening daily. We must start to-day and not to-morrow limiting CO₂ emission globally. The Antarctic is melting with alarming speed and causing sea water levels to rise by 24 inches in the Southern Hemisphere. Central Australia is experiencing its worst ever drought and forest fires causing immense damage; on 55 days in 2019 temperatures rose to 48°C while the ground temperature reached 62 °C. Vast tracts of land have been burned with loss of life, homes, produce and wildlife. Yet government reaction was skeptical of the Climate Change connection. At the same time Europe and England have had extreme rainfall and serious extensive flooding. Nowadays many countries have started to take Climate Change extremely seriously and put together plans to reduce or stop the use of coal and other fossil fuels. Most countries have pledged to stop using fossil fuels by 2030. The transport industry accounts for the major part of air pollution through the use of motor vehicles, ships and air transport. In this paper it is demonstrated that motor car usage contributes more than 3500 million metric tons of CO₂ each year. UK in November 2020 pledged to combat Climate Change and reduce the emission of CO₂ by 50% by 2030. Recently it has announced a ten-point drive to eliminate fossil fuels in transport, agriculture, industry and homes by 2035. Ajman should follow suit and use UK as an example. This paper will summarize the progress of renewable energy globally with examples. Renewable Energy is now a major source of generating electricity worldwide. It is clean, abundant and low cost.

1 Climate change

In 1976 at Renewable Energy Conference, Dhahran, Saudi Arabia, I stated the fact that CO₂ emission will leads to Thermal Warming. Since 1972 there have been more than 10 UN major renewable conferences. Climate change was recognized as a serious problem at the First World Climate Conference in 1979, in Geneva, Switzerland, and then in the Toronto Conference on the Changing Climate in 1988, wherethe Intergovernmental Panel on Climate Change (IPCC) was established. In 1990 in the Geneva Conference, the IPCC published its first assessment report. It warned: “emissions resulting from human activities are substantially increasing the atmospheric concentrations of greenhouse gases”. This led to widespread callsfor a global treaty. Prime Minister Margaret Thatcher addressed this second world climate conference. She praised the IPCC’s work as a “remarkable achievement”, and called for countries around the world to work together to “negotiate a successful framework convention on climate change by 1992”.

In the UN General Assembly 9 May 1992, the Convention was adopted and opened for signatures a month later at the UN Conference on Environment and Development (the Earth Summit) in Rio de Janeiro, Brazil. There were 197 Countries present. Prior to this, in 1987, the Montreal- Convention was held to reduce green gases in the atmosphere was signed by 154 nations. And yet climate change sceptics are still loudly voicing their denials.

The United Nations Framework Convention on Climate Change, (UNFCCC) in 1992 was signed by 154 nations.

The Kyoto Protocol, which was signed in 1997 and was adopted in 2005, was the first extension and it was superseded by the UNFCCC.

Paris Agreement, which entered into force in 2016. As of 2020, the UNFCCC has 197.The 2007 Bali Action Plan launched talks aimed at a new agreement providing for the UNFCCC’s “full, effective and sustained implementation”. The agreement was to be adopted at (Conference of People – COP) COP-15 in Copenhagen in 2009. More than 100 world leaders attended the Copenhagen summit, but negotiators were unable to overcome their differences, later the Copenhagen Accord was proposed, but a handful of countries objected, keeping it from being formally adopted by the COP.

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Australia (A)



Forest Fire (B)



Flooding in USA (C)



Antarctic melting ice (D)

**Fig. 1.** Effects of climate change.**Table 1.** Top 10 most destructive in California wildfires.

Rank	Fire Name & Cause	Date	County	Acres	Structures	Deaths
1	Camp Fire (Power lines)	November 2018	Butte	153 336	18 804	85
2	Tubbs (electrical)	October 2017	Napa & Sonoma	36 807	5636	22
3	Tunnel-Oakland Hills	October 1991	Alameda	1600	2900	25
4	Cedar (Human related)	October 2003	San Diego	273 246	2820	15
5	North Complex*	August 2020	Butte, Plumas & Yuba	318 930	2,352	15
6	Valley (Electrical)	September 2015	Lake, Napa & Sonoma	76 067	1955	4
7	Witch (Power lines)	October 2007	San Diego	197 990	1650	2
8	Woolsey*	November 2017	Ventura	96 949	1643	3
9	Carr (Human related)	July 2008	Shasta County & Trinity	229 651	1614	8
10	Glass Fire*	September 2020	Napa & Sonoma	67 484	1520	0

*Number is not final.

At COP-16 the following year in Cancun, parties adopted the Cancun Agreements which effectively formalized the essential elements of the Copenhagen Accord under the UNFCCC. The Cancun Agreements were regarded as an interim arrangement leaving the door open to further negotiations toward a legally binding successor to the Kyoto Protocol.

At COP-17 in Durban, South Africa, the Durban Platform for Enhanced Action was adopted, launching talks aimed at achieving a comprehensive new agreement starting in COP-20.

World leaders met once again at COP-21 in Paris, and on December 12, 2015, parties adopted the landmark **Paris Agreement**. The agreement represents a hybrid of the “top-down” Kyoto approach and the “bottom-up” approach of the Copenhagen and Cancun agreements. It establishes common binding procedural commitments for all countries, but left it to each to decide its nonbinding “nationally determined contribution” (NDC). The agreement establishes an enhanced transparency framework to track countries’ actions, and calls on countries to strengthen their NDCs every five years.

COP-2020 in Glasgow has been postponed due to Covid-19 to November 2021.

This brief history indicates that since 1972 till 2021, nearly 49 years have passed without any binding commitment to totally stop emitting CO₂ globally.

At this point there is no universal agreement as to the deadline date to stop CO₂ emission. For instance, China,

India, Brazil and US are proposing 2050 as the deadline. The UK has proposed 2035. Notwithstanding these deadlines it takes at least 20 years to stabilize the global temperature rise to less than 2 °C.

It is now indisputable that climate change and global warming are happening and they are happening on a vast scale that we cannot ignore. In many parts of the world the situation is causing blackouts, more than 3000 self-ignited fires are happening per year, glaciers are melting faster than predicted and flooding is happening everywhere. In the Antarctic sea-ice has been melting at an alarming rate and shrank by 1,463 km² between 2010 and 2016, [Figure 1](#).

