Annexure-I

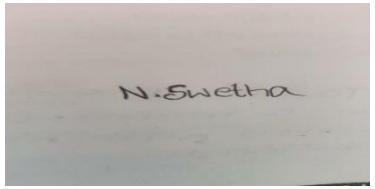
WIND ENERGY

Name of the Organization: COURSERA

Submitted in partial fulfilment of the requirements for the award of degree
of B. tech
at LOVELY PROFESSIONAL UNIVERSITY PHAGWARA, PUNJAB

From 06-05-2021 to 14-06-2021

Narni. Yoga Sai Swetha
12013251



DTU Technical University of Denmark

COURSE CERTIFICATE

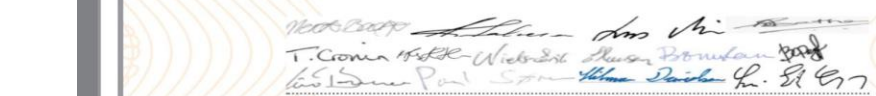
Jun 14, 2021

Narni Yoga Sai Swetha

has successfully completed

Wind Energy

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



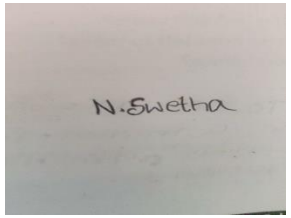
Merete Badger, Alma Salnaja, Lars Pilgaard Mikkelsen , Ameya Sathe, Vladimir Fedorov, Tom Cronin, Torben Krogh Mikkelsen, Morten Hartvig Hansen, Niels-Erik Clausen, Bonnie Ram, Sven-Erik Gryning, Kim Branner, Poul Ejnar Sørensen, Hilmar Kjartansson Danielsen, Henrik Bredmose

EDUCATION FOR EVERYONE · COURSE CERTIFICATE · coursera

Annexure-II

STUDENT DECLARATION To whom so ever it may concern I N. Yoga Sai Swetha , Registration Number 12013251, hereby declare that the work done by me on "WIND ENERGY" from May 2020 to June2020 is a record of original work for the partial fulfilment of the requirements for the award of the degree, B. Tech (Computer Science and Engineering).

Name of the student (registration number) Signature of the student: Narni. Yoga Sai Swetha (12013251)



INDEX

Chapter 1

Introduction to wind energy

- In recent years, wind energy has become one of the most economical renewable energy technology. Today, electricity generating wind turbines employ proven and tested technology, and provide a secure and sustainable energy supply. At good, windy sites, wind energy can already successfully compete with conventional energy production. Many countries have considerable wind resources, which are still untapped.
- The technological development of recent years, bringing more efficient and more reliable wind turbines, is making wind power more cost-effective. In general, the specific energy costs per annual kWh decrease with the size of the turbine notwithstanding existing supply difficulties.
- Many African countries expect to see electricity demand expand rapidly in coming decades. At the same time, finite natural resources are becoming depleted, and the environmental impact of energy use and energy conversion have been generally accepted as a threat to our natural habitat. Indeed, these have become major issues for international policy.
- A technology which offers remarkable advantages is not used to its full potential:

a) Wind energy produces no greenhouse gases

b) Wind power plants can make a significant contribution to the regional electricity supply and to power supply diversification.

c) A very short lead time for planning and construction is required as compared to conventional power projects.

d) Wind energy projects are flexible about an increasing energy demand - single turbines can easily be added to an existing park.

e) Finally, wind energy projects can make use of local resources in terms of labour, capital, and materials.

