Cdp Report - cdp summer

Community development project (Lovely Professional University)

<u>Annexure-1</u>
<u>Community Development Project</u>

<u>Wind Energy</u>

Submitted by

KSHITIZ SHARMA

Registration Number: 12001348

A Project Report

In partial fulfilment for the requirements of the award of the degree

"<u>B. TECH(Hons) CSE</u>"

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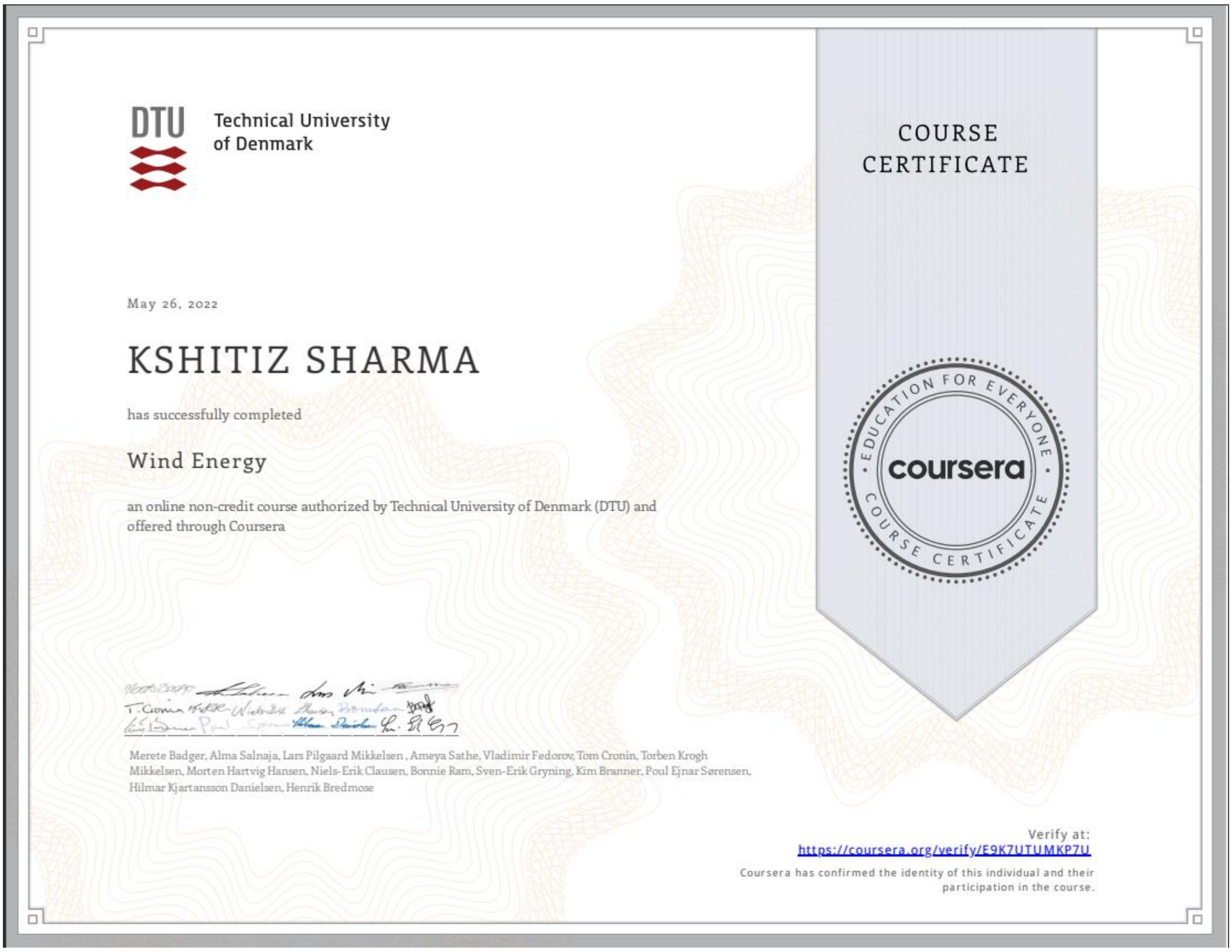
"School of Computer Science and Engineering"