Many UN meetings in the last three decades have warned of the dangers of global warming and have urgently called for carbon emissions to be significantly reduced. Targets have been set, targets have been agreed, targets have been cut back and targets have been ignored. Yet the economic and social costs, and environmental dangers have increased. Global warming has accelerated while it has been disputed or ignored. Those who pay the price are the elderly, the young, and mostly the poor.

There have been numerous examples in the last 100 years of the consequences of ignoring scientific research and advice. Hence the consumption and trade in wild life meat gave rise to the AIDS and Covid-19 pandemic, many thousands of people died from lung cancer caused by smoking despite the warnings from medical researchers before society took notice, [\[1\]](#) and [\[2\]](#). It is the same with climate change, renewable energy proponents,

environmentalists, biologists, botanists, geologists, and economists have all been warning of the disastrous impact of the continuing use of fossil fuels. For far long they have been ignored mostly by powerful financial and political institutions intent on preserving the status quo whereby money and not human welfare was the major goal.

In 2019: In 2019 there were 50 477 wildfires compared with 58083 wildfires in 2018, according to the National Interagency Fire Center (NIFC). About 4.7 million acres were burned in 2019 while there were 8.8 million acres burned in 2018, [3]. **Table 1** shows the worst 10 examples of self-ignited fire in California up to October 2020 [4].

At the start of February, Storm Ciara hit the UK with gusts of up to 97mph with torrential rain, causing electricity outages, flooding and travel chaos across the country with at least 20 000 homes left without power [4] (**Fig. 2**). In Baghdad in the 5th of August, 2020 a boy can only cool himself by jumping into the river Tigris because the daily temperature reached 50°C [5] (**Fig. 3**).

In the UK 35 °C is a heatwave. Temperature of 40 °C used to occur once every two centuries, then from 1990 to 2016 it occurred every fifteen years, now the prediction is that it will happen every 3-years.

According to the National Geographic [6]: “While land degradation has occurred throughout history, the pace has accelerated, reaching 30–35 times the historical rate,



Fig. 2. Storm Ciara, February 2020, UK.

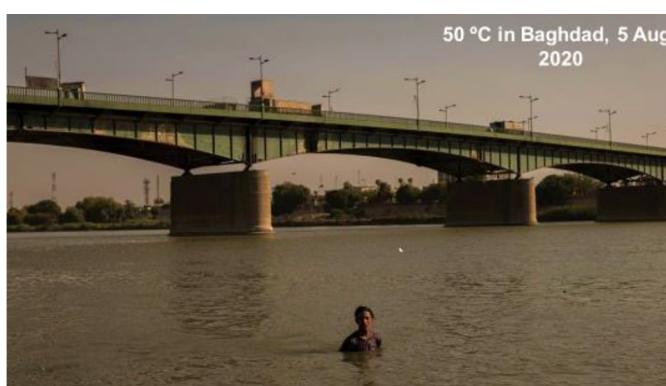


Fig. 3. Global temperature rise UK sun having 40°C.

according to the United Nations. This degradation tends to be driven by a number of factors, including urbanization, mining, farming, and ranching. In the course of these activities, trees and other vegetation are cleared away, animal hooves pound the dirt, and crops deplete nutrients in the soil. Climate change also plays a significant role, increasing the risk of drought”. See **Figure 4**.

Lake Chad - a source of water to millions of people in West Africa has shrunk by 90% since the 1960s due to climate change, population growth and irrigation, due to climate change, an increase in the population and unplanned irrigation [7].

1.1 World renewable energy combatting climate change

It has to be clarified that all forms of renewable energy lead to a certain degree of carbon emission due to manufacturing processes, see **Figure 5**.

2 Geothermal energy

“Geothermal is tapping the earth heat at different depth. The deeper you drill the hotter layer you will reach. Heat has been radiating from the center of the Earth for some 4.5 billion years. At 6437.4 km (4000 miles) deep, the center of the Earth has around the same temperatures as the sun’s surface, 9932 °F (5500 °C). Scientists estimate that 42 million megawatts (MW) of power flow from the Earth’s interior, primarily by conduction. Geothermal energy is a renewable resource. One of its biggest advantages is that it is constantly available. **Figure 6** shows the top ten countries in geothermal energy” [8]. The amount of geothermal energy generated globally will rise from 16 GW in 2020 to an estimated 24 GW in 2025 [9].

In the USA, the Geysers Geothermal Complex located about 121 km north of San Francisco, California, is comprised of 18 power plants making it the biggest geothermal installation in the world. The complex has an installed capacity of 1517 MW and active production capacity of 900 MW, See **Figure 7**.

3 Hydropower progress

Hydropower generation at the end of 2019 is 1308 GW, without inclusion of mini hydro [11]. It is expected to remain the world’s largest source of renewable electricity generation



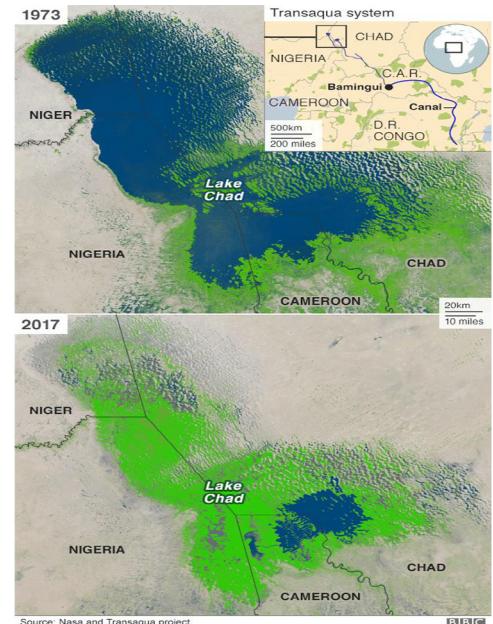


Fig. 4. Desertification in Tibet and Africa [6].

