Scheme Of Evaluation
Internal Assessment Test 1 –Mar.2019

Sub:	Integration of distributed generation							**Code:**	15EE833
Date**:**	07/03/2019	Duration:	90mins	Max Marks:	50	**Sem:**	VIII	**Branch:**	EEE

Note: Answer Any Five Questions

Question #	Description	Marks Distribution	Max Marks
1	**Briefly explain status and properties of the wind power** • About wind power • Technologies used for wind energy conversion • Explain wind speed spectrum with diagram • Explain variation of wind power for different location.	2M 2M 3M 3M	10 M
2	**Discuss about variation in wind speed and variation in production capacity of wind power** • Explain variation of wind power with different time scale • Diagrams showing the variation with respect to different time scale • Reason for the variation in production capacity.	4 M 4M 4 M	10 M
3	**Explain distribution of power production and expected energy production.** • Explanation of distribution with neat diagram • Statement of expected energy production with diagram	5 M 5 M	10 M

4	**Show the weibull distribution of wind speed with neat diagram.** • Equations of probability distribution function, probability density function, and mean value of weibull distribution • Diagram showing effect of shape factor on probability density function and probability distribution function	6 M 4 M	10 M
5	**Describe the power distribution as a function of wind speed** • Draw power curve and explain about different region(Cut in speed and cut out speed)	10M	10 M
6	**Briefly explain status and properties of solar power** • About solar power • PV cell installation and its rating in different place • Conventional method of using solar power	3M 4M 3M	10 M
7	**Discuss photovoltaic and different methods used for MPPT calculation** • Explanation of PV cell with simplified equivalent circuit • Perturb and observe • Incremental conductance • Constant voltage method	4M 2 M 2 M 2 M	10 M

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Internal Assesment Test - I

Sub:	Integration of distributed generation							Code:	15EE833
Date:	07/03/2019	Duration:	90 mins	Max Marks:	50	Sem:	8	Branch:	EEE(A/B)
Answer Any FIVE FULL Questions									

		Marks	OBE	
			CO	RBT
1	Briefly explain status and properties of the wind power.	[10]	CO1	L2
2	Discuss about variation in wind speed and variation in production capacity of wind power	[10]	CO1	L2
3	Explain distribution of power production and expected energy production.	[10]	CO1	L2
4	Show the weibull distribution of wind speed with neat diagram.	[10]	CO1	L3
5	Describe the power distribution as a function of wind speed.	[10]	CO1	L3
6	Briefly explain status and properties of solar power.	[10]	CO1	L3
7	`2.	[10]	CO1	L2

1.Briefly explain status and properties of the wind power.

The kinetic energy from the horizontal displacement of air (i.e., wind) is transformed into kinetic energy of the rotation of a turbine by means of a number of blades connected to an axis. This rotational energy is then transformed into electrical energy using an electrical generator. Different technologies have been proposed and used during the years to produce electricity from wind power. Currently, the main technology the mechanical side is a two-or three-blade turbine with a horizontal axis. Three competing technologies are in use for the transformation into electrical energy and the connection to the power system: the directly connected induction generation; the double-fed induction generator (DFIG) (more correctly named “double-fed asynchronous generator”); and the generator with a power electronics converter. Wind power is the most visible new source of electrical energy. It started off as small installations connected to the low-or medium-voltage networks. The last several years have seen a huge expansion of wind power in many countries, with the current emphasis being on large wind parks connected to the sub transmission or transmission system. Single wind turbines of 2MWsize have become the typical size and turbines of 5–6MW are available, although they are not yet widely used. Developments are going fast, so these values could well have become outdated by the time you read this book. Single wind turbines in Europe are now mainly being connected to medium voltage networks; but in more and more cases, groups of turbines are connected together into a wind park. Smaller wind parks, 3–10 turbines is a typical range, can still be connected to the medium-voltage network, but the larger ones require connection points at sub transmission or transmission level. Several parks larger than 500MW are in operation or under construction in the United States, with Texas and California taking the lead. The biggest wind park at the moment is the Horse Hollow Wind Energy Center in Texas. It consists of 291 turbines of 1.5MWand 130 turbines of 2.3MW giving it a total capacity of 735MW. However, even more larger ones are already under construction or planned. For example, a very large wind park is planned near the north Swedish town of Pite°a, with 1100 turbines of 2–3MW each and an expected annual production between 8 and 12 TWh, that is, between 5 and 8% of the total consumption in Sweden. News items about large wind parks appear almost continuously and the wind power production is growing fast in many countries. Several countries have planning targets of 20% electrical energy from wind power by 2020. Some European countries already produce more than 10% of their electrical energy from wind power; Denmark being on top with 20% of its electrical energy produced by wind. Of the large European countries, Germany (with 7% of electricity coming from wind) and Spain (12%) are the main wind power producing countries.

