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Comprehensive Study of Different Renewable Energy Resources such as Hydro Energy, Solar Energy and Wind Energy

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ABSTRACT- Depletion of fossil fuel resources is the main cause of hike in fossil fuel price which lead to concern for alternate resources of energy such as nuclear energy, renewable energy resources but Fukushima Daiichi accident was a turning point in the call for renewable energy. Now it is considered that renewable energy resources are more desirable source of fuel than nuclear power due to the absence of risk and disasters. In order to meet challenges, future energy policies should put more emphasis on developing the potential of energy sources, which include hydro energy, solar energy biofuel energy, wind energy all these comes under renewable energy resources. By replacing fossil fuels with renewable energy sources Co_2 emission in environment can be reduced which is the main factor for greenhouse gas effect. In this paper, the alternative resources of renewable energy are studies.
Keywords: Energy resources, green energy, renewable energy, GHGs, Co_2

1. Introduction

Conventional energy sources such as oil, coal, and natural gas have proven to be highly effective for industrial revolution but at the same time emissions from such sources have harmful effect on our environment and responsible for global warming and consequent climate change since the major component of greenhouse gases (GHGs) is Co_2, there is a global concern about reducing carbon emissions.

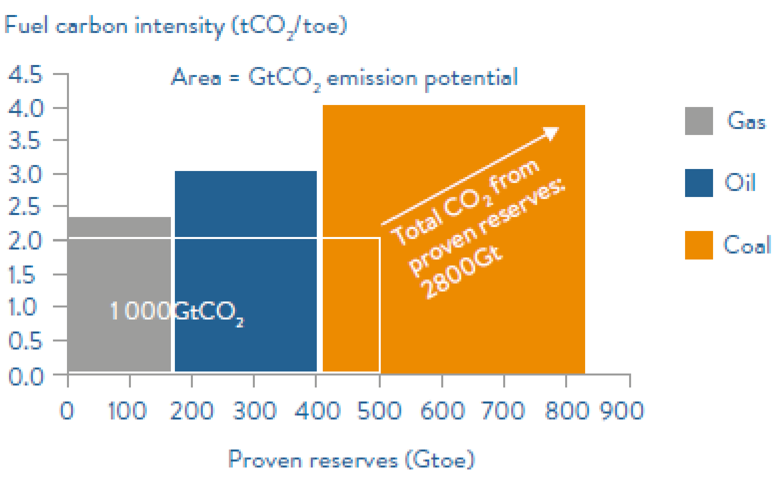

Figure 1: Co_2 emission potential of fossil fuel

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In this regard, different policies could be applied to reduce carbon emissions, and focus on renewable energy development and encouraging technological innovations. In addition, supporting mechanisms, such as feed-in tariffs, renewable portfolio standards and tax policies, are employed by governments to enhance the renewable energy generation. Countries of the EU such as Denmark, Germany, Austria and Spain as well as China have already demonstrated the impressive pace of transition which can be achieved in renewable energy deployment, if the right policies and frameworks are in place. According to IEA (2012d) two significant global trends have been observed the deployment of renewable technologies. First, as renewable electricity technologies hike, from a total global supply of 1,454 gigawatts (GW) in 2011 to 2,167 GW in 2017, they should also spread out geographically. Second, the more recent years of high fossil fuel energy use has led renewable technologies to become increasingly competitive on a cost basis with their alternatives in a number of countries and circumstances. According to IEA data, wind is the most competitive type of renewable energy technology as compared to other options, if local conditions such as financing, CO2 emission levels and fossil fuel prices prove favorable (OECD, 2010)

According to world energy council Solar and wind energy account for only 4% of power generation in 2014, but by 2060 it will account 20 % to 39 % and Fossil fuel share of primary energy has shifted just 5% in the last 45 years from 86% in 1970 to 81% in 2014. To 2060, the momentum of new technologies and renewable energy generation results in the diversification of primary energy. Fossil fuel share of primary energy will fall to 70% by 2060 in Hard Rock, 63% in Modern Jazz, and 50% in Unfinished Symphony.