Lovely Professional University

Phagwara, Punjab

Annexure-2

CERTIFICATE FROM COURSERA:



DTU Technical University of Denmark

COURSE CERTIFICATE

May 26, 2022

KSHITIZ SHARMA

has successfully completed

Wind Energy

an online non-credit course authorized by Technical University of Denmark (DTU) and offered through Coursera

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Annexure-3

(Format of Report)

INTRODUCTION

Renewable energy sources are those energy sources that aren't destroyed once their energy is controlled. Human use of renewable energy needs technologies that harness natural phenomena, like daylight, wind, waves, water flow, and biological processes like anaerobic digestion, biological element production and geothermal heat. Amongst the above-mentioned sources of energy there has been loads of development within the technology in the technology for harnessing energy from the wind.

Wind is the motion of air masses created by the irregular heating of the earth's surface by sun. These variations consequently produce forces that push air masses around for balancing the worldwide temperature or, on a far smaller scale, the temperature between land, ocean or between mountains.

Wind energy isn't a constant source of energy. It varies continuously and offers energy in sudden bursts. regarding fifty percent of the whole energy is given out in simply fifteen percent of the in-operation time. Wind strengths vary and so cannot guarantee continuous power. it's best utilized in the context of a system that has vital reserve capability like hydro, or reserve load, like a desalination plant, to mitigate the economic effects of resource variability.

The power extracted from the wind can be calculated by the given formula:

$$\mathbf{Pw = 0.5\ \pi p R^3 Vw^3 C_p(\lambda,\beta)}$$

Pw= extracted power

p= air density

R= blade radius (in m)

Vw= wind velocity (in m/s)

C_p= power coefficient which is a function of tip speed ratio (λ) and blade pitch angle(β).

How wind energy Works

Wind is a form of solar energy. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetation. Humans use this wind flow, or motion energy, for many purposes: sailing, flying a kite, and even generating electricity.

The terms wind energy, or wind power, describe the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity.

So how do wind turbines make electricity? Simply stated, a wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

Types of Wind Turbines

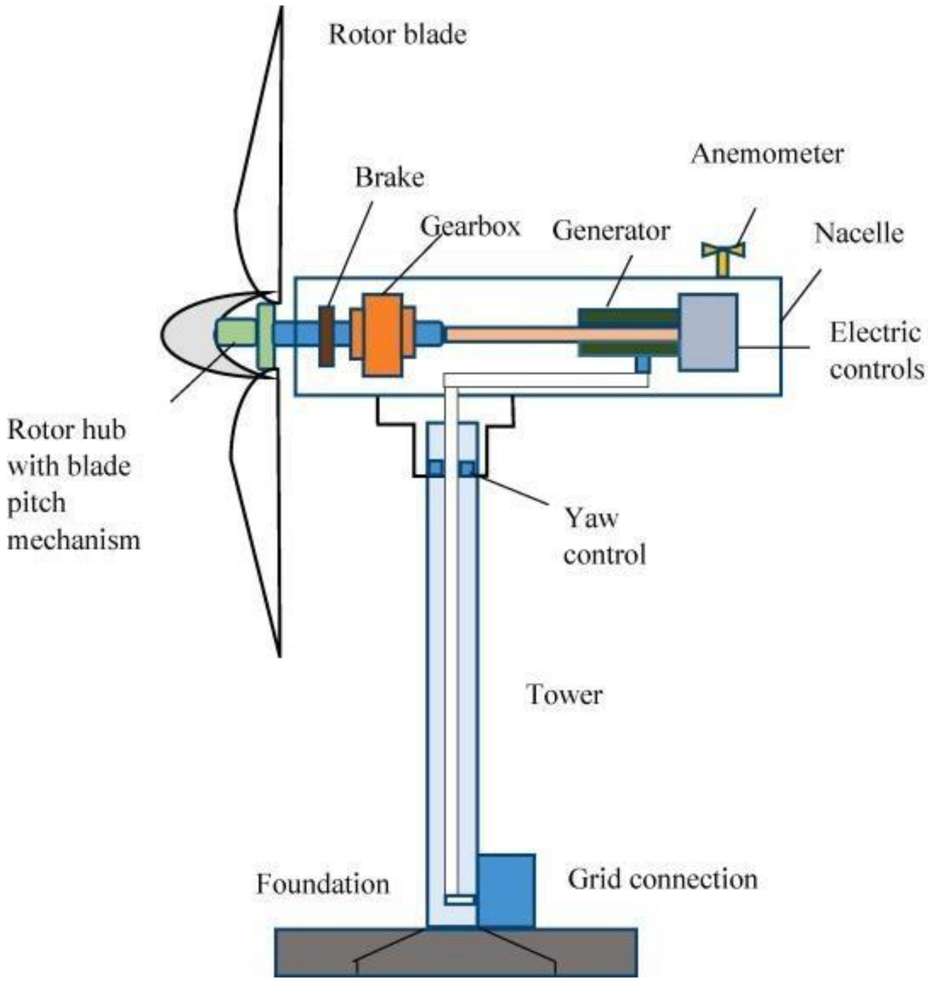
Modern wind turbines fall under two basic groups: the horizontal-axis variety, and the vertical-axis style, just like the eggbeater-style Darrieus model, named after its French inventor. Horizontal-axis wind turbines generally either have two or three blades. These three-bladed wind turbines are operated "upwind," with the blades facing into the wind.