Chapter 2

How wind energy works

- How Wind Turbines Work 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:

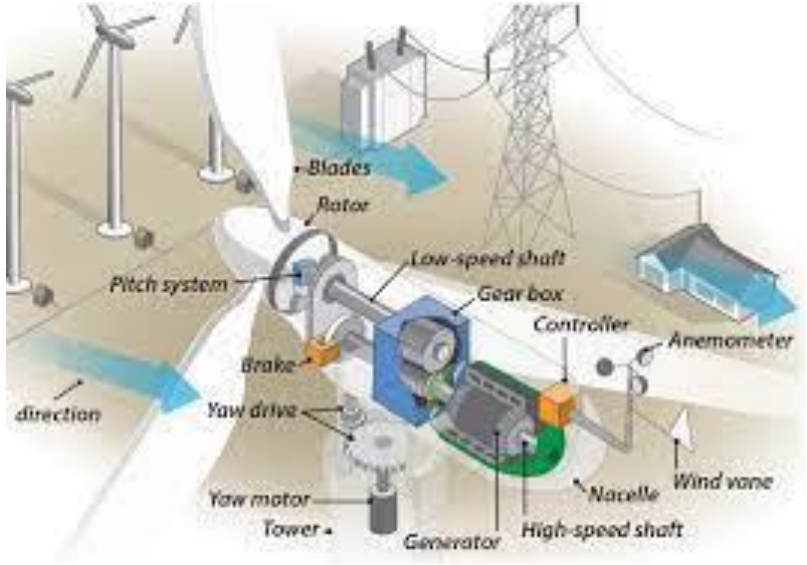
  Modern wind turbines fall into two basic groups: the horizontal-axis variety, as shown in the photo, and the vertical-axis design, like the eggbeater-style Darrius model, named after its French inventor. Horizontal-axis wind turbines typically either have two or three blades. These three-bladed wind turbines are operated
  "Upwind," with the blades facing into the wind.

Sizes of Wind Turbines:

Utility-scale turbines range in size from 100 kilowatts to as large as several megawatts. Larger turbines are grouped together into wind farms, which provide bulk power to the electrical grid. The average size wind turbine being installed at wind farms currently is approximately 1.5 MW. Single small turbines, below 100 kilowatts, are used for homes, telecommunications dishes, or water pumping. Small turbines are sometimes used in connection with diesel generators, batteries, and photovoltaic systems. These systems are called hybrid wind systems and are typically used in remote, off-grid locations, where a connection to the utility grid is not available.

Inside a Wind Turbine:

Below is a diagram of the inside of a wind turbine, along with descriptions of each part.



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

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

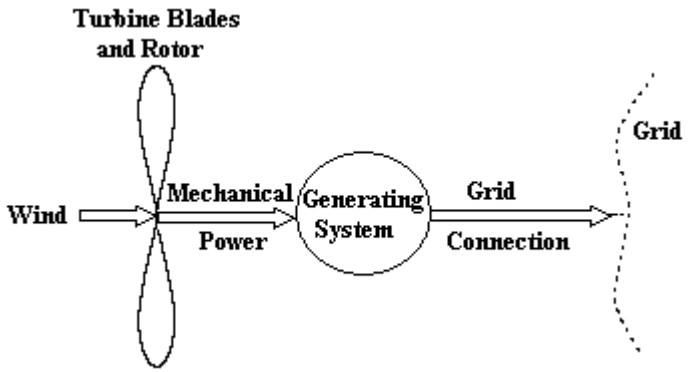
- Brake: A disc brake, which can be applied mechanically, electrically, or hydraulically to stop the rotor in emergencies.

- Controller: The controller starts up the machine at wind speeds of about 8 to 16 miles per hour (mph) and shuts off the machine at about 55 mph. Turbines do not operate at wind speeds above about 55 mph because they might be damaged by the high winds.

- Gear box: Gears connect the low-speed shaft to the high-speed shaft and increase the rotational speeds from about 30 to 60 rotations per minute (rpm) to about 1000 to 1800 rpm, the rotational speed required by most generators to produce electricity. The gear box is a costly (and heavy) part of the wind turbine and engineers are exploring "direct-drive" generators that operate at lower rotational speeds and don't need gear boxes.

- Generator: Usually an off-the-shelf induction generator that produces 60-cycle AC electricity.
- High-speed shaft: Drives the generator.
- Low-speed shaft: The rotor turns the low-speed shaft at about 30 to 60 rotations per minute.