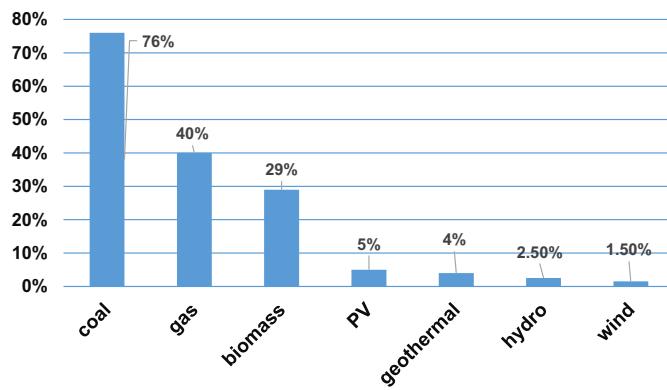


Fig. 5. CO₂ emission and imbedded carbon of all power generation sources.

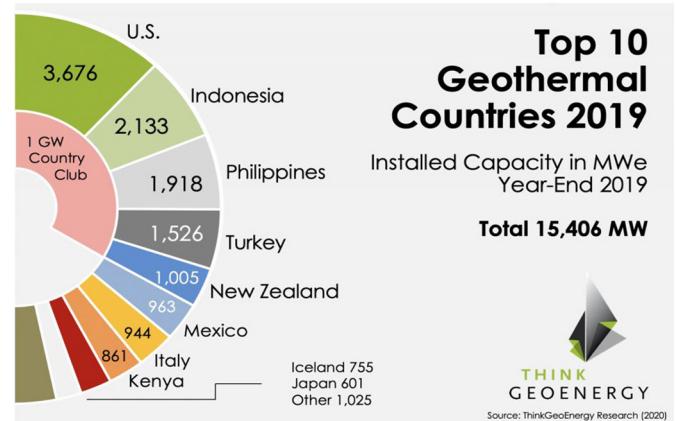


Fig. 6. The Top 10 Geothermal Countries 2019—installed capacity in MW.

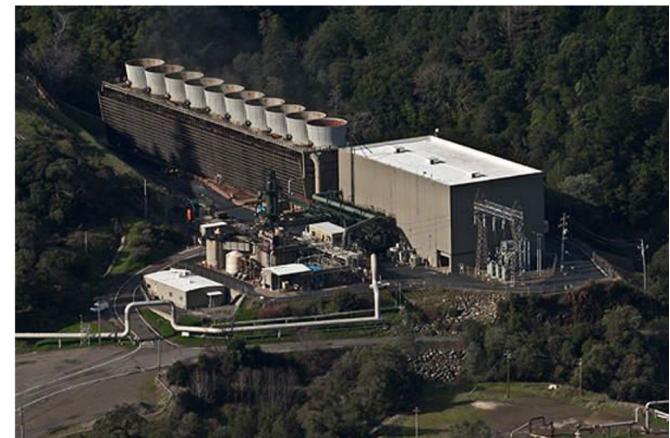


Fig. 7. USA, the Geysers Geothermal Complex [10].

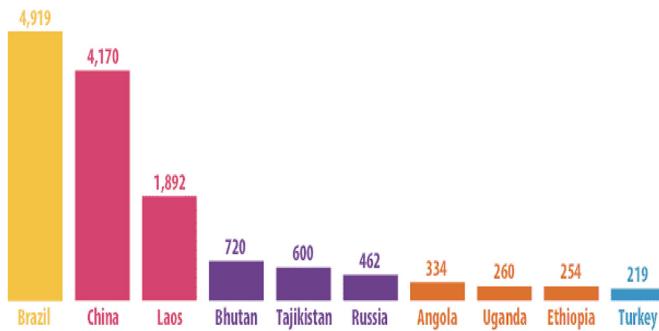


Fig. 8. Top ten countries added new Hydropower installations, (TWH), to their records, [12]. This is a rise of 1.2% per year.

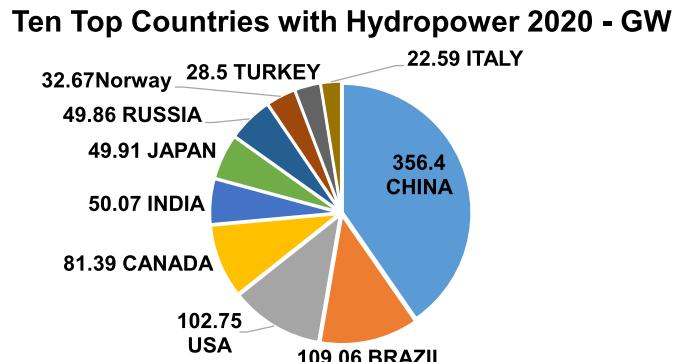


Fig. 9. The top 10 countries with hydropower in the world [14].

Table 2. Hydropower in the Middle East and North Africa.

Country	Turkey	Iran	Egypt	Iraq	Syria	Lebanon	Morocco	Israel
Power MW	28 500	10 500	2800	2500	2100	1900	1770	800

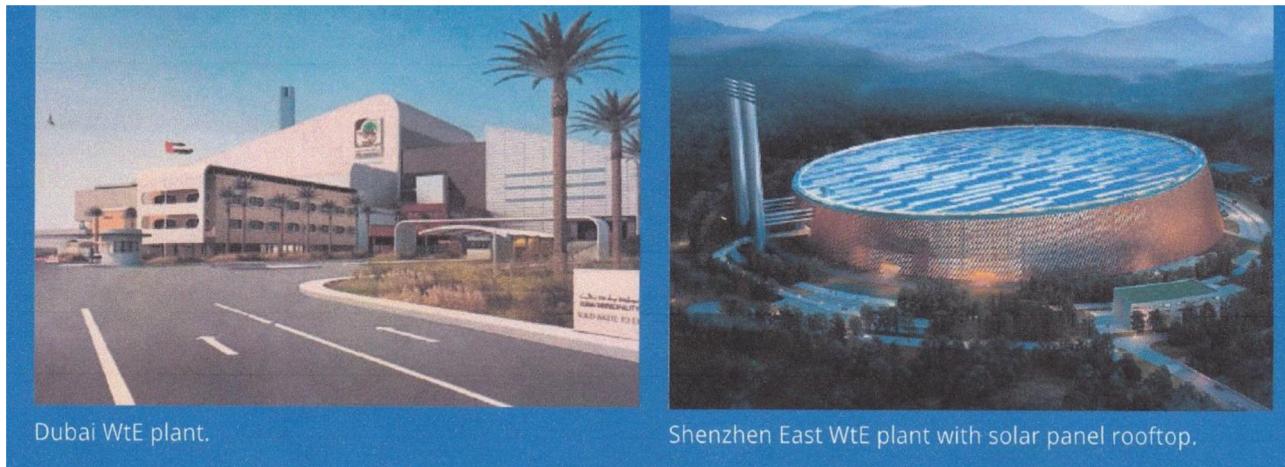


Fig. 10. Dubai WtE largest plant and Shenzhen – East largest plant with PV on top [18].

and play a critical role in reducing emission while supplying electricity to many parts of the world. Hydropower capacity increases forecast to be led by China, India and Brazil.

