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# **NATIONAL INSTITUTE OF WIND ENERGY**

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New & Renewable Energy, Government of India).

*An internship report*

*On*

## **WIND ENERGY DEVELOPMENT AND ITS ENVIRONMENTAL IMPACT**

*Submitted By*

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## **Abstract**

Wind energy, is widely acknowledged as a clean and readily available renewable energy resource that can reduce our usage of fossil fuels. It has evolved as an important source of energy, in recent years. However, there are significant challenges in wildlife management. Such challenges include the installation and operation of large size turbines. This study aims to provide an overview of world wind energy production, the current status of wind turbine development of onshore and offshore wind farms, the wild life and the environmental impact of wind farms. It provides a brief overview of the birds' fatalities due to wind energy in US and India.

## 1. INTRODUCTION

The conventional fossil fuels, which have been a key energy source since the industrial revolution. The massive usage of fossil fuels such as oil, coal and natural gas, has led to adverse impact on the entire eco systems. Concerning the fast depletion of fossil fuels, the quest to develop renewable energy sources is imperative. Renewable energy sources such as solar, wind, hydro, tidal, geothermal, biomass energy helps to create a balance between economical, technical, environmental systems. The advantage of renewable energy include safety, diversifying energy supply, reducing dependence on imported fuels, generating energy with no greenhouse gas emissions, reduces some types of air pollution and job establishment. Among these solar and wind energy offers a mature technology for large scale electricity generation. Wind energy has grown rapidly since 2000. In 2021 wind electricity generation increased by a record 273 TWh. This was 55% higher growth than that achieved in 2020 and was the highest among all renewable power technologies.

China was responsible for almost 70% of wind generation growth in 2021, followed by US at 14% and Brazil at 7%. However, the wind energy that use today mostly comes from onshore winds. Meanwhile, there is a growing interest in offshore wind, as the wind is normally stronger and more uniform than land. The global leaders in offshore wind are China, Germany and the UK ( IEA's Data).



**Fig. 1.1.** Global wind power installations capacity in GW, 2021.(GWEC,2021).

Though wind power has performed well in recent years, it also creates a strong environmental impact, such as noise, visual and impact on wild life. Although these impacts seems minor when compared with fossil fuels, it is necessary to figure out its effects on humans and wild life creatures and find solutions to them in order to retain the long term sustainability of wind energy.

This report intent to provide an overview of the world wind energy scenario, current status in development of wind turbines, development of offshore wind power and the environmental and wild life impact.

## 1.1. Historical background

Human kind has exploited wind energy throughout the history; in fact it was harnessed to propel boats along the River Nile as long ago as 5000 BC. In around 200 BC, simple windmills were used to pump water in China. In the 11<sup>th</sup> century, new ways of using wind energy spread throughout the world; The Middle east used windmills extensively for milling grain to produce foodstuffs and the inhabitants of Netherlands to refine the windmill and adapt it to drain the lakes and marshes of the Rhine delta.

Chinese farmers start to use wind wheels with a vertical axis of rotation to drain rice fields. However, the horizontal axis windmill was probably invented in Europe, and was first found in the year 1180 in the duchy of Normandy.

In 1887, the American scientist Charles F. Brush built the first wind turbine for the electricity generation. That structure had a rotor diameter of 70m and 144 rotor blades and was made of cedarwood. This generator operated for 20 years and charged the batteries installed in the basement of his home. Danish scientist Poul la Cour, who discovered that wind turbines with fewer rotor blades are more efficient for producing electricity than multiple bladed turbines. In 20<sup>th</sup> century, the theoretical bases of the use of wind energy to generate electricity were developed by German Physicist Albert Betz.

In the 1940s, during World War II, the largest known wind turbine of the time, a 1.25-megawatt turbine known as Grandpa's Knob, produced electric power for the local utility in Vermont. Over the following decades, the use of wind power declined in the favor of cheaper energy sources such as oil, until the 1970s, when the US started suffering from oil shortages. This bloomed the interest in alternative and renewable energy sources, and people began to back towards wind power. The US federal government supported research and development of large wind turbines. In the early 1980s, thousands of wind turbines were installed in California.

When examining the development of wind power, it is clear that the popularity of wind energy has always fluctuated with the prices of fossil fuels. The share of us electricity generation from wind power grew from less than 1% in 1990 to 9.2% in 2021. China has invested heavily in wind energy and is now the world's largest wind electricity generator. In 1990, 16 countries generated a total about 3.6 billion kWh of wind energy. In 2020, 129 countries generated about 1597 billion kWh of wind electricity.

## 2. ONSHORE WIND FARMS

Onshore wind energy is generated by harnessing the power of the wind through wind turbines located on land. These wind turbines transform kinetic energy into mechanical rotational energy in order to generate electricity. Wind farms are installed in locations where data support the prediction of adequate wind energy. It has been extremely successful technological revolution in recent years.