Wind power shows variations in production capacity over a range of timescales, from less than 1 s through seasonal variations. There remains difference of opinion about which timescale shows the biggest variation. This depends strongly on the application. We will discuss variations at different timescales in this chapter and in some of the other chapters. The term intermittent generation is often used to refer to the strong variation with time of wind and solar power. What matters to the power system is however not just the variation with time but also the extent to which the variations can be predicted. For the distribution system, it is merely the actual variations that matter; while for the transmission system, it is both the variations and their predictability that are of importance. The wind speed and thus the wind power production are difficult to predict longer than a few hours ahead of time. Over larger geographical areas, which is what matters at transmission level, predictions of total production become somewhat better.
But even here large prediction errors are not uncommon.

2)Discuss about variation in wind speed and variation in production capacity of wind power

One of the most discussed properties of wind power is its so-called “intermittent” character—the wind speed and thus the power production vary strongly with time over a range of timescales. The variability of the wind is often presented as a power spectrum. This is discussed among others in Ref. 389, according to which the wind speed variance spectrum shows 5-day variations probably related to major weather patterns, daily variations becoming less with altitude, and variations in the range between 10 s and 1 min. The so-called “spectral gap” is present between 2 h and 3 min. It is said to be confirmed by many measurements that such a gap appears at almost all locations. It provided a clear distinction between large-scale motion (at timescales above 2 h) and small-scale motion (at timescales less than 10 min). the wind power production “varies very little in the time frame of seconds, more in the time frame of minutes and most in the time frame of hours.” Typical standard deviations are as follows:

• 0.1% at 1 s timescale,
• 3% at 10 min timescale, and
• 10% at 1 h timescale.

power spectrum with three distinctive peaks:

• “turbulence peak” between 30 s and 3 min,
• “diurnal peak” around 12 h, and

• “synoptic peak” between 2 and 10 days.

The measurements showed that there is very little energy in the region between 10 min and 2 h. This region is often referred to as the “spectral gap.” The presence of this has been confirmed by measurements performed at other locations, for example, From a power system operation viewpoint, this is good news. The turbulence peak is a local phenomenon and will average out when many turbines are connected over a wider geographical area. The result is that wind power production will be in general rather constant for timescales up to a few hours. From this it should not be concluded that there are no changes in this range of timescales. For transmission system planning and operation, it is often the worst-case situations that matter. The fact that they are rare does not always matter. We will come back to this topic in Chapter 8. Not all measurements do however show the presence of the spectral gap, nor the diurnal or synoptic peak. This may depend on local conditions, which will especially impact the turbulence part of the spectrum. , for example, that the output power from two wind parks (with 6 and 10 turbines) follows the so-called “Kolmogorov spectrum” (proportional to frequency to the power of−5/3) over the time range of 30 s–2.6 days. It should also be noted here that the “power spectrum” in this context is not the spectrum of the power production but (for a deterministic signal) the square of the magnitude of the spectrum (Fourier series) of the wind speed. For a stochastic signal, the power spectral density is the Fourier transform of the auto covariance function