Hydropower capacity expected to increase in China, India and Brazil despite concerns over its social and environmental impact. Figure 8 gives a breakdown of national hydropower installations in ten countries (Fig. 9).

3.1 Mini-hydropower

There are two types of mini-hydropower, those less than 1 MW which represent 20% of all mini hydro and those greater than 1 MW but less than 10 MW account for 80% of mini hydro. The role of mini hydro is often overlooked, its market size was 170 GW in 2018 and is expected to reach 214 GW at the end of 2026 [13].

Table 2 shows hydropower situation in the Middle East and North Africa [15].

3.2 Biomass and biogas and waste to energy

Wood fuel, is a carbon neutral resource and can make a significant contribution to reducing climate change, however wood fuel particulates have a negative impact on pollution. Plants absorb 30% CO₂ with the help of sunlight and photo synthesis, they will grow and reduce emissions. One of the benefits in cold climate countries is to use biomass community heating schemes utilizing wood boilers. Biogas plants use agricultural and agro-industrial waste, animal manure and waste water. When sourced from sustainably managed forests, switching from coal to biomass brings substantial environmental benefits.

Table 3. Power generation from 1615 plants of WtE in major 11 Countries.

No	Country	Number of plants	Million tonnes/day	Power MW
1	China	286	5	154.55
2	USA	77	30	927.27
3	UK	46	10	309.10
4	France	126	14	432.74
5	Austria	65	4	123.64
6	Sweden	34	6	185.46
7	Germany	121	26	803.66
8	Italy	41	6	185.46
9	Japan	754	30	927.27
10	South Korea	35	5	154.55
11	Switzerland	30	4	123.64
Total		1615	140	4327.34

Lifecycle emissions of carbon dioxide, a greenhouse gas, are reduced 74–90% and emissions of other pollutants such as lead, mercury and arsenic are also reduced or eliminated.

According to “S. Ladanai and J. Vinterbäck – Report 013, ISSN 1654–9406, Uppsala, Sweden, 1970” [16]: “It is the fourth largest energy source after coal, oil and natural gas – is the largest and most important renewable energy option at present and can be used to produce different forms of energy. Moreover, compared to other renewables, biomass resources are common and widespread across the globe. The annual global primary production of biomass is equivalent to the 125×10^{10} GW of solar energy captured each year. If one take 5% of this power, or 6.25×10^{10} GW. This should cover more than 50% of the world’s total primary power demand. The potential for energy from biomass depends in part on land availability. Assuming, the amount of land devoted to growing energy crops for biomass fuels is only 0.19% of the world’s total land area and only 0.5–1.7% of global agricultural land. Biomass potential for energy production is very large”.

According to IEA [17], power generation from biomass end of 2019 was 68.5 GW, and expected to reach 137 GW by 2030.

The World’s largest waste to energy (W-t-E) plants are in Shenzhen, China and in the United Arab Emirates – Dubai. They were finished in 2020 and each plant can process 5500 tonnes of waste per day (Fig. 10).

Dubai plant capacity is 185 MW, producing 2% of Dubai annual energy consumption, while the Chinese in Shenzhen East has a capacity of 165 MW, handling one third of the city’s waste.

If one converts the W-T-E plants in the major eleven countries to power as in Table 3, they will produce more than 4.300 GW. By the end of 2019, there were 2450 plants globally using 368 million ton a year. Each ton of waste produces 550 kWh. Therefore in 2019, W-t-E equivalent to 23.1 GW. Combining Biomass and W-t-E, they generated: **91.6 GW**.



Fig. 11. Anaerobic digesters in the UK.

3.3 Anaerobic digestion (AD)

This is a process by which organic material is broken down by micro-organisms in the absence of oxygen, producing biogas, a methane-rich gas used as a fuel, digestant, or a source of nutrients as fertilizer. The process normally takes 15–30 days for the organic waste to be processed by an AD plant. The biogas created in sealed tanks and it is used to generate electricity or heat with a combined heat and power unit (CHP). The bio-fertilizer is pasteurized to make it pathogen free and can be applied twice a year on farmland, successfully. The technology is widely used to treat wastewater and can also be effectively employed to treat organic wastes from domestic and commercial food waste, to manures and biofuel crops, see Figure 11 [19]. In UK There are 473 operational anaerobic digestion plants, and a 327 are under development [20].

4 Solar thermal

The most effective way of using the sun is directly in heating. Solar water heaters have been used since the Babylonian times in Iraq. If one study the solar radiation intensity globally, then the area of Middle East and North Africa, MENA Region, are the richest in the sun than rest of the globe, See Figure 12.

In the early stages of solar water heaters development the absorbing surface was painted black which absorbs 100% of the solar radiation but also emits 100% of it back to the atmosphere. Not until 1946 were selective coatings (Chemical) were invented which when applied to a surface absorb 100% of the solar radiation but emit less than 10% to the atmosphere. Figure 13 shows some of the modern collectors.

In 2019, solar thermal systems globally produced 479 GW thermal. This equates to 43 million tons of oil saved and 138 million tons of CO₂ emissions avoided [22].

A major example of low-temperature flat plate collector system is the 27.5 MWth at Codelco mining company’s Gaby copper mine in northern Chile, Figure 14. It is the largest such system in service so far: it has 39 300 m² of flat-plate collectors and 4000 cubic metres (m³) of thermal energy storage, and supplies 85% of the process heat needed to refine copper [23].