(A) (B)

Vertical Axis Wind Turbine

Horizontal Axis Wind Turbine

Components of wind turbine



Anemometer:- It measures the wind speed and transmits wind speed data to the controller.

Controller:- The controller starts up the machine at wind speeds of about eight to sixteen miles per hour (mph) and shuts off the machine at about fifty-five mph. Turbines do not operate at wind speeds above about fifty-five mph because they might be damaged by the high winds.

Blades:- Most turbines have either two or three blades. Wind blowing over the blades causes the blades to rotate.

Brake:- A disc brake, which can be applied mechanically, electrically, or hydraulically to stop the rotor in emergencies.

Generator:-It is an off-the-shelf induction generator that produces sixty-cycle AC electricity.

Pitch:- Rotation of the blade about their length wise axis due to pitch control action. Blades are pitched out of the wind to control the rotor speed and keep the rotor from turning in winds that are too high or too low to produce electricity.

Rotor:- generates aerodynamic torque from the wind

Nacelle:- converts the torque into electrical power

Tower:- The tower holds nacelle and rotor blades up in the wind and provides access to the nacelle. Wind speed increases with height, taller towers enable turbines to capture more wind energy and generate more electricity.

Wind vane:- Measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.

Yaw drive:- It is used to keep the rotor facing into the wind if the wind direction changes.

PROBLEM IDENTIFICATION AND IT'S CAUSES

Despite the economic and ecological advantages, so far even good wind resources in developing and emerging countries have not been used to the desirable extent. The essential reasons for this are based in the lack of knowledge in the developing and emerging countries.

From the view of international wind energy companies, beside the difficulties of raising of capital and risk covering, the barriers for private investment are especially:

- Lack of information on foreign markets.
- Lack of knowledge of the energy-sector framework conditions and support mechanisms.
- Insufficient wind energy legal framework (technical and economical conditions for feeding wind-generated electricity into power grids, permit procedure)
- Lack of qualified staff, especially in the field of service/maintenance. Technicians and buyers are often unfamiliar with wind technology, and in remote locations instalments often break down because of a lack of servicing, spare parts, or trained manpower to administer them. In reality, wind pumps are less maintenance intensive than diesel pumps. However, the wind pump technology is "strange" to many people and there is a need to train maintenance staff where pumps are installed.
- Infrastructure to support the installation, commissioning and maintenance of wind generators is not developed. Users and technicians are generally unaccustomed to the technology.