### 2.1. Advantages

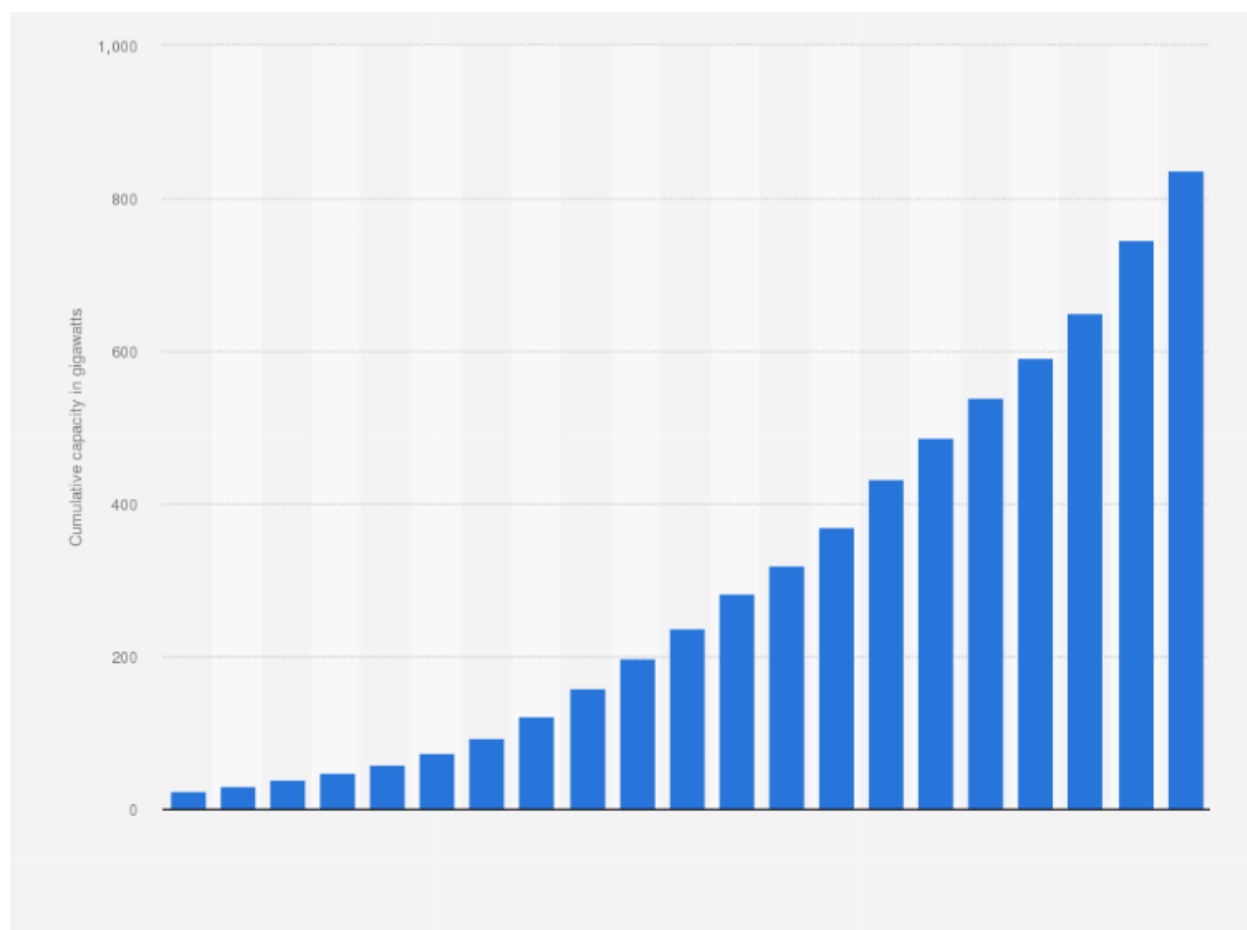
- The most affordable renewable energy sources.
- Has a relatively small carbon footprint.
- Compared to offshore wind turbines, onshore wind projects cost less to install and take less time to install.
- Onshore turbines do not release harmful toxins that can damage surrounding area.
- It allows the development of agricultural and stockbreeding activities in the surrounding area.

### 2.2. Disadvantages

- Onshore wind is an intermittent source of energy, as turbine cannot generate electricity on demand, but only when the wind is blowing, and at sufficient strength. Hence the fossil fuel based power supply is always needed as backup, which can temporarily increase greenhouse gas emissions.
- Onshore wind turbines have been criticized for their visual impact and noise pollution. Although other power infrastructure like nuclear power stations can also modify landscapes and habitats, onshore wind turbines are typically more spread out and affect a larger area and ruining what previously have been areas of natural beauty.
- Another criticism is that species such as birds and bats are affected by wind turbines-though bird fatality causes, such as communication towers.
- Impact on wildlife can be minimized by careful site selection and by avoiding areas of high conservation or habitat value.

### 2.3.Current status of wind energy production

In 2021 wind electricity generation increased by a record 273 TWh (up 17%). This was 55% higher growth than that achieved in 2020 and was the highest among all renewable power technologies. The cumulative capacity of installed wind power worldwide amounted to approximately 837 GW in 2021. Onshore wind power accounted for the majority of the total wind power capacity at about 780 GW.