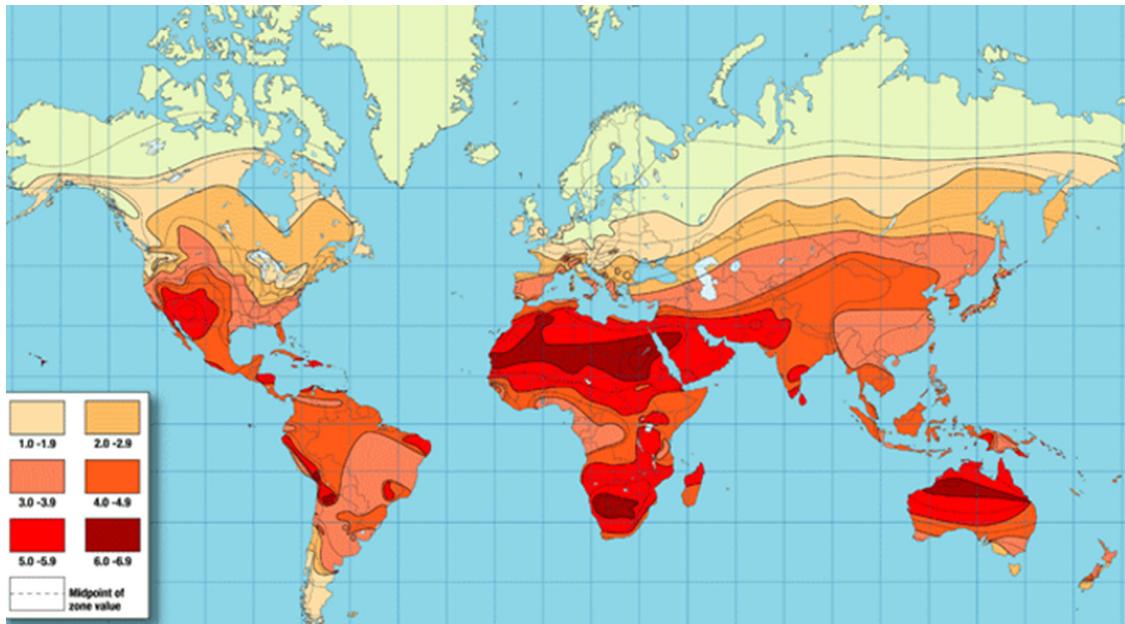


Fig. 12. Solar radiation globally- kWh/m².

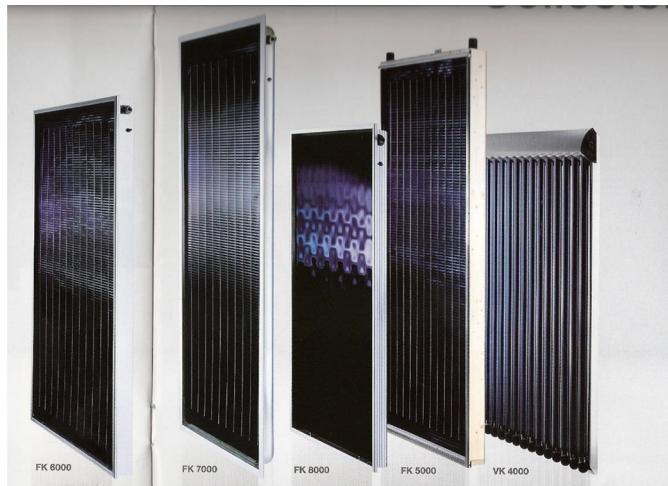


Fig. 13. Some of the recent flat plate collectors made by an Austrian Company [21].

4.1 Concentrating solar power – CSP

Concentrated solar power, (CSP) had a global total installed capacity of **6451 MW in 2019**. Spain accounted for almost half of the world's capacity, at 2300 MW. The United States follows with 1740 MW, then Morocco has 1320 MW, China has 715 MW, Dubai has 700 MW, Chile has 210 MW, India has 125 MW, South Africa 100 MW, and Saudi Arabia has 25 MW. An example of CSP is that of Morocco, Ourzazate solar complex having 410 MW of CSP power and 10 MW of PV capacity, see [Figure 15](#) [24].

Solar thermal applications globally are estimated at more than 700 GW thermal, this is equivalent to power of 280 GW if a 40% converting factor is used.



Fig. 14. Chile cooper mining heat process.



Fig. 15. Moroccan Ourzazate solar complex.

5 Photovoltaic technology- PV

In the last 50 years the development of PV technology has advanced considerably, while the cost has reduced more than a hundredfold. Thus PV has become a viable every day source of energy, see [Figures 16 and 17](#) [25].