- Investment Cost. Although the lifetime cost of wind is often less than diesel or petrol-powered pumps, the investment cost of purchasing a wind pump is usually higher than that of diesel pumps. Groups purchasing water supplies often have limited funds and cannot take a long-term view toward the technology.
- Wind energy does not have as consistent an output as fuel-fired power plants. Small-scale wind generators require battery storage to allow usage in periods of low or no wind. For grid connected systems, a stable grid is required to act as the storage. Wind pumps require water storage.
- Wind generators are designed to work over a given range of wind speeds, usually 4– 12m/s. This means that the technology can only be used in areas with sufficient winds.

OBJECTIVE'S TO BE ACHIEVED

- **INCREASE THE PRODUCTION OF WIND ENERGY:** The production of wind energy reduces reliance on fossil fuels and consequently reduces fossil-driven CO_2 emissions, but a given CO_2 reduction is more effective in mitigating global warming if made earlier than later. Wind energy growth rate will depend on cost (see RO2), but it will also depend on other factors, including government policy, public perception, our manufacturing base, and the rate at which local and national transmission is reinforced.

- **DECREASE THE COST OF WIND ENERGY:** Building a wind farm is not cheap. On average, wind power development costs around $1 million per megawatt of generating capacity installed. To take advantage of economies of scale, wind power facilities should be in excess of 20 MW. Assuming the average turbine is rated at 750 kilowatts (kW) in capacity, this means at least 26 turbines and an initial investment of $20 million. wind energy to this level will occur only if investors can earn a return, an ability that depends on several factors, chief among them being the life cycle cost, the wind resource available and financing. We will explore all of these measures.

- **EXTEND PENETRATION LIMITS:** Limitations to wind energy build-out are largely dictated by operational issues associated with the power grid. These issues include maintaining enough rotational inertia to withstand generation outages, maintaining continuous balance between generation and load through regulation and load following, avoiding CO_2 emission increase due to cycling of fossil-fired power plants not built for this purpose, and obtaining sufficient local and national transmission to move the energy.

STEPS TAKEN TO ACHIVE THE OBJECTIVE'S

- ## Wind Economics, Policy, and Public Perception

Public acceptance and unintended consequences: Public surveys show that support for wind energy is high. For example, attitudinal data from a 2008 MIT Energy Survey showed that people favour wind *a priori* and that a substantial majority of Americans support local siting of wind facilities. Yet, studies have also demonstrated that this support declines significantly at the local level when specific initiatives are proposed. Since local opposition may delay or even prevent the development of wind energy, it is critical to consider individual and community attitudes and perceptions toward wind farm implementation and develop their ability to assess communication, policy, and planning initiatives that can mitigate local concerns. In Iowa, the best wind power resources are in areas with small rural communities and family-run farms that grow primarily corn and soybeans. An additional 25,000 wind turbines will potentially affect community vitality and the cost of producing row crops. Designing innovative policies that address local concerns while achieving national goals of expanded wind power will be a major effort of this research thrust. To help accomplish this, an assessment of the intended and unintended socio-economic and environmental impacts of wind turbine development on local communities is necessary to ensure a sustainable and equitable distribution of costs and benefits. We will conduct a multi-state survey to determine people's knowledge regarding wind energy, what misconceptions are held about wind, and its perceived disadvantages. This study will also employ nonmarket valuation techniques to estimate the economic costs of the unintended consequences (both positive and negative) associated with the local production of wind power. The results of this survey will help determine effective communication and planning strategies and test fundamental hypotheses concerning local and global externalities from wind power generation.

Mental models research to identify information needs for wind energy expansion: Reconciling the trade-offs between the risks and benefits of wind energy is contingent upon informed, directed, and two-way communication between experts and stakeholders. To aid in the design of such a communication effort, we will apply the mental models approach to determine the unique information and decision-making needs of stakeholders residing near potential wind farm sites. Based on the notion that people tend to assemble their knowledge of risks into a conceptual map of ideas, the goal of this approach is to identify misconceptions and important gaps in understanding on the part of both experts and nonexperts and contribute to the development of a more efficient and effective risk communication process.