**Fig.2.1.** Global cumulative installed wind power capacity in GW, 2001-2021.(<https://www.statista.com/statistics/268363/installed-wind-power-capacity-worldwide/>)

## 2.4. Installed Wind power capacity in selected countries

The top five market contributors of the global installed wind energy capacity are China, the US, Germany, India and Spain respectively. The following section will give a brief overview of wind power installed capacity.

The table 2.1 shows the installed wind capacity of top 5 countries.

**Table 2.1:** Installed Wind power capacity (MW).([https://en.wikipedia.org/wiki/Wind\\_power\\_by\\_country](https://en.wikipedia.org/wiki/Wind_power_by_country)).

Country / Territory	2019	2020	2021
China	236320	281993	328973
United States	105466	117744	132738
Germany	61357	62184	63760
India	37506	38559	40067
Spain	25808	27089	27497

### 2.4.1.China

China is the world leader in wind power generation, with the largest installed capacity of any nation and have rapid growth in new wind facilities.

China began to utilize wind power in the 1970s. However, its use of wind power developed slowly until 2006, when “The Renewable Energy law of China” was issued.

China is forecast to have 1200 GW of combined wind and solar capacity by 2030 as of the government’s pledge to increase the share of non-fossil fuels in primary energy consumption.

### 2.4.2. The United States

In 1980 the world's first wind farm consisting of twenty 30 kW wind turbines was installed at Crotched Mountain, in New Hampshire.

The Alta Wind Energy Center in California is the largest wind farm in the United States with the capacity of 1548 MW.

The table 2.2 shows the list of wind farms in united states and their capacity.

**Table. 2.2.** List of wind farms in the United States and their Installed capacity in the capacity. ([https://en.wikipedia.org/wiki/List\\_of\\_onshore\\_wind\\_farms](https://en.wikipedia.org/wiki/List_of_onshore_wind_farms))

Wind farms	Capacity (MW)	State
Alta Wind Energy Center	1548	California
Western Spirit	1050	New Mexico
Traverse	998	Oklahoma
Los Vientos Wind Farm	912	Texas
Shepherds Flat Wind Farm	845	Oregon
Meadow Lake Wind Farm	801	Indiana
Roscoe Wind Farm	781.5	Texas
Horse Hollow Wind Energy Center	735.5	Texas
Tehachapi Pass Wind Farm	705	California
Capricorn Ridge Wind Farm	662.5	Texas
San Geronio Pass Wind Farm	615	California
Limon Wind Energy Center	601	Colorado

US had growth by 50% in 2008 over the prior year. By 2014, the wind industry in the US was able to produce more power at lower cost by using taller wind turbines with longer blades, capturing the faster winds at higher elevations, this opened up new opportunities. As of 2021, the United States has over 130 GW of installed wind power capacity.

### 2.4.3. Germany

As of the end of 2021, Germany was the third largest producer of Windpower, behind China and the US. Since 1995, Onshore Wind energy has been an important and major industry in Germany. In 2021, with 23.1% a contribution to German electric generation, wind was the second most important contributor, followed by coal.

### 2.4.4.India

As of 2022, the total installed wind power capacity was 41.666 GW, the fourth largest installed wind power capacity in the world. 70% of annual wind generation is during the five months duration from May to September coinciding with Southwest monsoon duration.

The table 2.3 below shows India's installed wind power by state-wise(MNRE,September,2022).

**Table 2.3.** India's Installed wind capacity

State	Installed capacity (MW)
Andhra Pradesh	4096.65
Gujarat	9798.5
Karnataka	5268.15
Madhya Pradesh	2844.29
Maharashtra	5012.83
Rajasthan	4576.82
Tamil Nadu	9873.92
Telangana	128.1

Kerala	63.50
Other States	4.30
<b>Total</b>	<b>41666.08</b>

The below table 2.4 shares the list of the 10 largest wind power plants in India.(<https://byjus.com/free-ias-prep/wind-energy-in-india/> )

**Table 2.4.** Wind power plant in India.

<b>Wind power plant</b>	<b>Location</b>
Muppandal wind farm	Kanyakumari, Tamil Nadu
Jaisalmer Wind farm	Jaisalmer, Rajasthan.
Brahmanvel Wind farm	Dhule, Maharashtra.
Dhalgon wind farm	Sangli, Maharashtra
Vankusawade Wind Park	Satara, Maharashtra.
Vaspert	Vaspert, Maharashtra
Tulijapur	Osmanabad, Maharashtra
Beluguppa Wind park	Beluguppa, Andhra Pradesh.
Mamatkheda Wind power	Mamatheda, Madhya Pradesh
Anantapur Wind park	Nimbagallu, Andhra Pradesh

The Muppandal Wind Farm is India's largest operational onshore wind farm and operational onshore wind farm in the world. It is located in Kanyakumari district,

Tamil Nadu. Developed by Tamil Nadu Energy Development Agency with installed capacity of 1500 MW.

### **2.4.5. Spain**

Spain was an early leader in development of wind power, ranking second after Germany by installed capacity until 2006, when it was surpassed by the United States.