Turbulence, leading to power fluctuations in the timescale from less than 1 min to about 1 h, is discussed in detail in, among others, A distinction thereby has to be made between “turbulence” and “gusts.” Turbulence is a continuous

phenomenon, present all the time, whereas a wind gust is an occasional high value of the wind speed superimposed upon the turbulent wind. Readers familiar with power quality will recognize the similarity in the distinction between “power quality variations” and “power quality events Turbulence is a complicated process, which is very difficult if not impossible to quantify. It depends not only on local geographical features (like hills and rivers) but also on the presence of trees and buildings. Also, vertical movement of the air due to heating of the earth surface by the sun results in turbulence. As turbulence is a surface-related phenomenon, it will reduce with increasing height. The higher a wind turbine, the less affected by turbulence. In terms of the power density spectrum, the turbulence peak diminishes with increasing height. The shift from individual small turbines to wind parks consisting of large turbines implies that turbulence has become less of an issue for the power system. It remains an issue for the mechanical design of the turbine, but this is beyond the scope of this book. The level of turbulence is quantified by the so-called “turbulence intensity.” To obtain this, the wind speed is sampled with a high sampling frequency (one sample per second or higher) over an interval between 10 min and 1 h. The turbulence intensity is the ratio of the standard deviation to the average over this interval the turbulence intensity is typically between 0.1 and 0.4, with the highest values obtained during low wind speed. However, some of the standard models for turbulence recommend the use of a turbulence intensity independent of the wind speed. it also states that the Gaussian distribution is an appropriate one to describe turbulence. The distinction between turbulence and gusts is very important here: the probability of a wind gust exceeding a certain value is not found from the Gaussian distribution for turbulence. Of more interest from a power system viewpoint is the spectrum of the turbulence, that is, which frequencies occur most commonly among the fluctuations in wind speed. Several such spectra are shown in Section 2.6.4 of Ref. 71, with their peak between 1 and 10 min. The 50% value of the turbulence peak is between 10 s and 1 h. As mentioned before, the actual spectrum strongly depends on location and time, for example,

depending on the wind direction. When the turbulence peak exceeds beyond 1 h, the above-mentioned spectral gap will disappear and the turbulence peak will go over into the diurnal and synoptic peaks. From a power system viewpoint, what matters are not the variations in wind speed but the variations in power production. The power production is a nonlinear function of the wind speed; variations in wind speed have the strongest impact on the power production when the wind is between (about) 5 and 10m per second Further, the interest is not in the relative variations in power production (in percent) but in the absolute variations (in kilowatt). It is the absolute variations that cause variations in voltage magnitude, that result for example in the kind of fluctuations in light intensity that give complaints from nearby customers about light flicker.
variations in production capacity for wind power over a range of timescales, starting at the shortest timescales. The current way of operating wind power implies that variations in production capacity in almost all cases result in the same variations in actual production. In other words, the production is always equal to the capacity. It is possible to reduce the amount of production below the capacity, but that would result in “spilled wind.” Any reduction in wind power production will have to be compensated by other sources, in most cases fossil fuel. At the shortest timescale, seconds and lower, the production of an individual turbine varies mainly due to the impact of the tower on the flow of air around the turbine. This has been studied in detail because the fluctuations in power production because variations in voltage magnitude that could result in observable variations in light intensity of certain types of lighting. Another source of power fluctuations at the shortest timescale is the fact that the wind speed is higher at higher altitudes. When a blade is pointed upward, it will catch more energy from the wind than when it is pointed downward; the total amount of energy for the three blades will depend on their position. Also, mechanical oscillations in the turbine and the tower as well as the gearbox cause some fast variations in power. All this holds for individual turbines. For large wind parks and for larger regions, these variations will add randomly and become less and less important. Using power electronics techniques and a small amount of storage, variations at a timescale of seconds can be limited even for individual turbines. Energy storage can be present in the form of capacitors connected to a DC bus or by letting the rotational speed of the turbines vary somewhat. At a longer timescale (minutes), turbulence is the main cause of variations in produced power. The level of turbulence strongly depends on local conditions (landscape as well as weather) and is very difficult to predict. Recommended values for turbulence given in standards and in the literature are mainly used as input in the mechanical design of the installation. In practice, the level of turbulence is not constant at all even at a single location.