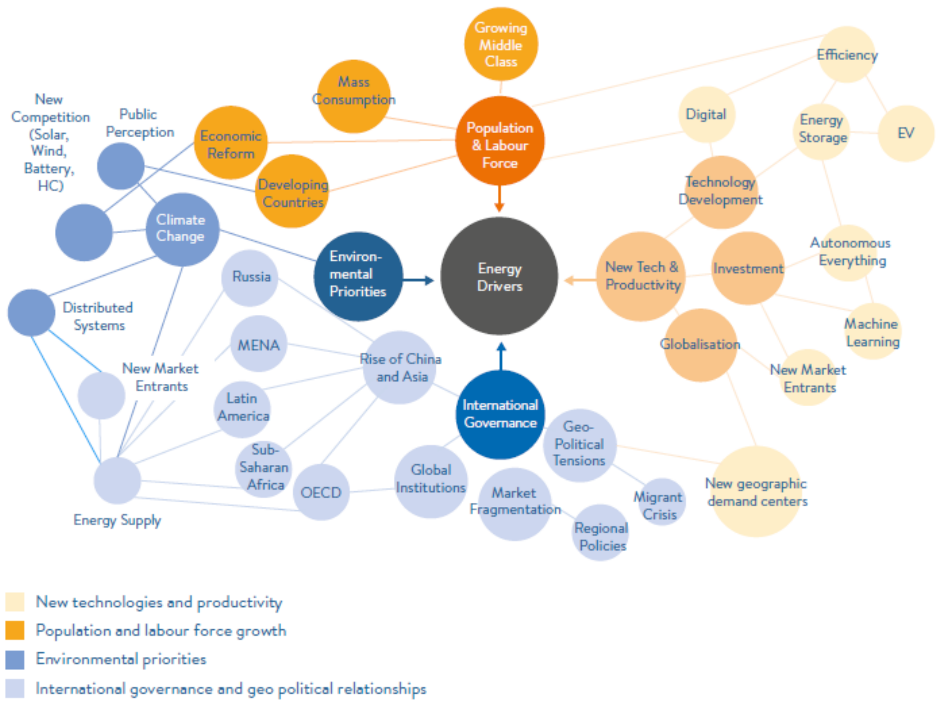

Figure 2: Factor that shaped world energy

The possible future contribution of various renewable energy technologies which should remain the first priority (solar, wind, hydro, biomass, geothermal) is shown in Figure 3.

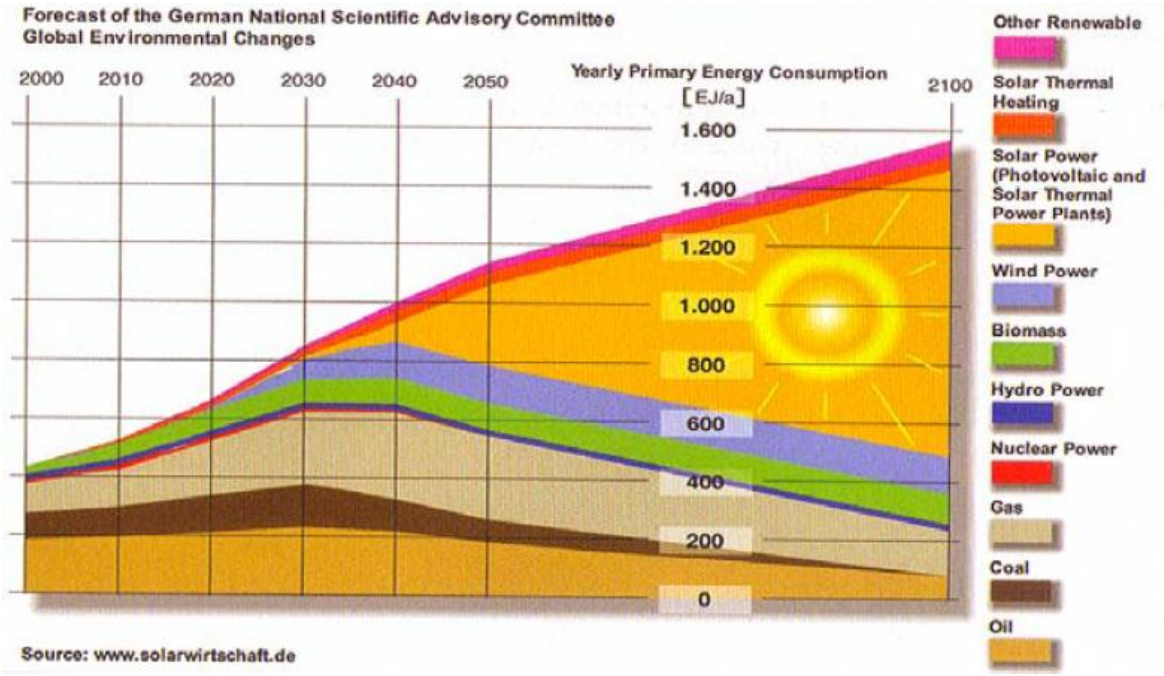

Figure 3: The possible future contribution of various renewable energy

From figure 3 it can be say that upcoming future is for solar energy, hydro energy and wind energy