In 2009, A wind Storm caused wind farms to produce a peak of 53% of total electricity demand of Spain (11.546 GW). In the field of exporting of wind turbines, Spain stands in third position after Denmark and Germany.

After more than three decades since the first wind turbine was installed, the government plans to reach at least 50 GW of the installed capacity by 2030.

### 3. OFFSHORE WIND

While onshore wind is developing by leaps and bounds, in the mean time, offshore wind has also attracted people's attention in recent years. Recently, offshore wind power has been widely focused on and developed, as it is reliable, intensive, and its source is abundant and offers vast offshore areas.

#### 3.1. Advantages

- Offshore wind power is more efficient than onshore alternatives.
- Consistency of higher wind speeds in direction means that fewer offshore turbines installations will lead to produce the same amount of energy as onshore wind farms.
- Have reduced environmental impacted.
- Bigger turbines with less visual impact, compared with its onshore counterparts.

#### 3.2. Disadvantages

- Sound pollution due to seabed drilling, affects marine creatures' health.
- Surface-level bio diversity loss

#### 3.3. Offshore wind scenario

The global offshore wind market grew nearly 30% per year between 2010 and 2018, benefitting from rapid technology improvements and about 150 new offshore wind projects are in active development around the world.

The table 3.1 listed the cumulative installed offshore wind power capacity by countries.

**Table. 3.1.** List of countries by cumulative installed offshore wind power capacity in MW. ([https://en.wikipedia.org/wiki/Offshore\\_wind\\_power](https://en.wikipedia.org/wiki/Offshore_wind_power))

Country	2019(MW)	2020(MW)	2021(MW)
China	6838	9996	24851
United Kingdom	9723	10428	13601
Germany	7493	7689	7701

Netherlands	1118	2611	3010
Denmark	1703	1703	2343

### **3.3.1. European Union**

European companies have invaluable experience by being “First Movers”. The first offshore wind farm was installed in Denmark already in 1991. The installed offshore wind capacity in the European Countries was 14.6 GW in 2021 and is set to increase by least 25 times by 2030.

#### **3.3.1.1. Denmark**

The Danes were pioneers in the developing commercial wind power during 1970s and today almost half of the wind turbines around the world are produced by Danish manufacturers such as Vestas and Siemens Wind Power. Wind power capacity in Denmark increased by 220 MW in 2020 with total wind power capacity is 6,311 MW. As per the Energy Agreement published on 29<sup>th</sup> of June 2018, The Danish set a target by 2030 is that 55% of the nation’s energy needs are met by renewable energy, mainly wind and solar.

#### **3.3.1.2. Germany**

Offshore wind energy also has great potential in Germany. On July 2009, the first offshore German wind turbine completed construction. This turbine is the first of a total of 12 wind turbines for the alpha ventus offshore wind farm in the North Sea. Alpha Ventus wind farm consists of twelve turbines, all with capacity of 5 MW. The installed capacity of offshore wind is 7701 MW.

#### **3.3.1.3. United Kingdom**

The United Kingdom is the best location for the wind power in Europe and one of the best in the world. Wind power generated about 25% of UK electricity, having surpassed coal in 2018. It is the largest source of renewable electricity in the UK.

The total offshore wind power capacity installed in the United Kingdom at the start of 2022 was 11.3 GW.

### **3.3.2. China**

China expanded its position as the world's largest offshore wind market by far with 24.9 GW of installed capacity.

In 2021 alone, China built more offshore wind capacity than the rest of the world had built in the last 5 years put together. It commissioned 16.9 GW of offshore wind capacity, which accounted for 80% of all new capacity in 2021 worldwide.

That massive expansion had meant that China today operates almost half of the world's installed offshore wind, with 26 GW of a total of 54 GW worldwide.

### **3.3.3. India**

India is blessed with a coastline of about 7600km surrounded by water on three sides and has good prospects of harnessing offshore wind energy.

According to National offshore wind energy policy, National Institute of Wind Energy (NIWE), Chennai, installed 74 nos of met masts with various heights across the coastline to find out the wind velocity.

The offshore wind energy project are focused on the states of Gujarat and Tamil Nadu as potential offshore zones (as of the collected data from the mast)