Characterizing the public's perception of risks related to wind energy: Research within what has been called the psychometric paradigm has explored the ability of psychophysical scaling methods and multivariate analysis to produce meaningful representations of risk attitudes and perceptions. This study will ask people to judge the current riskiness (or safety) of wind energy based on what are called "outrage factors" (i.e., perception of risk is greater for innovations whose adverse effects may be seen as uncontrollable, dreadful, catastrophic, not offset by compensating benefits, and delayed in time so the risks are borne by future generations). Respondents also will be asked to indicate their desires for risk reduction and regulation of perceived hazards. The goal is to identify similarities and differences among groups with regard to risk perceptions and attitudes related to wind energy to inform potential communication strategies and efforts.

Communication with different stakeholder groups: Communicating with technical and political stakeholder groups will help ensure that the pace and ultimate scale of any expansion takes place at an optimal level. Expanding too rapidly may disrupt electricity markets whereas too slow or an inadequate scale of expansion may increase the cost of meeting greenhouse gas reduction objectives to unacceptable levels. In addition, information campaigns are an important means for reassuring the public regarding, for example, perceived environmental harms. However, the assumption that public support can be created or increased via information campaigns alone is problematic since it erroneously assumes that critics lack relevant knowledge and are responding emotionally or illogically. Instead, wind projects are more likely to gain high levels of public acceptance when there is a high level of public participation and collaboration in the process. We will consider how developers can collaborate with the public to provide locals with an opportunity to become invested in wind projects.

• Wind Resource Characterization and Aerodynamics of Wind Farms

Improving wind speed forecasting with lead times of 0-54 hr: Alternative forecasting techniques employing multiple mesoscale models combined with advanced statistical analyses will be used to improve forecasts in the time window of highest economic value for power sales.

Cost effectiveness of taller towers for extracting energy from the low-level jet: Wind resources at elevations of ~140 m are substantially higher than those at current turbine hub height (~80 m) due both to a general increase in speeds with height and an enhanced increase on occasion due to the presence of the Low-Level Jet. Because the costs for construction and maintenance also will be higher, a combined meteorological/economic analysis is needed to evaluate this potential.

Wind farm siting and wind turbine interaction within a wind farm: The Aerodynamic/Atmospheric Boundary Layer (AABL) Wind and Gust Tunnel at Iowa State University will be used to generate an AABL in flat and complex terrains to study the wind flow characteristics (e.g., vertical wind speed profiles, turbulence, wake) with and without wind turbines as well as turbine interactions. Flow measurements with a multi-hole Omni probe and Particle Image Velocimetry (PIV) will reveal the influence of upstream terrain, turbine blades and surrounding turbines for use in wind farm siting, optimization of wind power generation and calculation of wind loads on turbine components. Large eddy simulations, validated with wind tunnel data, and complemented with field measurements in local operating wind farms in our neighbourhood using Lidar will help provide a comprehensive strategy for wind farm siting and turbine interactions.

Interactions of turbine-generated turbulence with agricultural crops: Turbulence from turbines can change the temperature, humidity, and fluxes of heat, moisture, momentum, and CO_2 concentrations over crop canopies. The impact of this on the productivity of crops is unknown. Field measurements are needed to refine surface-layer models for evaluating season-accumulated impacts.

- ## **Manufacturing, Construction, and Supply Chain**

Nacelle weight and cost reduction: As the size of rotors continues to increase, major advances will be required to achieve the necessary weight reductions. The weight and cost of a wind turbine is proportional to the cube of the diameter of the rotor. Reducing cost and weight will involve an interdisciplinary focus on issues in component design, materials, and manufacturing. Two major components of the nacelle, the gearbox and generator, account for much of the weight. Housings for the gearbox and generator are made of ductile cast iron due legacy design practices. In the automotive industry, weight reductions of 20-70% have been achieved using magnesium alloys. However, the use of these alloys is not scalable to nacelle housings. Given their improved stiffness to weight ratio, steel castings hold promise in achieving significant weight reductions on the order of 10%. With the current trend of increasing size and height of wind turbines, research on component designs using steel castings is warranted. Studies are needed on design and process optimization, selection of steel alloy, and market acceptance using finite element analysis (FEA).