2.1 Solar Energy

Solar cells are used to convert sunlight into electricity, using sunlight hitting solar thermal panels to convert sunlight to heat water or air, using sunlight hitting a parabolic mirror to heat water (producing steam), or using sunlight entering windows for passive solar heating of a building. It would be advantageous to place solar panels in the regions of highest solar radiation. During the two last decades, the economic feasibility of solar power for residential, commercial and industrial consumption has been investigated by researchers. Industrial countries like Japan and Germany are looking for alternative sources of energy such as solar power due to the limited availability of natural primary energy sources recently India has developed an extensive solar power capacity due to cheap labor and government subsidies, in turn, decreasing the cost of solar power generation. China is leading the solar power generation with total installed capacity exceeding 100 GW

Following two technologies are used to generate solar power

- Photovoltaic (PV) systems use solar panels, either on rooftops or in ground-mounted solar farms which convert directly sunlight into electric power.

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- Concentrated solar power (CSP) also known as "concentrated solar thermal plants use solar thermal energy to make steam that is thereafter converted into electricity by a turbine

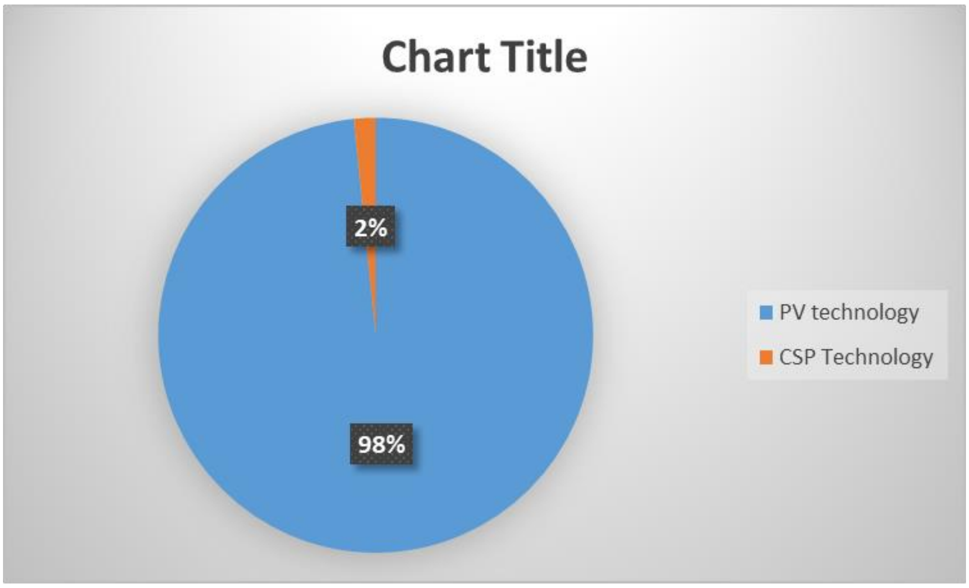

Figure 4: Worldwide electric capacity of solar_power by PV and CSP technology in 2016

Worldwide growth of photovoltaics is extremely dynamic and varies strongly country to country. By the end of 2016, cumulative photovoltaic capacity increased by more than 75 gigawatt (GW) and reached at least 308 GW, sufficient to supply 1.8 percent of the world's total electricity

Table 1: National CSP capacities (GW) in 2016 according to REN21 global status report 2017

Nation	Total Power (GW)	Added Power (GW) in 2016
SPAIN	2.30	0
UNITED ATATE	1.738	0
INDIA	0.225	0
SOUTH AFRICA	0.2	0.100
MOROCCO	0.18	0
UAE	0.1	0
ALGERIA	0.025	0

EGYPT	0.02	0
AUSTRALIA	0.012	0
CHINA	0.010	10
THAILAND	0.005	0

According to IEA report 2016 China top in both total PV capacity and added PV capacity in 2016. Data for first 35 countries with total PV and added PV capacity is compiled in Table 2