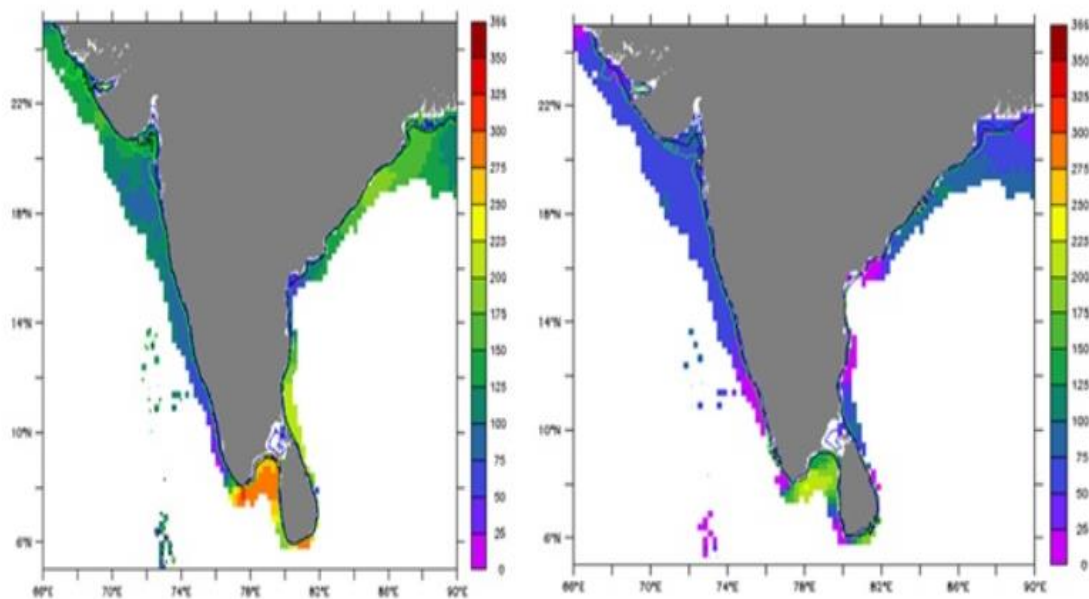
#### **Gujarat offshore wind energy development**

- ✓ Gujarat as wind velocity of 7.52m/s at 100m hub height(as per record).
- ✓ NIWE has established first liDAR based wind measurement platform in Gulf of Khambhat, Gujarat Coast.
- ✓ The LiDAR support platform is 5 m diameter, 5 ton weighs, coated with epoxy paint, supported on monopile.
- ✓ Installed in March 2017
- ✓ Collected data in the period from November 2017 – October 2018.

#### **Tamilnadu offshore wind energy development**

- ✓ NIWE is planning to deploy LiDAR in three different locations of Gulf of Mannar.
- ✓ Planning to establish testing cum research station at Dhanushkodi, Ramanathapuram.
- ✓ Dhanushkodi has wind speed of 8.36m/s.

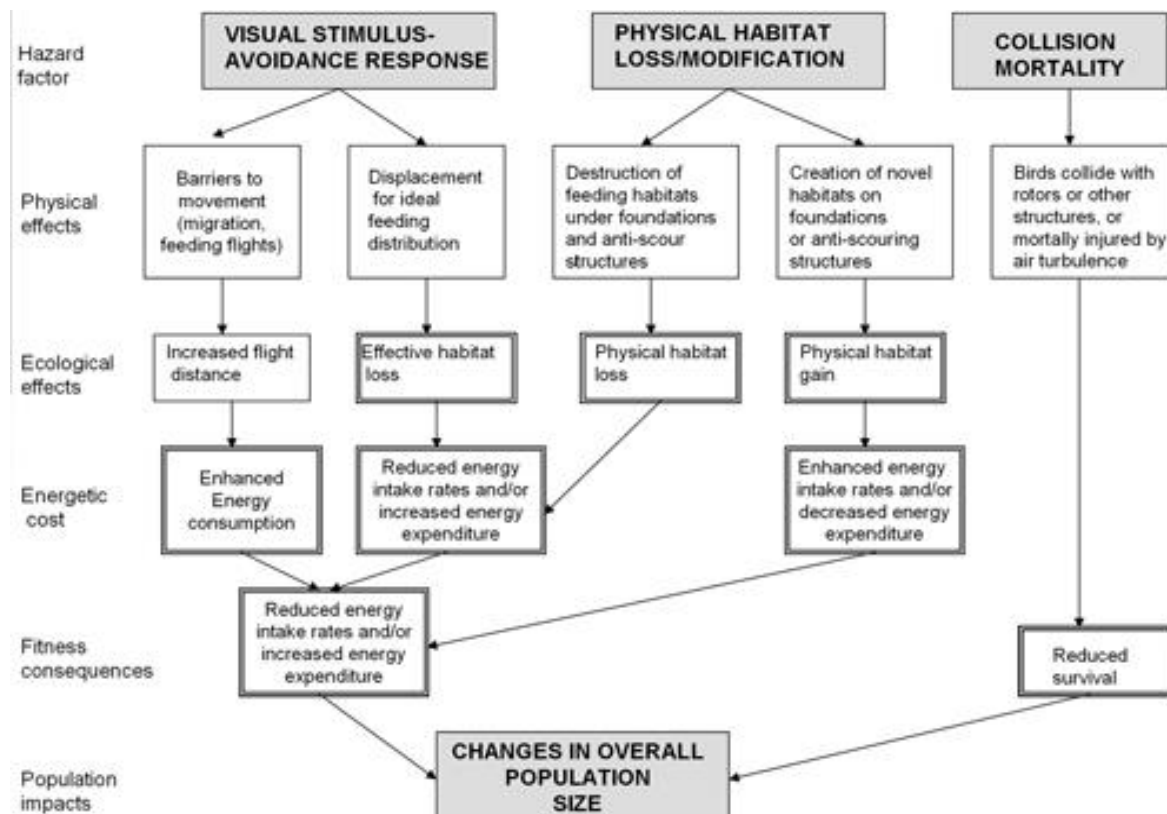
The ministry of new and renewable energy has set a target of 30 GW of offshore wind installations by 2030.