Transportation infrastructure planning: The current transportation infrastructure was not designed to support the transport of large scale products such as blades, nacelles, and towers. A fragmented set of regulations exist due to individual states that define a constrained set of routes for trucks. The wind industry has pushed super load permits to astronomical numbers. Four to five are needed for each load — last year, 22,000 were needed for 5,000 wind turbines. Transportation preplanning is critical to delivery. There are many obstacles, including overhead objects, height requirements, and weight limits. Students will study optimization methods for the routing of shipments given current transportation infrastructure constraints. Transportation planning for the future of wind energy will examine the infrastructure necessary to support larger scale wind energy deployment using simulation models to predict infrastructure performance and identify critical infrastructure needs.

Design of taller towers and their foundations: Today, steel towers are fabricated in a factory, transported to the site as three cylinders, and erected in the field. The 80m height of these towers is limited by the transportation system. Given that taller towers will provide a cost-effective means to increase wind energy production in less turbulent and increased wind velocity conditions, increasing the tower height will significantly boost our nation's wind energy production. Potential options to increase the tower height include manufacturing the tower in more pieces with additional fabrication on site, using a combination of concrete and steel, utilizing higher strength steel, concrete or other advanced materials that can facilitate towers of smaller diameters, or a combination of different techniques, all of which require collaborative research between material scientists, structural engineers, construction engineers and supply chain experts. As tower height increases, their foundations should also be designed cost-effectively, which is not done in current practice.

- # **Wind Energy Conversion System and Grid Operations**

Generator condition monitoring and sensor-fault-tolerant operation: The dissertation will develop new condition monitoring techniques for the electromechanical energy conversion system. In addition, we will investigate advanced sensor-fault-tolerant techniques to enable the operation of the turbine after the failure of sensors used in the control system (thus leading to increased energy yields and reduced maintenance requirements).

MIMO adaptive control of wind turbines: It is now common to provide individual pitch actuators at each blade so that the number of control inputs available to the system designer is increased above the traditional generator torque control. In addition, force/moment sensing or accelerometers can be installed at each blade individually as well as on the nacelle and tower. These additional inputs and outputs, and the fact that the turbine structural modes couple with the drive train and pitch actuation through torque and bending moments, make the wind turbine an inherently multi-input-multi-output (MIMO) system. Sensors used for the turbine health monitoring could be integrated in the control systems to provide robustness and adaptation mechanisms to wearing and faults. Modelling the stochastic nature of the change in wind profile as it travels and optimizing feed-forward control for operation in the presence of the resulting measurement errors will help to realize performance improvement.

Optimal control of wind farms: This work will develop optimal control strategies to regulate wind farm power production to the reference power ordered by the system operators. In this situation, operating each wind turbine at its own maximum power extraction point is not globally efficient due to aerodynamic interactions between the turbines. Rather, turbines should be orchestrated so that the wind farm achieves maximal power extraction compatible accounting for system operator demands and wind conditions.

Aerodynamic and aeroelastic loads: Aerodynamic and aeroelastic loads expected on future wind turbine systems must be considered for optimum design and in the development of new materials and processes necessary to achieve efficiency in these systems. We will use both time and frequency domain models for predicting the aerodynamic and aeroelastic loads on blades and towers to understand the aerodynamic drag/lift, stall and flutter characteristics of blades as well as vortex-induced/buffeting response of towers as influenced by surrounding terrain and wind turbines in a typical wind farm. Accurate dynamic modelling of wind turbine and its components based on realistic wind loads with parameters measured in the Aerodynamic/Atmospheric Boundary Layer (AABL) Wind and Gust Tunnel in an atmospheric boundary layer flow will help provide a more robust and reliable design of wind turbines to produce higher energy yields.

Electromechanical energy conversion systems: This topic involves analysis, modelling, and design of integrated multi-MW drive train systems that satisfy several (usually conflicting) design objectives related to parameters such as weight, cost, reliability, efficiency, maintenance requirements, mechanical stress, thermal losses, and operating characteristics, including the turbine's dynamic behaviour during grid disturbances. An approach that treats the energy conversion system as an integral component of the entire wind turbine is needed. A detailed analysis of dynamic effects of wind loading and overall operation will be coupled with a complete system design, which will lead to advances in drive trains. This effort will involve the modelling of continuously variable drives, medium speed hybrid drives, semi-integrated drive systems, and unique combinations of gearing and generators.