Table 2: National PV total installed and added capacities (GW) in 2016

Sr. No:	NATION	TOTAL CAPACITY (GW)	ADDED CAPACITY (GW)
1	CHINA	78.07	34.54
2	JAPAN	42.75	8.6
3	GERMANY	41.22	1.52
4	UNITED STATE	40.3	14.73
5	ITALY	19.28	0.37
6	UK	11.63	1.97
7	INDIA	9.01	3.97
8	FRANCE	7.13	0.56
9	AUSTRALIA	5.9	0.84
10	SPAIN	5.49	0.06
11	SOUTH KOREA	4.35	0.85
12	BELGIUM	3.42	0.17
13	CANADA	2.72	0.2

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14	GREECE	2.6	0
15	THAILAND	2.15	0.73
16	CZECH REPUBLIC	2.1	0
17	NETHERLAND	2.1	0.53
18	SWITERZERLAND	1.64	0.25
19	CHILE	1.61	0.75
20	SOUTH AFRICA	1.45	0.54
21	TAIWAN	1.38	0.37
22	ROMANIA	1.3	0
23	AUSTRIA	1.08	0.15
24	BULGARIA	1.0	0
25	ISRAEL	0.91	0.13
26	PHILIPPINES	0.9	0.76
27	DENMARK	0.9	0.07
28	TURKEY	0.83	0.58
29	PORTUGAL	0.51	0.06
30	ALGERIA	0.35	0.05
31	MEXICO	0.32	0.15
32	MALAYSIA	0.29	0.05
33	SWEEDEN	0.18	0.06
34	NORWAY	0.027	0.011
35	FINLAND	0.015	0.010

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2.2 Hydro Energy

Hydropower is the leading renewable source for electricity generation globally, supplying 71% of all renewable electricity. Reaching 1,064 GW of installed capacity in 2016, it generated 16.4% of the world's electricity from all sources. Significant new development is concentrated in China, Latin America and Africa. Asia has the largest unutilized potential, estimated at 7,195 TWh/year, making it the likely leading market for future development. China accounted for 26% of the global installed capacity in 2015, far ahead of USA (8.4%), Brazil (7.6%) and Canada (6.5%). Hydro power is currently the largest renewable energy source for power generation around the world. Hydro electricity generation has had a strong increase over the past 50 years. It was 340 terawatt-hour (TWh) in 1950 which is around one-third of the global electricity demand. It increased to 1,640 TWh in 1980 and further there is historic increase in hydro power from 1980 to 1995 it is about 2700 TWh in 1995. Stagnation phase of hydro power start form 1996 and continue up to 2003. From 2004 increased development phase of hydro power start and it reached about 3950 TWh in 2015 as per IHA, IEA and World council for energy. Currently, hydro power development is difficult due to a large initial fixed investment cost and environmental concerns. Additionally, hydro power has caused problems for local residents associated with the need to relocate large populations, as well as the construction of dams is permanent with a sunk cost of utilities which cannot be removed. The environment is also influenced by hydro power construction because of large engineering works. On the other hand, hydro power is attractive due to a preexisting supply of water for agriculture, household and industrial use, and hydro power is clean and enables the storage of both water and energy. Also, the stored energy can be used for the application of both base-load and peak time power generation.