- Nacelle: The nacelle sits atop the tower and contains the gear box, low- and high-speed shafts, generator, controller, and brake. Some nacelles are large enough for a helicopter to land on.
- Pitch: Blades are turned, or 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: The blades and the hub together are called the rotor.
- Tower: Towers are made from tubular steel (shown here), concrete, or steel lattice. Because wind speed increases with height, taller towers enable turbines to capture more energy and generate more electricity.
- Wind direction: This is an "upwind" turbine, so-called because it operates facing into the wind. Other turbines are designed to run "downwind," facing away from the wind.
- Wind vane: Measures wind direction and communicates with the yaw drive to orient the turbine properly with respect to the wind.
- Yaw drive: Upwind turbines face into the wind; the yaw drive is used to keep the rotor facing into the wind as the wind direction changes. Downwind turbines don't require a yaw drive; the wind blows the rotor downwind.
- Yaw motor: Powers the yaw drive1. 1 U.S. Department of Energy. Wind and Hydropower Technologies Program.



Chapter 3

Advantages and Disadvantages of wind energy

- **Advantages of wind energy**
- Wind energy is renewable and green energy which provides clean electricity for many countries at a global level.
- **Renewable and sustainable**
- This type of energy is both sustainable and renewable since the wind is a resource we will never run out of. On the other hand, using fossil fuel to produce energy would not only affect the overall resource of fossil fuel, but it will also pollute the air.
- **Environmentally friendly**
- Wind power is an environmentally friendly energy source that facilitates the planet. After specialists manufacture and install wind turbines, the quantity of pollution will diminish due to the use of the wind turbines. They do not generate greenhouse gases like methane or carbon dioxide. We all know that these dangerous gases contribute to the amplification of climate change effects.
- **Reduction of fossil fuel consumption**
- If we were all to use wind energy, we would reduce the consumption of fossil fuel which is very harmful to the environment. Therefore, we will no longer use gas, oil, and coal in industrial amounts. Hence, we will be able to conserve out planet's natural resources, preserving them to support future generations.
- **Wind energy is free**
- This energy source is entirely free, unlike other energy sources. Therefore, there is no market for the demand and supply of wind energy. Anyone can use it, and we will never run out of it. Hence, wind energy is a viable option to produce cheap electricity.
- **Reduction of fossil fuel consumption**
- If we were all to use wind energy, we would reduce the consumption of fossil fuel which is very harmful to the environment.

Therefore, we will no longer use gas, oil, and coal in industrial amounts. Hence, we will be able to conserve out planet's natural resources, preserving them to support future generations.

- **Wind energy is free**
- This energy source is entirely free, unlike other energy sources. Therefore, there is no market for the demand and supply of wind energy. Anyone can use it, and we will never run out of it. Hence, wind energy is a viable option to produce cheap electricity.
- **Industrial and domestic installations**
- Wind turbines are not only helpful when it comes to industrial-scale installations, but they can also be used on a domestic scale. Furthermore, many landowners can choose to install less powerful and smaller wind turbines to facilitate their houses by providing part of their domestic electricity supply. Usually, landowner couple domestic wind turbines with other green energy technologies like solar panels.
- **Low maintenance**
- Wind energy is a low maintenance solution. A wind turbine from the new generation can

  last quite a while before needing maintenance work. You should know that each generation of wind turbines helps to enhance reliability.