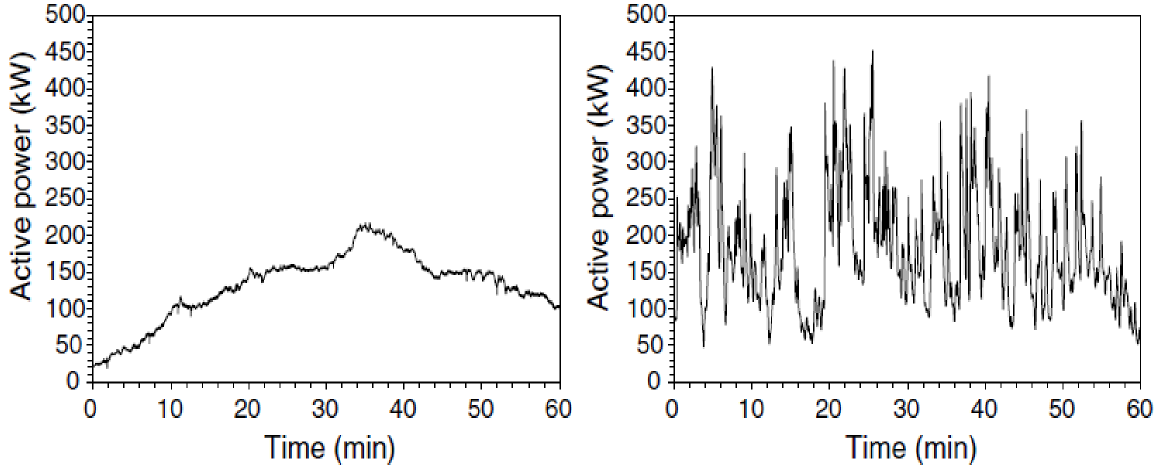

Figure 2.1 Active power fluctuations for the same turbine at the same location during two different 1 h periods.

A measurement of the power fluctuations for a 600kW turbine with full power converter, over two different periods of 1 h, is shown in Figure 2.1. Active power values were obtained every second. The two 1 h periods were about 20 h apart. The level of turbulence varies a lot between these two 1 h periods.

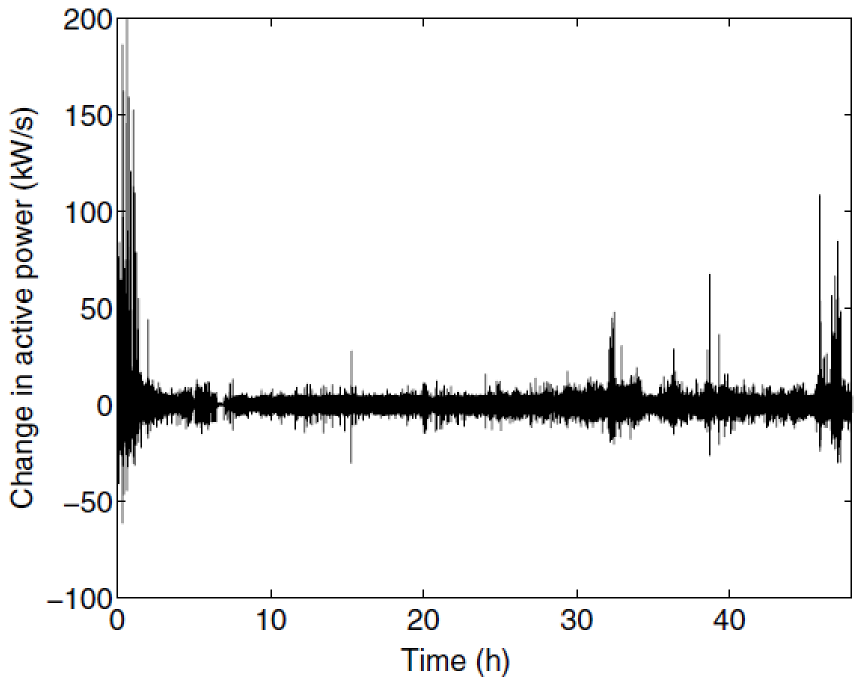

Figure 2.2 Second-by-second change in active power for a 600-kW wind turbine during a 48 h period.

From the measured values of active power for the 600kW turbine, the second by-second variations in power are calculated. The curve in Figure 2.2 is calculated as the difference between two consecutive 1 s averages. Most of the time two consecutive values do not differ more than 20kW; however, extreme values up to 200kW can be seen. The fast changes occur only during certain periods, and the largest changes are positive (i.e., a fast rise in power).