**Fig.3.1.** Wind velocity observed across India(NIWE).

## 4. ENVIRONMENTAL IMPACT

In Contrast to fossil fuels and nuclear power, wind turbines do not pollute our atmosphere with greenhouse gases or with radioactive waste. But it still imposes some impacts on the ecosystem which cannot be ignored. Some of the impacts are reviewed here.



**Fig.4.1** Represents the effects of wind farms. (<https://www.wind-energy-the-facts.org/impacts-on-marine-mammals-and-sea-birds.html>)

### 4.1. Noise pollution

The noise caused by operating onshore wind turbines can be a major annoyance in people's lives.

Wind turbines cause noise by two ways- Mechanical noise and aerodynamic noise.

Noise used to be a very serious problem for the wind energy industry. The primitive types of turbines built in early 1980s were extremely noisy. The industry

quickly realized the problem and the manufacturers went to work on making their machines quieter by handling the strategies for reducing aerodynamic noise include

1. Decreasing rotational speed under 65m/s at the tip
2. Blade design modification.

## 4.2. Visual Impact

Among all the effects on the environment caused by wind turbines, the visual impact is the most difficult to assess. Unlike with noise and shadow flicker, there is no formula to determine the impact. The VIA (Visual Impact Assessment) is assessing how the wind park development blends into overall landscape.

Some of the techniques used in the visual impact assessment are:

1. ZTV(Zone of the theoretical visibility)
2. Photomontages
3. Observation on the turbine layout.

Visual impact decreases with the distance. The ZTV zones can be defined in the table below.

**Table.4.1.** Represents the ZTV zones.(<https://www.wind-energy-the-facts.org/onshore-impacts.html>)

Zone 1	Visually dominate The distance up to 2 km
Zone 2	Visually Intrusive. Blades movement is clearly visible and can attract the eye. Distance between 1 and 4.5 km
Zone 3	Noticeable. Movement of blades is visible and the turbines appear small in the overall view. Distance between 2 and 8 km.
Zone 4	The apparent size of the turbines is very small. Distance of over 7 km.

Measures to minimize the visual impact of wind farms on landscape:

1. Underground Cables
2. Selection of wind turbine color according to landscape characteristics.

### 4.3. Shadow Flicker

Shadow Flicker is the effect of the sun shining through the rotating blades of a wind turbine, casting a moving shadow. Computer models can accurately predict shadow flicker impact. So, Developers can mitigate this impact during the site selection process.

### 4.4. Birds and Bats

#### 4.4.1. USA

One of the criticisms of wind power that continues to draw significant attention is the number of birds killed by spinning blades. According to American Bird Conservancy, US, Mortality will reach more than 1.4 million by 2030 or earlier if the US meets its goal of producing 20% of its electricity demand by wind and if it reaches 35%, the fatalities of 5 million birds will occur.

Table.4.2. The following studies are made on the birds' mortality due to wind turbine.(Johnson, D.H.,et.al(2016))

**Table 4.2.**The birds' mortality due to wind turbine

<b>Study</b>	<b>Year Published</b>	<b>Average number of Bird's Fatalities per Year</b>	<b>Minimum-Maximum number of birds, fatalities per year</b>
Loss and Others	2013	234000	140000-328000
Small wood	2013	573093	467097-679089
Erickson and others	2014	291000	214000-386800

As of 2021, 681000 Fatalities of birds are occurred by wind turbines in US, which is comparatively less when compared with other causes of death.

Other causes of Birds death

1. Communication towers – 5 to 6.8 million per year
2. Automobiles – 60 to 80 million per year
3. Pesticides – 67 to 90 million per year
4. By cats – 365 million to billion per year.

The Number of birds killed annually at wind power facilities in Europe and America. The data are collected regularly during one season and more.

Table 4.3 shares the fatality rate in America and European Countries These data were collected between the period of 1999 to 2009(Green, M.,et al (2012)). The plot of the fatality rate in America and Europe countries is given in figure 4.2.