- **Disadvantages of wind energy**
- **Wind reliability**
- Since this type of green energy relies on wind power, this infinite resource does not usually blow reliably. Furthermore, wind turbines use only 30% of their capacity to function. Hence, if the weather does not support your wind turbine, you will not be able to generate power using the turbines. Therefore, you will need to rely on the electric company for a while.
- Another disadvantage is that if the winds are too powerful or a storm starts, then it may cause a lot of damage to your wind turbine. The most damaging and unpleasant event that might occur during a storm is for your wind turbines to get struck by lightning.
- **Visual pollution and noise**
- Apparently, wind turbines may be difficult to install, and they deliver a sound estimated at 50 to 60 decibels. Some people may also complain about the fact that these huge turbines can represent visual pollution, being unattractive. They think these giants can ruin the beauty of landscapes.
- **The effect on the environment**
- Ironically, this renewable energy requires for massive areas of open space. Therefore, it encourages deforestation. Hence, the green effect of this source of energy fades away. Furthermore, when you want to install a wind turbine, mandates and consistence with city codes may necessitate a lot of time and effort. On the other hand, there may be some height confinements which may also prohibit you from installing one on your property.
- **People’s safety**
- During a powerful storm, the wind turbine’s blades may damage, probably falling. This can constitute a safety hazard to those working near it. Wind turbines may malfunction from different reasons, and they may fall on people, causing different injuries or even death.

Chapter 4

Steps to building a wind farm

- 1. Understand Your Wind Resource:

The most important factor to consider in the construction of a wind energy facility is the site's wind resource. A site must have a minimum annual average wind speed in the neighbourhood of 11-13 mph to even be considered. Local weather data available from airports and meteorological stations may provide some insight as to averages. You can also check the wind maps for your state on the National Renewable Energy Laboratory In time; you will want to install you own monitoring devices to record the site's wind characteristics.

- 2. Determine Proximity to Existing Transmission Lines:

A critical issue in keeping costs down in building a wind farm is minimizing the amount of transmission infrastructure that has to be installed. High voltage lines can cost thousands of dollars per mile. (An article from the USA Today on 2/26/08 cited high voltage line cost at $1.5 million per mile.) Whenever possible, availability and access to existing lines should be considered in selecting a site.

- 3. Secure Access to Land:

Landowners, both private and public, will expect to be compensated for any wind energy development that occurs on their land. Royalty or lease agreements will need to be discussed with all parties involved. Roads, transmission equipment, maintenance infrastructure, turbines, and the like all need to be considered. Moreover, the construction of a wind farm necessitates the use of heavy industrial equipment. Developers will need to invest in roads capable of accommodating significant weight. To do so will require the cooperation of landowners and, in some case, the local community.

4. Establish Access to Capital:

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 more than 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. (In the first quarter of 2008, 1,479 MW of capacity was added to the U.S. market from 955 turbines. This averages to 1.55 MW of capacity per turbine. The average size of the wind projects was 61.6 MW, which would equate to approximately 40 turbines. Investment costs in wind turbines has risen to over $2.1 million per MW recently, which would mean that a 61.6
MW wind project would cost over $129 million)

5. Identify Reliable Power Purchaser or Market:

To date, wind energy is the most cost competitive renewable energy option on the market. In fact, wind energy's cost has declined so much that it rivals many traditional power generation technologies. However, utilities will tend to purchase power from what they consider to be the cheapest and most reliable technology. In most cases today, that is natural gas. That does not mean there is not a market for wind, though. Demand for "green power" (electricity from clean sources like wind that is sold to customers at a premium price) and environmental requirements are creating buyers for wind energy and competitive rates. Before investing thousands of dollars into wind resource assessments, permitting, and pre-construction activities, a developer will secure tentative commitments from one or more buyers for the wind plants output over 10 to 30 years of its operational lifetime.

6. Address Siting and Project Feasibility Considerations:

The fact that a site is windy does not mean it is suitable for wind power development. A developer needs to consider many factors in siting a project. Is there high raptor activity in the area? Are there endangered or protected species that could be jeopardized by the presence of the facility? Is the site's geology suitable and appropriate for industrial development? Will noise and aesthetics be issues for the local community? Will the turbines obstruct the flight path of local traffic? There are quite a few environmental and social issues that will need to be addressed in the siting of a wind power facility. Wind farms can make great neighbours, but it is the obligation of the developer to work to ensure that a project proceeds in a fashion that is acceptable to regulators and the local community.