Wind power variability: At high wind penetration levels, grid integration requirements for maintaining power balance require increased regulation (time frame of seconds), load following (minutes), and dispatch (hour) capabilities. We will develop inter-farm control methods to address this, comparing it in terms of cost and performance to other proposed solutions, including individual turbine control, increased levels of fast-response reserves, and use of energy storage.

Collection circuit design: A central factor in any wind plant is the local lower-voltage collection system used to move energy from individual turbines to transmission substations while considering turbine placement for maximum energy extraction and agricultural constraints such as location of field drainage systems. We will explore various collection circuit technologies, including high phase order, high surge impedance loading and high temperature conductors, dynamic loading equipment, and direct 34.5 kV to 345 kV and 765 kV connections to obtain more capacity for a given right of way.

Increased transmission: Much of the nation's best wind resources are in regions of low population densities, constraining wind penetration levels due to long distance interstate high-voltage transmission necessary to move energy to the load centres. Although transmission is a relatively small fraction of the cost to produce electric energy, it is essential. For example, it was found that without significant additional investments, the Eastern U.S. Interconnection would not be able to reach even a 6% wind penetration level (by energy), much less than DOE's desired 20% by 2030. Conductor materials, the electric circuit design, and their deployment raise research issues related to the cost of circuit capacity, and interaction with rail and highway right of way (for transmission). Policy questions are key for transmission cost allocation, federal versus local power to force or block right of way access, and wind plant interaction with day ahead and real-time electricity markets.

EFFECTIVENESS OF THE PROJECT

A wind turbine is typically 30-45% efficient – rising to 50% efficient at times of peak wind. If that sounds low to you, remember that if turbines were 100% efficient, the wind would completely drop after going through the turbine. Wind turbines in the UK are producing electricity 70-80% of the time, making them a reliable source of power throughout the year.

Approximately 2% of the solar energy striking the Earth's surface is converted into kinetic energy in wind. Wind turbines convert the wind's kinetic energy to electricity without emissions. The distribution of wind energy is heterogeneous, both across the surface of the Earth and vertically through the atmosphere. Average annual wind speeds of 6.5m/s or greater at 80m are generally considered commercially viable. New technologies, however, are expanding the wind resources available for commercial projects. Approximately 3% of U.S. electricity was derived from wind energy in 2020, but wind capacity is increasing rapidly.

- High wind speeds yield more power because wind power is proportional to the cube of wind speed.
- Wind speeds are slower close to the Earth's surface and faster at higher altitudes. The average hub height of modern wind turbines is 90 meters.
- Global onshore and offshore wind power potential at commercial turbine hub heights could provide 840,000 TWh of electricity annually. Total global electricity consumption from all sources in 2018 was about 23,398 TWh.
- Similarly, the annual continental U.S. wind potential of 68,000 TWh greatly exceeds annual U.S. electricity consumption of 3,802 TWh.

A 2015 study by the U.S. Department of Energy found wind could provide 20% of U.S. electricity by 2030 and 35% by 2050

CONCLUSION

Wind energy is probably the solution for our energy demands. It has great potential and is easy to manage. All you have to do is build the turbine and everything else is going to be free. With only 1 turbine, you can power over 200 homes. Every wind turbine lasts for about 20-25 years. As long as the wind blows, wind turbines can harness the wind to create power. Wind power only makes up a tiny percent of electricity that is produced. Unlike coal, wind turbines don't create greenhouse gases and are completely renewable source. Many people believe that the wind energy could soon be our main source of energy. Though wind turbines can cause complaints and fatalities of wildlife, it could be the energy solution we have been looking for. From the report we learn about wind energy, brief introduction on it and also cost of wind farms. From the report we also studied that wind has a lot of potential in it and if properly harnessed then it can help solve the energy crises in the world.