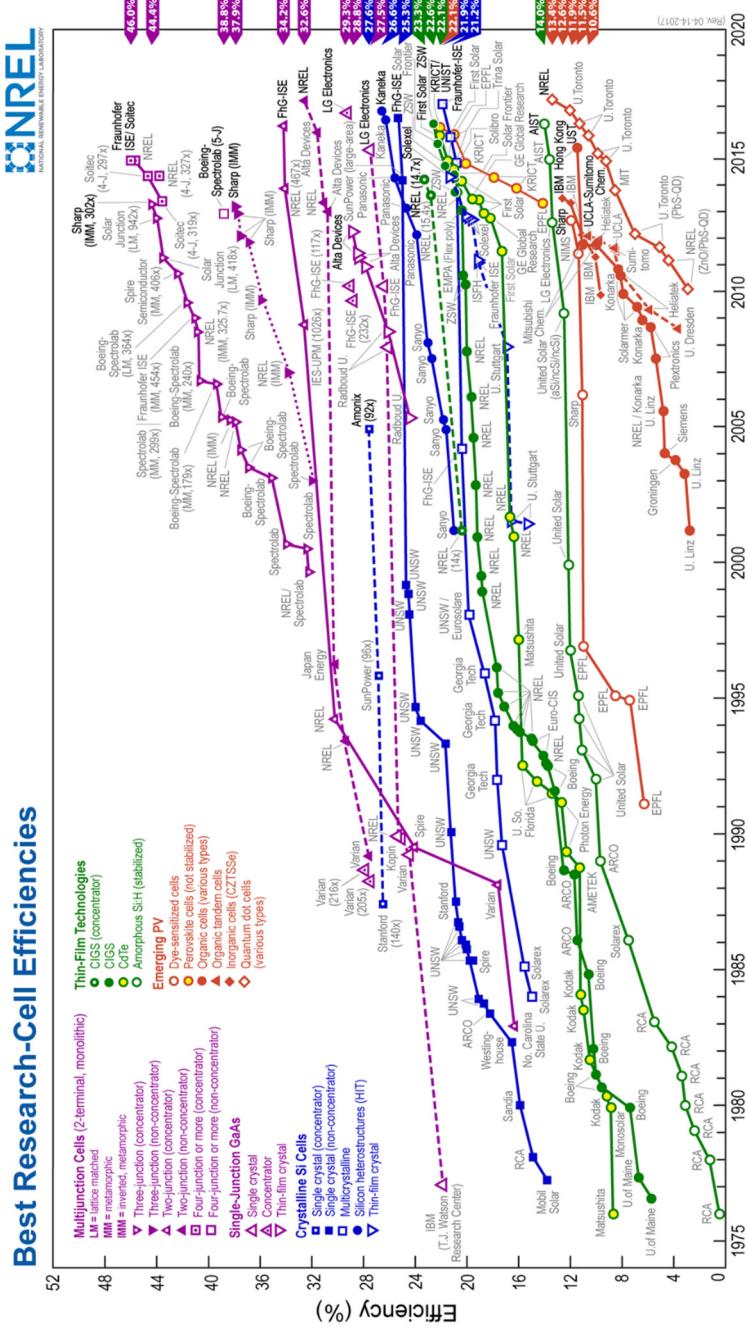


Fig. 16. Cells efficiency improvement with time.

Some of the largest PV systems in the world are: Longyangxia Dam Solar Park, China, 850 MW. Spread over 25 km², and consists of 4 million solar panels. And it was completed in February 2017. It is located in the Qinghai province of China. The park generates around 220-gigawatt hours of electricity per year, which is the equivalent of powering 200 000 households [26]. An other is 1000 MW Kurnool Ultra Mega Solar Park, in India. Selected countries with PV installation in GW size, (Tab. 4).

A more recent development for PV is floating PV systems on reservoirs, lakes and sea. It normally, dearer than used on land, but it has the advantage of utilizing unused space and will be less dust on the covers than on land. One of the biggest floating PV farm is in China, see Figure 18.



Fig. 17. A very large PV farm, Longyangxia Dam Solar Park in Qinghai province – China.

Table 4. Selected countries with Photovoltaic capacity at the end of 2019.

No.	Country	PV-GW	No.	Country	PV- GW
1	China	200	7	Australia	14.6
2	USA	115	8	United Kingdom	13.3
3	Japan	54	9	South Korea	11.2
4	Germany	49.2	10	France	9.9
5	India	42.8	11	Spain	8.4
6	Italy	20.8	12	Rest of the World	113.2

Table 5. Generating electricity per installed PV (kW) in some locations.

Country & City	kWh/kW	Country & City	kWh/kW
Abu Dhabi – UAE	1635	China – Beijing	1148
Egypt – Cairo	1635	USA – Washington	1133
South Africa – Cape Town	1538	France – Paris	938
India – New Delhi	1523	Japan – Tokyo	885
U S A – Los Angeles	1485	Germany – Berlin	848
Mexico – Mexico City	1425	Russia – Moscow	803
Australia – Sidney	1343	UK – London	728
Brazil – Rio de Janeiro	1253		



Fig. 18. The 40 MW floating solar power plant at Huainan, China, is the world's largest. Enough to power a small town built June 2017 [27].



Fig. 19. A, B, and C are in Cologne – Germany. A- CIGS thin films, façade cladding testing, Project, Research Baden-Württemberg. C- A bridge in Germany, CIGS – thin films.

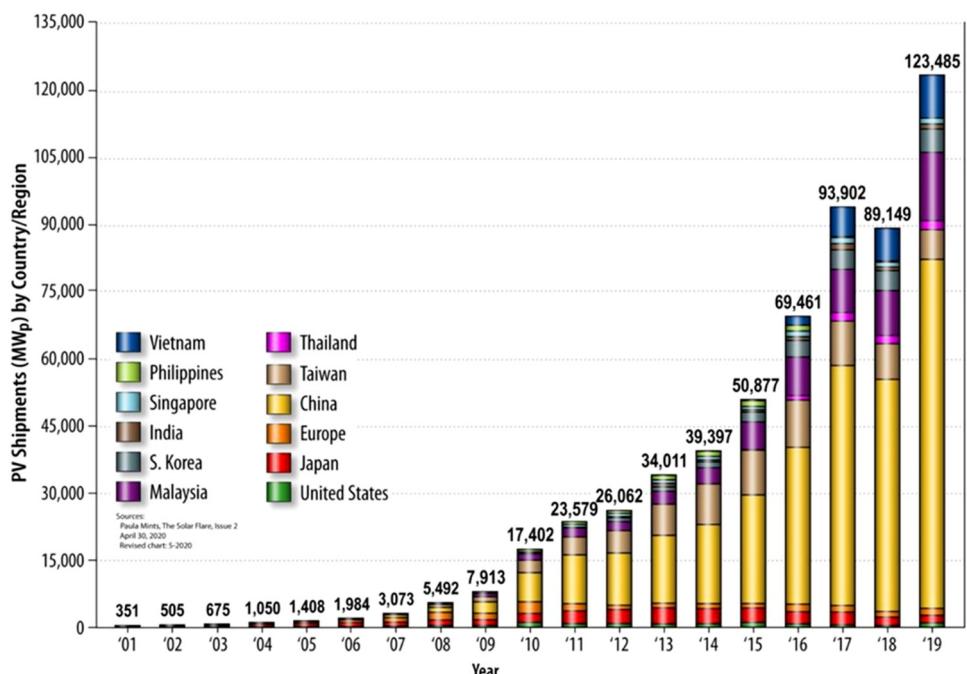
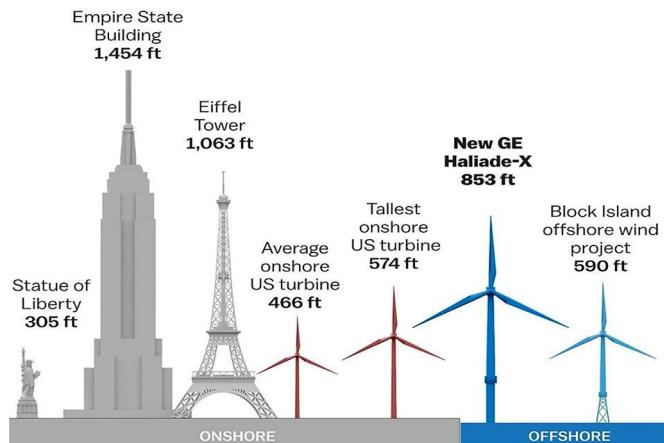


Fig. 20. PV Shipment 2019, World now has 583.5 GW of operational PV, 2020 [29].