7. Understand Wind Energy's Economics:

There are many factors contributing to the cost and productivity of a wind plant. For instance, the power a wind turbine can generate is a function of the cube of the average wind speed at its site, which means that small differences in wind speed mean large differences in productivity and electricity cost. Additionally, the swept area of a turbine rotor is a function of the square of the blade length (the radius of the rotor's swept area). A modest increase in blade length boosts energy capture and cost-effectiveness. Financing methods can make a major difference in project economics as well. Securing significant investment capital or joint ownership of a project can cut costs significantly. Furthermore, there are federal and state incentives for which a project may qualify, and which could reduce costs and encourage more favourable investment.

8. Obtain Zoning and Permitting Expertise:

Siting any power project can be a daunting task due to the dizzying array of social and environmental factors at play. A wind power developer would be well served to obtain the services of a professional familiar with the regulatory environment surrounding wind power development. Additionally, legal counsel familiar with the local political climate may be able to help navigate the permitting process.

9. Establish Dialogue with Turbine Manufacturers and Project Developers:

Every wind turbine is different despite seemingly similar power ratings. Some machines are designed to operate more efficiently at lower wind speeds, while others are intended for more robust wind regimes.

10. Secure Agreements to Meet Operation and Maintenance Needs:

Wind turbine technology has made great strides in the recent years. Today's machines are more efficient and cost-effective than ever. However, they are also more complex. Turbine availability (reliability) is a major factor in project success, and the services of professionals familiar with the operation and maintenance of wind turbines can prove to be invaluable. Also, turbine manufacturers may offer more favourable product guarantees knowing that qualified project operators will be on site to maintain the equipment. Developer would be wise to investigate all the various considerations and compare the performance of existing machines. Moreover, anecdotal information and even the professional services of wind power developers may prove helpful.

Chapter 5

Local issues related to wind energy

- Wildlife:

One issue that often arises when building a new wind farm is the potential effect on local wildlife. The development of wind farms necessitates the building of new roads and other infrastructure in areas that were previously undeveloped. This changes the habitat of any wildlife living in the area.

One case in point that is often pointed to is the affect to migratory birds at the Altamont wind farm in California. The Altamont Pass is known for high winds and is on an important bird-migration route. The California Energy Commission found that 880 to 1,300 raptors were killed at Altamont every year. To avert legal proceedings, the owners of the wind farm agreed to shut down half of their turbines for four months of the year.

Wind energy proponents argue that bird kills related to wind farms is very insignificant. They point to research on bird mortality that shows that for every 10,000 birds killed by human activities, less than one death is caused by a wind turbine, while buildings/windows are responsible for 5,500 deaths. This issue is most likely not as large of an issue in Illinois as wildlife habitat has already been significantly affected by the conversion of a large percentage of the State's acreage to agricultural purposes previously.

- Noise:

Another issue that is brought up in trying to stop the development of wind projects is that wind turbines are noisy. Wind energy proponents claim that an operating modern wind farm at 750 to 1,000 feet is no noisier than a kitchen refrigerator or a moderately quiet room.

Industry studies estimate wind turbine noise levels to be around 45 decibels. They do acknowledge that two situations can occur where wind farms can be louder. The first situation is when older turbines are in operation. Older turbines form the 1980's tended to be louder.

The other situation occurs in hilly terrain with modern turbines. Homes located in sheltered dips or hollows downwind from a wind farm could experience a noisier environment due to noise carrying further. The second situation can often be anticipated and avoided in the development process through adequate setbacks.

- Aesthetic:

Some opponents find the thought of dozens of wind turbines to be an eyesore on the landscape. Other people find a wind farm to be beautiful. This complaint is somewhat subjective. One thing that developers can do is to virtually depict what the finished wind farm will look like from different vantage points to allow local stakeholders to assess the situation prior to development. Another aesthetic problem is lighting on wind turbines. The Federal Aviation Administration (FAA) recommends lighting for most structures more than 200 feet in height to ensure aviation safety. This lighting can be irritating to some people. The wind industry is currently working with the FAA on lighting setups that would limit the number of lights needed for a given wind project.