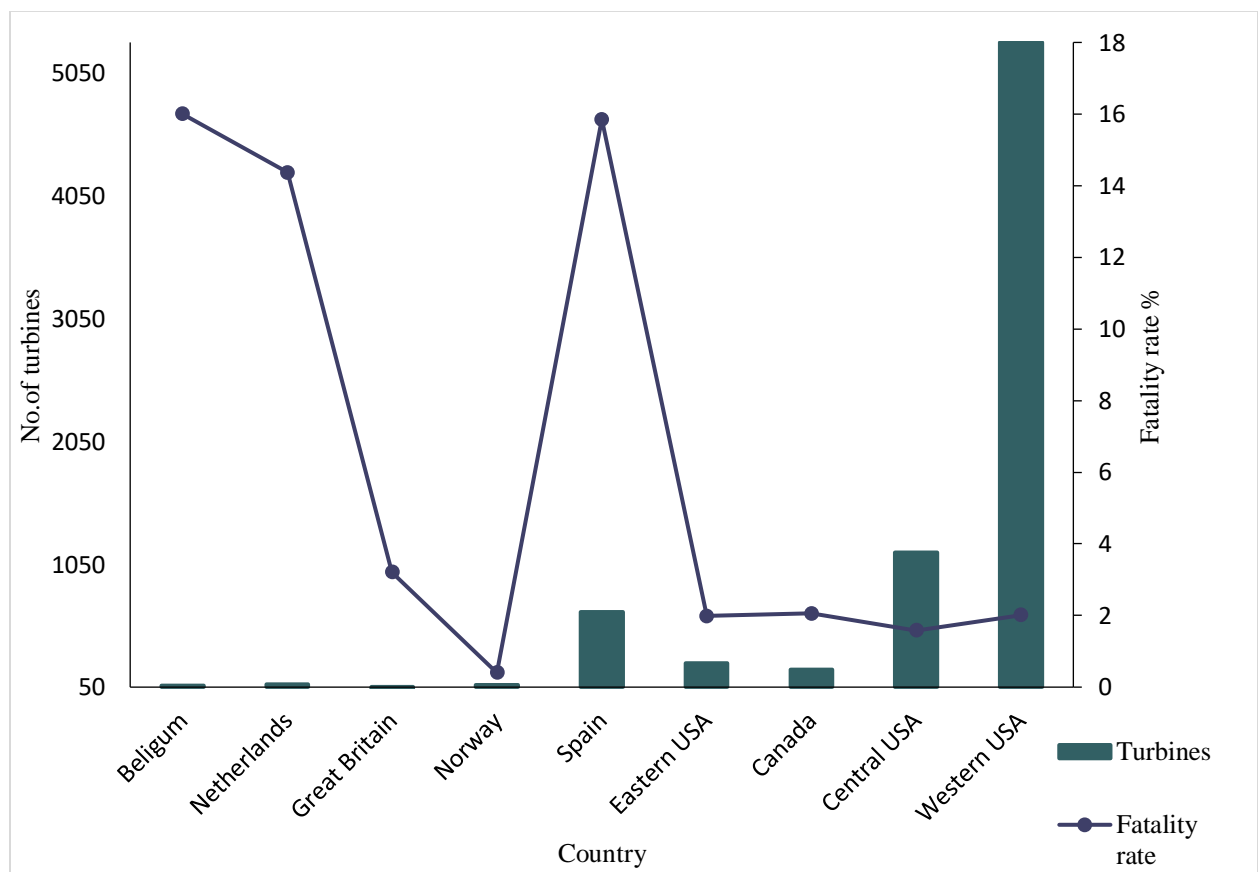
**Table 4.3.** The Fatality rate in America and Europe

<b>Countries</b>	<b>No. of turbines</b>	<b>Mean Fatality rate%</b>
Belgium	64	16
Netherlands	73	14.4
Great Britain	9	3.2
Norway	68	0.4
Spain	664	15.8
Eastern USA	244	1.98
Canada	190	2.06
Central USA	1146	1.6
Western USA	5298	2.01

The fatality rate for birds at wind farms up to 2017 period is given in the table. 4.4. (Ryndell et al 2017).

**Table 4.4.** The fatality rate for birds at wind farms,(Ryndell et al 2017).

Countries	Killed birds	Fatality rate%
USA	Small birds(songbirds, species of larks, swallows)	75
Europe	Song bird	28.6
Sweden	Passerine bird	25.9

**Fig.4.2.** Fatality rate. (Green, M.,et al (2012)).

The offshore wind developments in the North Sea threatened one particular seagull, the Kittiwake. The huge turbines over 200m will cause the deaths of 73

kittiwakes a year. In Canada, 23300 birds are died by 2011. Research (Johnston, A., et al (2014)) has found that low-flying birds are tend to avoid offshore turbines by flying under them. Gulls fly 20m above water put them in danger Zone.

Birds of prey and raptors like Golden Eagle, Yellow billed Cuckoos, and California Condors are mostly killed by the collision with wind turbines.

The mitigate measure to prevent the birds from collision with turbine is by painting the wind turbine's blade with black color.

Why, Black?

Birds may not always see obstructions ahead in assumed open airspace, increasing their risk of colliding. Birds have narrow binocular frontal field of view and use their monocular and high resolution lateral fields to view to detect prey.

The birds perceive these moving white blades as motion smears instead of motorized objects. A Study (Hodos, W., et al (2003)) made by University of Maryland by comparing the impact of various blade pattern and coloured blade to determine which was mostly clearly seen by birds and to return out to be colour black, mostly visible by birds.

A Paper (May, R., et al (2020)) published to Ecology and Evolution in June,2020 studied the effects of painting one blade of turbine black and hypothesized that the paint would allow birds to notice and avoid turbines sooner.

NINR(The National Institute of Nursing Research),US, had extend its hands in the discussion of painting the wind turbine black color.

At Smola Islands, Norway,38 dead eagles were found after 68 turbines installed (2005-2010). A trial made at the Smola wind power plant gathered results over 11 years, until July 2020. After painting one blade black, the fatality rate was 71.9% lower compared to unpainted turbine.