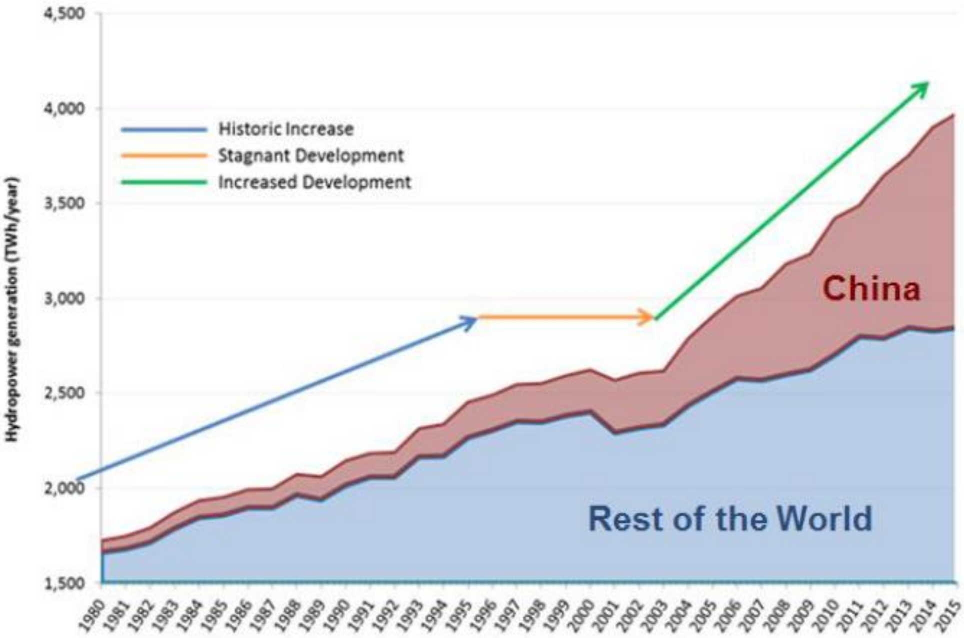

Figure 5: Global total hydropower generation since 1980

Table 3 shows the countries having the largest hydropower capacities in the world. In recent years China has taken centre stage for hydropower capacity, accounting for 26% of global installed capacity in 2015, far ahead of USA (8.4%), Brazil (7.6%) and Canada (6.5%). China has strengthened its dominant position by adding 19 GW in 2015, almost three times the new capacity of the next five countries combined

Table 3: Top six hydropower capacity as of 2015, by country

Country	Total capacity end of 2015 (GW)	Added capacity in 2015 (GW)	Total production (TWh)
CHINA	319	19	1126
USA	102	0.1	250
BRAZIL	92	2.5	382
CANADA	79	0.7	376
INDIA	52	1.2	120
RUSSIA	51	0.2	160

Source: REN21, IHA (2015)

Capacity additions in 2015 have strengthened China's lead, with new developments progressing at Baihetan (16 GW) and Wudongde (10.2 GW). Total capacity in China is expected to reach 350 GW of pure hydropower and 70 GW of pumped storage by 2020(China five year plan 2011-2015)

2.3 Wind energy

According to GWEC World wind power generation capacity has reached 486790 MW at the end of 2016, around 7% of total global power generation capacity. In 2016 54650 MW was added with an increase of 12.5 % compared to previous year. In 2015 global growth rate of 17.2% was higher than in 2014 (16.4%) With current policy plans, global wind capacity could rise from 435 GW in 2015 to 977 GW in 2030 (905 GW onshore and 72 GW offshore wind). The global wind power leaders as at end-2016 are China, United States, Germany. According to WEC report installed capacity of wind power has increased from 6500 MW in 2001 to 54600 MW in 2016. The capacity of installed per year is shown with the help of a chart in figure 6

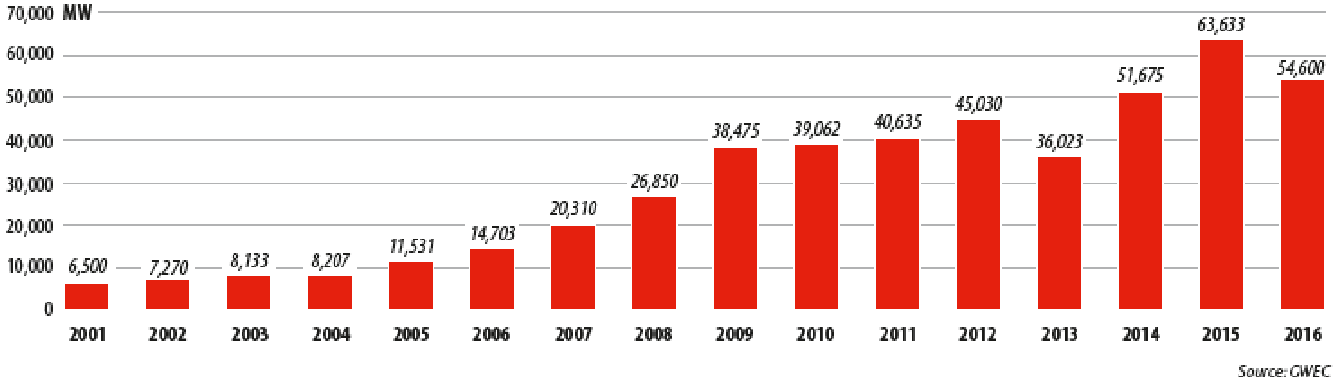

Figure 6: Installed capacity (MW) per year starting from 2001 to 2016

According to WEC the total installed capacity of wind power has increased from 23900 MW in 2001 to 486749 MW in 2016. The cumulative installed capacity per year is shown with the help of a chart in figure 7