Table 6. Below shows selected countries with Photovoltaic capacity at the end of 2019.

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How the Haliade-X compares

**Fig. 21.** Height comparison of turbines.

transmission and urgent necessity to combat climate change through fossil fuel final reduction. It is the cleanest form of energy.

Modern wind technology is based in two sectors: Onshore and offshore. Although there are other developments such as the floating wind mills and vertical axis wind mills and single blade mills.

The taller the turbine the better is the performance. 90% of all turbines are 3-bladed and the shape of the blade is like an airplane wing. Figure 21 shows the future height of hubs of wind turbines in comparison with existing structures in the US in particular the Haliade-X which will be ready in 2021 [30].

One of the largest onshore wind farm in the UK is **Whitelee Wind Farm**. It has 215 Siemens and Alstom wind turbines and a total capacity of 539 (MW), with the average of 2.5 MW per turbine, see Figure 22. Another large on-shore wind farm is Alta Wind Energy Centre (AWEC) in Tehachapi, Kern County, California. with capacity of 1550 MW, with 586 machines of varying sizes 1.5–3.0 MW, See Figures 23 and 24.

United Kingdom is leading the world in off-shore wind farms. In total UK has wind power capacity of 60.0, and 8 GW from offshore farms. The largest wind farm off-shore in the UK is Walney Extension (Orsted) of 659 MW from 87 turbines of varying height and capacity. It supplies power to almost 600 000 homes.

Recently in 2018, EON completed 400 MW off – shore wind farm in Brighton, supplying electricity 1400 GWh per year to more than 350 000 homes, saving 600 000 tons of CO₂ a year. The farm consists of 116 MHI Vestas 3.45 MW turbines height is 140 m and blade length is 55 m, see Figures 25–27.

The cost of electricity from wind energy is one of the lowest so far compared to other forms of renewable energy. In Brazil it is US\$ 20.8 per MWh, while in Denmark it is US \$ 22.8 per MWh. In Saudi Arabia's first commercial wind farm, the 400 MW Dumat Al Jandal wind farm, 1 MWh was at US\$ 19.9.

6.1. The total world capacity at the end of 2020 is 719 GW

6.1.1 Electric cars – EV

Electric car sales have soared globally. Only about 17 000 electric cars were on road in 2010. By 2019, that number had swelled to 7.2 million, 47% of which were in China. Nine countries have more than 100 000 electric cars on the road. At least 20 countries reached market shares above 1%, see Figure 28 [32]. EV emissions are 50% of those from conventional cars.

6.2 PV EV Charger

6.2.1 NORWAY setting example in europe

Norway has declared that by 2025 there will be no fossil fuel transportation. There are 2.8 million vehicles, 260 000 are electric cars. Norway has 90% of its power comes from hydro.

One of the difficulty in manufacturing EV cars is requiring expensive and rare metals – Cobalt which the Congo produces 60% of the world Cobalt. Another environmental problem is how to get rid of old batteries [33].



Fig. 22. UK, On-shore wind farm, 539 MW.



Fig. 23. US largest on-shore wind farm, 1550 MW.

The recognition of the urgent necessity to combat climate change is driving researchers into areas of electric planes and other forms of transports.

Recently in May 2020, British Government introduced its New Green Policy. It outlined 10 sections [34]:

- Offshore wind growth – 40 GW by 2030.
- Hydrogen investment – 5 GW, by 2030, £500 m.
- Nuclear will have £525 m. to Breeder reactor, research
- Ending the use of Petrol & Diesel Cars by 2030, Hybrid cars end by 2035. All Electric, £1.3 billion Charging Stations.
- Public transport, cycling and walking: Investment of £5 billion.
- Jet Zero and greener maritime: Investment of £20 m
- Homes and public buildings: Stopping connection to the gas grid by 2023, extend the Green Homes Grant by 12 months, aiming to create 50 000 jobs by 2030, and a headline target to install 600 000 heat pumps every year by 2028.
- Carbon capture: Investment of £200 m aiming to remove 10 MT of Carbon Dioxide by 2030.

- Nature restoration: Reconfirming commitment to plant 30 000 hectares of trees every year.
- Also creation of new national parks and nature reserves.
- Innovation and finance: A target to make the City of London the global centre of green finance.

The Global use of Renewable Energy is shown in Chart of [Figure 28](#). Hydropower includes small hydropower which are less than 10 MW but greater than 1 MW. In solar thermal, CSP is included. Also the thermal power was converted to electric power with 40% efficiency. In biomass and biogas, waste-to-energy is included, see [Figure 28](#) [35].

7 Conclusions

It is paramount importance to tackle climate change by reducing or eliminating all fossil fuels in our daily life. We must reshape our thinking about the way we function. We must actively involve in energy conservation, efficiency and management. We should recycle materials, use waste to energy, and construct our buildings using materials. Such as wood and timber which are have less carbon imbedded, use natural ventilation, use plants for shading and utilize natural lighting, improve public transport with the introduction of EV and hydrogen fuel.

Renewable energy for electricity should be used, heating, cooling, agriculture, transport and industry. We must rationalize the use of food and water since world population presently is 7.8 billion and will be 10 billion in 2050.

If we try to assess renewable energy progress by the end of 2020, then starting with global electricity generation capacity which is **3082.2 GW** [35], then Assuming 50% of all renewable energy present potential is used for electricity power generation, this is 1633.25 GW, which is nearly 53%. Although we must not be complacent until we have all our energy produced by using renewable energy.