Shadow Flicker:

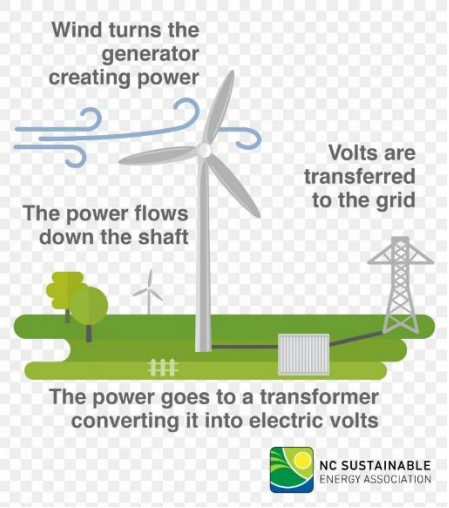
Shadow flicker is the term used to describe what happens when rotating turbine blades come between a viewer and the sun, causing a moving shadow. Shadow flicker can be annoying to people trying to read or watch television. In the U.S., shadow flicker should not be a problem as the sun's angle is not very low in the sky due to the U.S.'s latitude (except in Alaska). This problem is rare today due to better project planning and larger setbacks. If there is an affect, it is generally for a few hours total over a year's time.

- N.I.M.B.Y.ism:

  N.I.M.B.Y. stands for Not in My Back Yard.

  N.I.M.B.Y.ism occurs when a new idea or plan is thought to be a good idea by the general population until it is decided to be developed in the area that the population lives. Renewable energy is generally thought to be a good idea by many Americans but often this opinion changes when a new project is planned in their area. To overcome this problem, developers need to take actions to keep residents and communities fully informed. These actions need to be done early and often. The benefits of a wind farm are often seen as larger than the potential negatives, but this process can be hindered if the local community feels that they are not being included in the process and that their voices are not being heard by the developers and the owners. Other Issues:

- Opponents claim wind turbines interfere with television and other communication signals, industry counter that this is rare and easily avoided
- Wind farms depress home values, proponents say this is unfounded
- Turbines are dangerous due to ice throws and blade throws; proponents reply that new designs have basically eliminated this problem



Chapter 6

Wind energy future

- Wind energy's future appears to be bright. Annual growth rates of almost 30% over the last five years indicate that the industry has been growing by leaps and bounds. This growth could potentially be hindered if the Production Tax Credit is not renewed for 2009. Industry participants view the future as unlimited.

  Julius Steiner, CEO of Gamesa USA, declared that

  "The future horizons are truly limitless in terms of wind energy development in the U.S." Roby Roberts, Vice President of Government Relations for Vestas, agreed stating that "We believe that the U.S. is the world's greatest wind market.

" The industry continues to conduct research to make wind energy more efficient. Governments continue to promote the industry through grant programs and subsidies. These efforts may lead to technological breaks in off-shore wind energy and more efficient land-based wind energy, which may lead to greater energy independence and a lessening effect on the environment by the American people. A recent study by the U.S. department of Energy found that a scenario where wind energy would achieve a 20 percent contribution to the U.S. electricity supply is feasible.

Conclusion

- Conclusion Wind energy is being widely accepted as a favoured form of renewable energy. Wind farms have not only taken significant steps to address issues critical to the environment and people but have also been instrumental in addressing economic concerns by creating job opportunities and reducing dependence on fossil fuels. Despite being accepted as a form of clean energy, wind energy development farms still face issues regarding landscape aesthetics and impacts on wildlife which are specific to a region and cannot be addressed by means of a pre-defined generalized model. With increasing acceptance of wind energy throughout the globe, technological advances are being made to increase efficiency and reduce the negative impacts thus showing promising future in energy industry.

REFERENCES

coursera

Google

WIKIPEDIA
The Free Encyclopedia