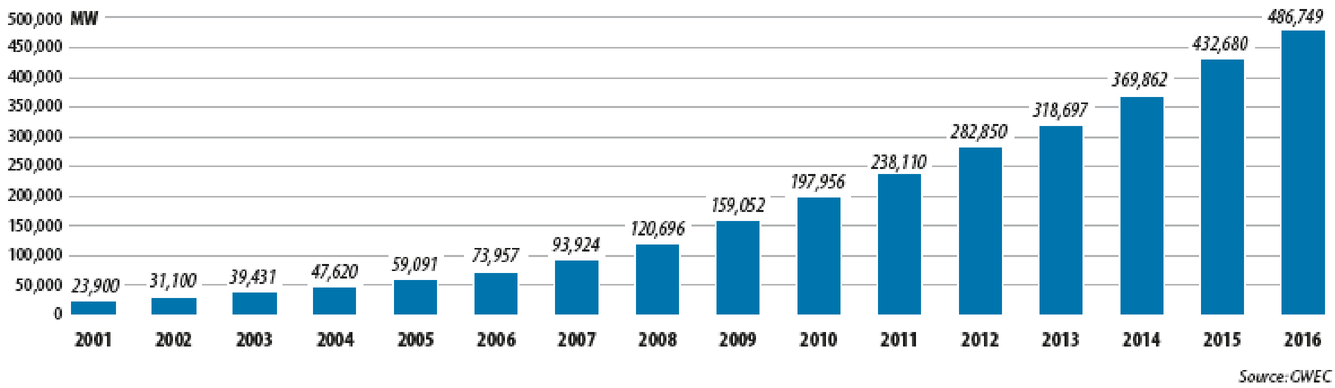

Figure 7: Cumulative installed capacity (MW) per year starting from 2001 to 2016

According to IEA and WEC report in 2016 China top the world in term of wind power installed capacity with installation of 23328 MW wind power capacity which is 42.7 % market share of total installation of wind power in 2016.
USA stand at rank two with installed capacity 8203 MW and Germany at three with installation capacity of 5443 MW all the related data for world top ten countries is compiled in table no. 4

Table 4: World top 10 country with wind power installed capacity and % share

Rank	Country	Installed capacity in 2016 (MW)	% share
1	CHINA	23328	42.7
2	USA	8203	15.0
3	GERMANY	5443	10.0
4	INDIA	3612	6.6
5	BRAZIL	2014	3.7
6	FRANCE	1561	2.9
7	TURKEY	1387	2.5
8	NETHERLANDS	887	1.6
9	UK	736	1.3
10	CANADA	702	1.3
	REST OF THE WORLD	6727	12.3

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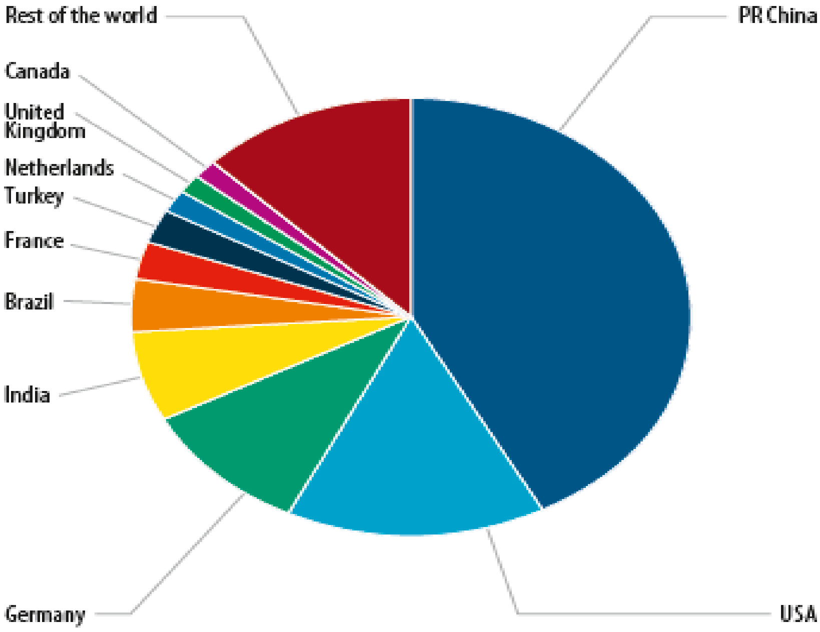