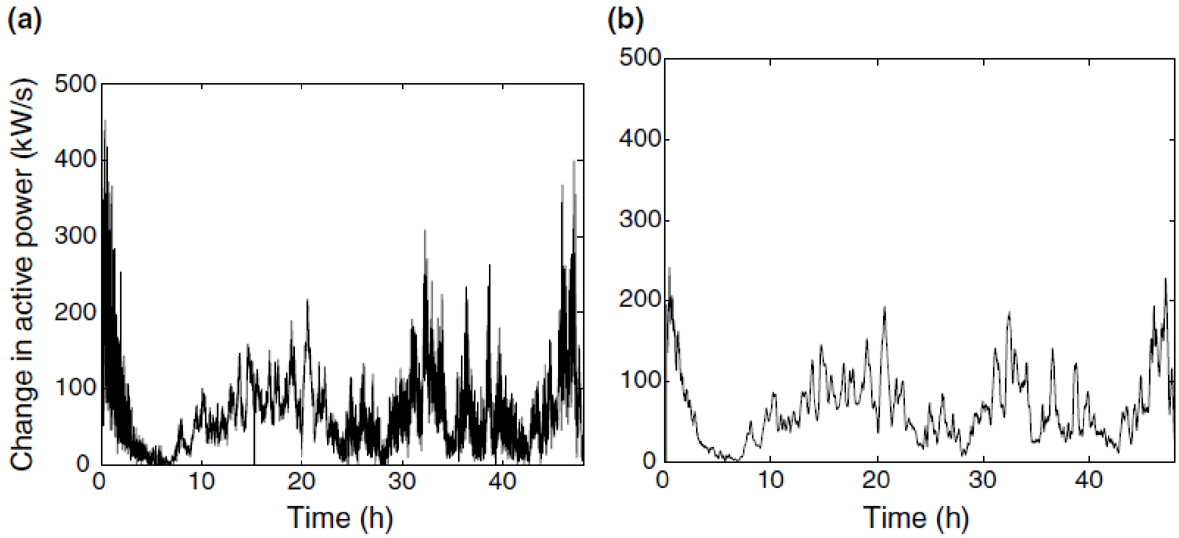

Figure 2.3 1 s (a) and 10 min (b) averages of the active power production for a 600 kW wind turbine during a 48 h period.

3)Explain distribution of power production and expected energy production.

The amount of power generated by a wind turbine is a strongly nonlinear function of the wind speed. The power curve, the relation between wind speed and generated power, is shown in Figure 2.19 for five turbines, all with rated power of 600kW the power curves for these five turbines are very similar; the differences are mainly in the high wind speed part of the curves

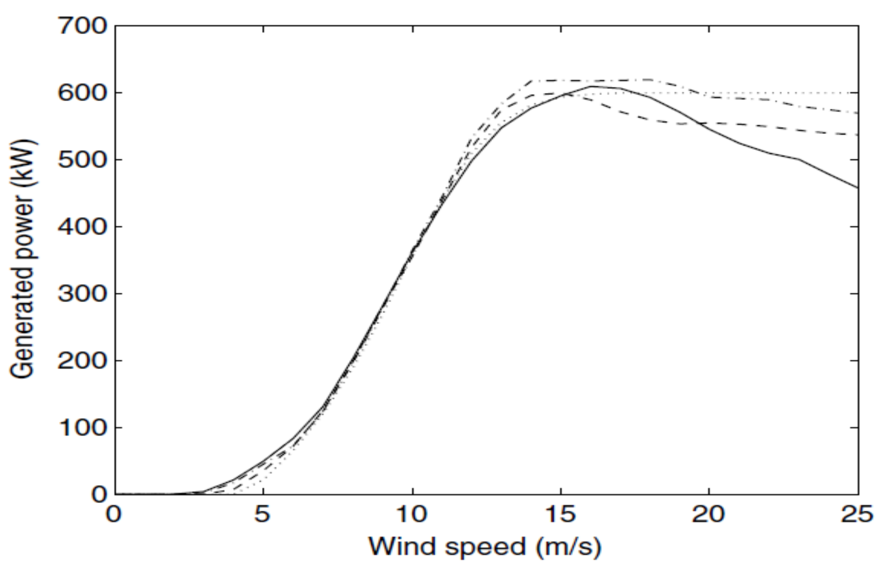

Figure 2.19 Generated power as a function of the wind speed for four different 600 kW wind turbines: type I (solid); type II (dashed); type III (dash-dotted); and type IV (dotted).