#### **4.4.2. India**

In India, A study (Kumar et al (2012)). was made in the villages of Gujarat, which covered 127 acres and had 51 wind turbines locations and found six birds carcasses. The crashed birds were found from 20 m to 120 m from the turbines.

The species are:

**Table.4.5.** The species of bird carcasses, (Kumar,S.R.,et.al(2012)).

Species	Conditions	Distance from turbine (m)
Blue Rock Pigeon	Intact	20
Corvus Species	Feathers and bones	55
Egret Species	Feathers	25
Eurasion Collared Dove	Feathers	55
Spotted Dove	Feathers	80
Cattle Egret	Scavenged	120

An another study (Kumara, H.N., et al 2022)in the villages named Chitradurga, Gadag, Karnataka, recorded any a dead birds/bats once a week and stated that raptors are likely to get killed and the mean annual fatality rate per wind turbine was 0.26 per year. The chitradurga with 0.33/wind turbine/year, had a higher fatality rate than in Gadag with 0.20/windturbine/year after spent 124-144days in carcass search.

Great Indian Bustard (GIB),endangered species (nearly 50 to 249 alive) found in Gujarat and Rajasthan. According to the Wildlife Institute of India, almost 18 ie. One fifth of the population of GIBs, die each year from the collision with power lines . GIBs unable to change the direction once they are closer to the wire because of its weight and poor view.

As step of preventing the extinction, The Supreme court issued an order to install bird diverters in the priority areas and undergrounding the power cables (2500 km).

The impact of wind farms on birds from the Indian context is very less studied with almost no scientific literature available.

Bats are also a victim of wind farms just like the birds. But bats find their ways via echolocation, should have no trouble detecting fast moving objects. The researches

hypothesized the bats had been killed by burst blood vessel in their lungs (barotrauma), the air pressure difference created by the spinning wind mills had terminated them. Unprecedented numbers of migratory bats are found death beneath industrial scale wind turbine during late summer and autumn in North America and Europe. According to the journal Biological Conservation, the hoary bat population could be at arisk of extinction due to mortality from wind turbines. The widespread fatalities of hoary bats at wind turbine could cut down the population as much as 90 % in the next 50 years.

It is evident that that the mortality of bats due to wind turbine is an emerging threat. The rate is high as 67 bats/turbine/year on certain occasion.

#### **4.4.3. Precautions**

The measure to prevent the bats from extinction:

1. Turning turbines off from summer to late fall, low wind conditions - when bats are most active.
2. Having Ultrasonic Boom boxes.
3. Ultra violent Light.

In Casselman wind power project , Pennsylvania, the tests are conducted by made small changes to turbine like shutting downthe turbines when wind speeds were below 6.5 m/s. As result Bat deaths were reduced by 44 to 93 percents. And Bats Conservation International (BCI) found that by installing ultrasonic boom boxes which emit continuous high frequency sounds from 20 to 100 kHz in the turbine killed 21 to 51 % fewer bats.

#### **4.5. Impact by offshore wind turbine**

Off shore energy production can have both positive and negative impacts on marine ecosystems. Negative impacts are reported especially linked to birds, marine mammals, and ecosystem structure. The positive effects are related mostly to fish .

##### **4.5.1. Effects on sea bed**

Depending on the technology employed, wind farms with fixed foundations may require excavation works and installation of turbine platforms, which could cause disruption of the seabed and uplift of sediments throughout the water column. These could lead to significant effects on benthic communities.

**Remedial measure:** In the case of wind farms with floating foundations, these impacts are highly reduced.

#### **4.5.2. Effect on Marine water**

Both during the construction and operation phases of an offshore wind farm, the impacts of potential fuel or oil spills from the vessels and machinery should be taken into account. During the operation phase, occasional contamination can occur due to discharges from the wind turbine associated with malfunction, maintenance and repairing works.

#### **4.5.3. Effects of noise and vibrations**

In the operation phase of an offshore wind farm, due to the large surface in contact with the water, the vibrations of the wind turbine tower may cause significant underwater vibrations and also affect the sea bed. In the construction phase, the noise created while sea bed drilling have effect on habitat hearing.

#### **4.5.4. Seals**

To study the effects on the marine mammals, University of St. Andrews attached GPS data loggers to 24 harbour seals while the installations of offshore wind in the Wash, 2012. The model revealed that half of the tagged seals were exposed to noise levels that exceeded hearing damage threshold.

Seals may routinely be exposed to potentially hazardous levels of underwater noise during pile driving. On the other hand, the offshore wind farm appears to create a buffet for seals. The wind farm can become a sort of artificial reef, a home for invertebrates, especially fishes.

## 5. CONCLUSION

At present, wind energy is a renewable energy with mature technology, which has high potential to become a major primary source of energy in future. However, offshore wind is a new technology that still needs to be tested in the tough marine environment and its turbines need further development.

Even though, wind power is believed to be environmentally safe, compared to conventional fossil fuels, it still has effects on animals and on human life, such as noise and visual impact.

With a proper understanding of its environmental impact, wind energy can be clean and sustainable source of energy that can be successfully replace fossil fuels.

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