Figure 8: World top Ten country which new wind power installed in 2016

In 2016 total wind power capacity installed was 54600 MW out of this 47873 was installed by China USA ,Germany, India, Brazil, France, Turkey, Netherlands, UK and Canada which is 88% of total wind installed in 2016

According to IEA and WEC report China top the world in term of total wind power installed capacity with installation of 168690 MW wind power capacity which is 34.7 % market share of total installation of wind power up to December, 2016. USA stand at rank two with total wind power installed capacity 82184 MW and Germany at three with installation capacity of 50018 MW all the related data for world top ten countries is compiled in table no. 5

Table 5: World top 10 country with wind power installed capacity and % share

Rank	Country	Cumulative capacity (MW) Dec-2016	% Share
1	CHINA	168690	34.7
2	USA	82184	16.9
3	GERMANY	50018	10.3
4	INDIA	28700	5.9
5	SPAIN	23074	4.7
6	UK	14543	3.0
7	FRANCE	12066	2.5
8	CANADA	11900	2.4
9	BRAZIL	10740	2.2
10	ITALY	9257	1.9
	REST OF THE WORLD	75577	15.5

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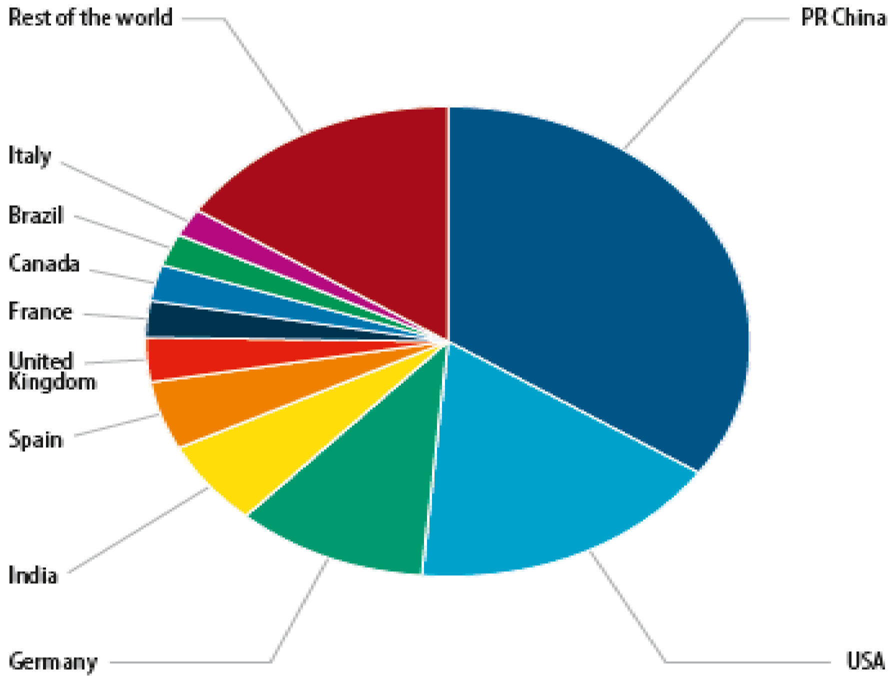

Figure 9: World top Ten county with cumulative wind power installed country up to Dec 2016

Up to December 2016 total wind power capacity installed was 486790 MW out of this 411172 MW was installed by ten country (China, USA, Germany, India, Spain Brazil, France, Canada, UK and Italy) which is 84% of total wind power installed by the world up to December 2016

3. Conclusion

This comprehensive study of renewable energy generation has provided detailed and useful information that can be used in the decision making of different stakeholders in the rapidly developing market. Each technology has both advantages and disadvantages that vary by location, availability, the technological capability of producers, financial limitations and environmental considerations. Every state, region or country has different economic and environmental conditions that determine the energy mix that can be generated at the lowest cost and minimum harm on the environment. Hence there is no single solution to every energy need and problem, but rather an optimal location specific solution among a set of possible renewable solutions

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