The power production is zero for small wind speed, below the so-called “cutin speed.” This is where the energy in the wind is insufficient to supply the mechanical and electrical losses. Energy from the grid would be needed to keep the blades moving. The cut-in speed is between 3 and 4 m/s.

The power production increases fast with the increasing wind speed. In this region, the turbine produces its maximum power for the given wind speed. The amount of energy in the wind is proportional to the cube (the third power) of the wind speed. It is this relation that is mainly responsible for the fast rise in power production. Variations in wind speed in this region will cause large variations in production.

• For further increase in the wind speed, the produced power increases less fast and eventually becomes constant or even decreases somewhat, depending on the type of turbine. The rated power of a wind turbine is the rated power of the electrical installation. This is what sets a limit to the amount of electrical power that can be produced. The power from the blades to the electrical machines should not exceed the machine rating too much, otherwise the machine will be overloaded and fail. There are two methods in use to limit this power: active control by slightly rotating the blades (pitch control), and passive control through the shape of the blades (stall control). With active control, the power is kept constant at its rated value resulting in a flat power curve. With passive control, the power is somewhat higher than rated for medium speed and somewhat lower for high wind speed. The speed at which 90% of rated power is reached ranges from 10.5 to 14 m/s. The wind speed at which the rated power is reached is sometimes referred to as the “rated speed.”

• For the very high wind speed, for most turbines from 25 m/s, the blades are fixed and the power production becomes zero to protect the installation against the high mechanical forces associated with high wind speeds. The wind speed at which this occurs is called the “cut-out speed.”

Expected Energy Production

To obtain the distribution of the produced power has been used to calculate the expected energy production of wind turbines at different places in Europe, using the information on the wind speed distribution Samples from the appropriate Weibull distribution were used to generate random wind speed data. These are next used to generate random values for the produced power. The capacity factor is next calculated as the average power production divided by the rated power of the turbine

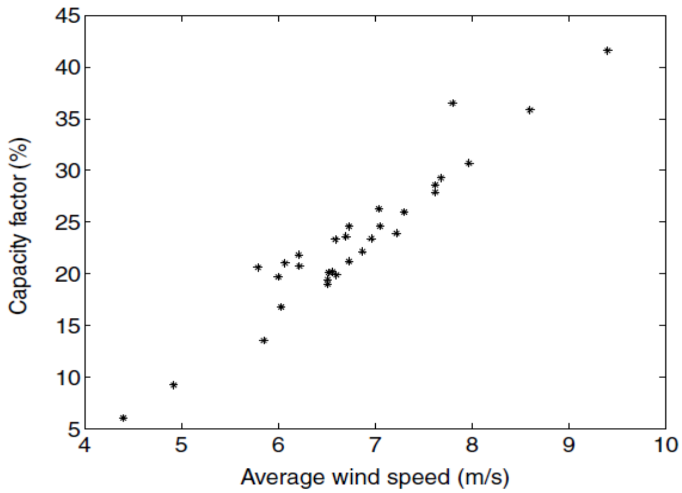

Figure 2.26 Capacity factor of a wind turbine as a function of the average wind speed.