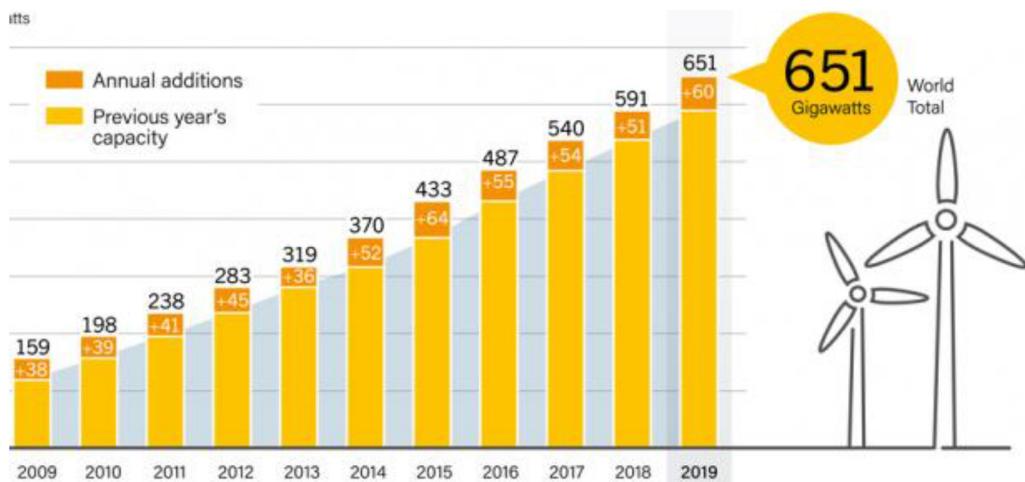


Fig. 24. Global wind energy capacity 2009–2019, in GW [31].



Fig. 25. Rampion Wind Farm Brighton, UK.

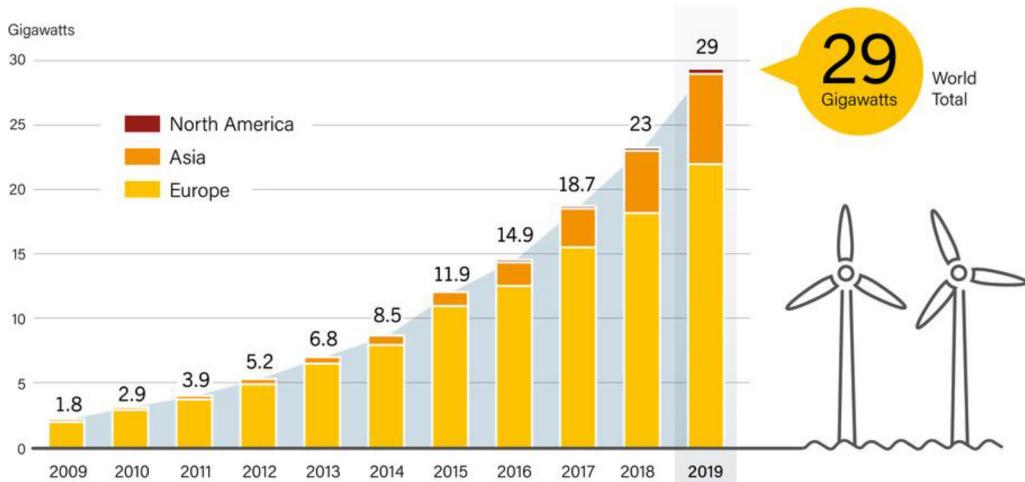


Fig. 26. Global offshore Wind Capacity in three regions 2009–2019.

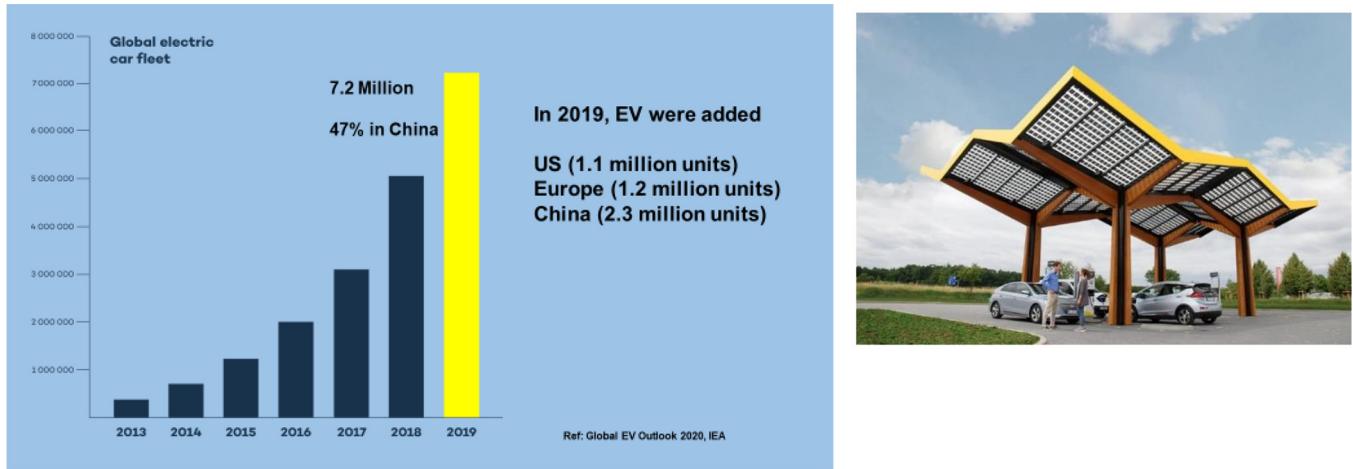


Fig. 27. Global offshore Wind Capacity in three Regions 2009–2019.

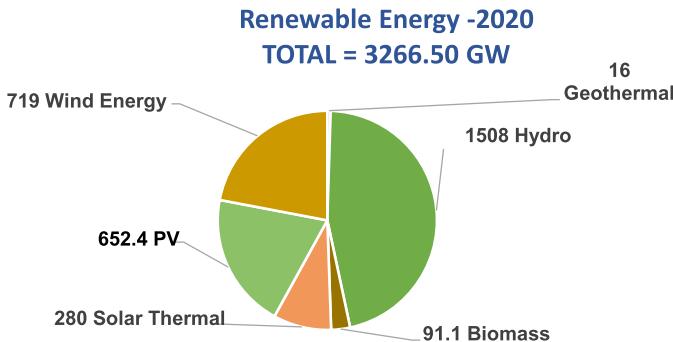


Fig. 28. Global Renewable Energy end of 2020.

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