4.)Show the weibull distribution of wind speed with neat diagram.

power production by a wind power unit strongly varies with time. To describe this in a stochastic way, typically the probability distribution function of the wind speed is used. The probability density function gives the probability that a random variable *X* is less than or equal to *x*:

$FX(x) = \Pr\{X \leq x\}$

From a known relation between wind speed and power production, the distribution of the power production can next be calculated. Instead of a probability distribution function, it is also possible to use measured wind speeds or wind speeds generated from an atmospheric model. The probability distribution function of the Weibull distribution reads as follows

$$F(t) = 1 - \exp\left(-\left(\frac{t}{b}\right)^k\right), \quad t > 0$$

Mean/Expected value of Weibull distribution is

$$\mathbb{E}(X) = b\Gamma\left(1 + \frac{1}{k}\right)$$

- **Γ:gamma function Γn= (n-1)!**
- **b:scale parameter/characteristics value**
- **K:shape parameter**

The probability density function of the Weibull distribution is given by the following expression

$$f(t) = \frac{k}{b^k} t^{k-1} \exp\left(-\left(\frac{t}{b}\right)^k\right), \quad t > 0$$

The influence of the shape factor on the wind speed distribution is illustrated in Figures 2.17 and 2.18. The former figure plots the probability distribution function of the wind speed for four different values of the Weibull shape factor, in all cases for an average wind speed of 6.5 m/s. The latter figure shows the probability density function.

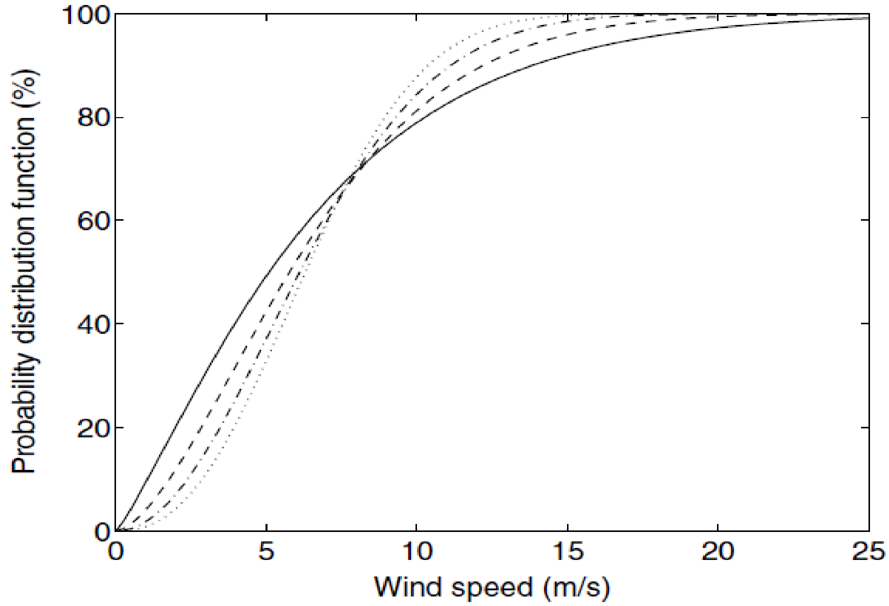

Figure 2.17 Probability distribution function of the wind speed for 6.5 m/s average wind speed and shape factors of 1.2 (solid line), 1.6 (dashed line), 2.0 (dash-dotted line), and 2.4 (dotted line).

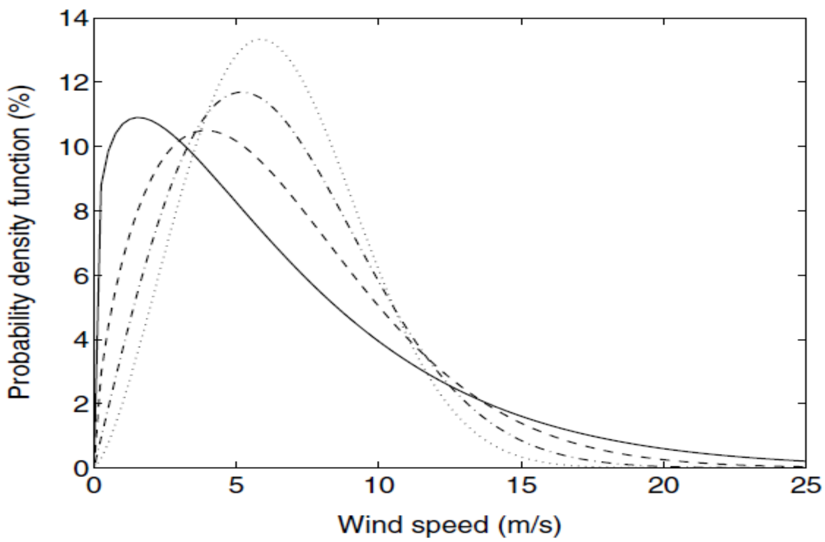

Figure 2.18 Probability density function of the wind speed for 6.5 m/s average wind speed and shape factors of 1.2 (solid line), 1.6 (dashed line), 2.0 (dash-dotted line), and 2.4 (dotted line).

5. Describe the power distribution as a function of wind speed.

The amount of power generated by a wind turbine is a strongly nonlinear function of the wind speed. The power curve, the relation between wind speed and generated power, is shown in

Figure 2.19 for five turbines, all with rated power of 600kW We see that the power curves for these five turbines are very similar; the differences are mainly in the high wind speed part of the curves. The power curves are shown in Figure 2.20 for 20 different turbines from 5 different manufacturers, with rated power between 300 and 2750kW .The generated power is given as a fraction of the rated power

- The power production is zero for small wind speed, below the so-called "cut in speed." This is where the energy in the wind is insufficient to supply the mechanical and electrical losses. Energy from the grid would be needed to keep the blades moving. The cut-in speed is between 3 and 4 m/s.
- The power production increases fast with the increasing wind speed. In this region, the turbine produces its maximum power for the given wind speed. The amount of energy in the wind is proportional to the cube (the third power) of the wind speed. It is this relation that is mainly responsible for the fast rise in power production. Variations in wind speed in this region will cause large variations in production.
- For further increase in the wind speed, the produced power increases less fast and eventually becomes constant or even decreases somewhat, depending on the type of turbine. The rated power of a wind turbine is the rated power of the electrical installation. This is what sets a limit to the amount of electrical power that can be produced. The power from the blades to the electrical machines should not exceed the machine rating too much, otherwise the machine will be overloaded and fail. There are two methods in use to limit this power: active control by slightly rotating the blades (pitch control), and passive control through the shape of the blades (stall control). With active control, the power is kept constant at its rated value resulting in a flat power curve. With passive control, the power is somewhat higher than rated for medium speed and somewhat lower for high wind speed. The speed at which 90% of rated power is reached ranges from 10.5 to 14 m/s. The wind speed at which the rated power is reached is sometimes referred to as the "rated speed." For the very high wind speed, for most turbines from 25 the blades are fixed and the power production becomes zero to protect the installation against the high mechanical forces associated with high wind speeds. The wind speed at which this occurs is called the "cut-out speed."

Four of the turbines from Figure 2.20 can be compared in more detail in Figure 2.21. All four are from the same manufacturer, but with different size and rating. Two of the turbines have a rating of 2MW (solid and dashed lines in the figure); for the large wind speed, they produce the same amount of power. This is the region in which the active control system determines the produced power

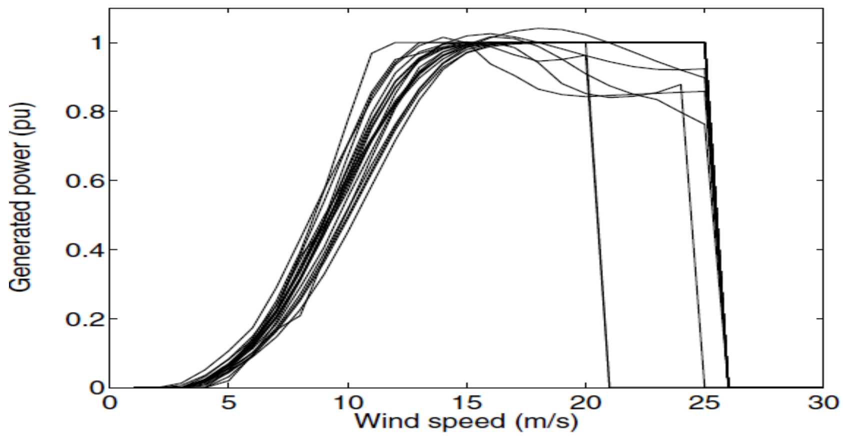

Figure 2.20 Generated power as a function of the wind speed for 20 different turbines.

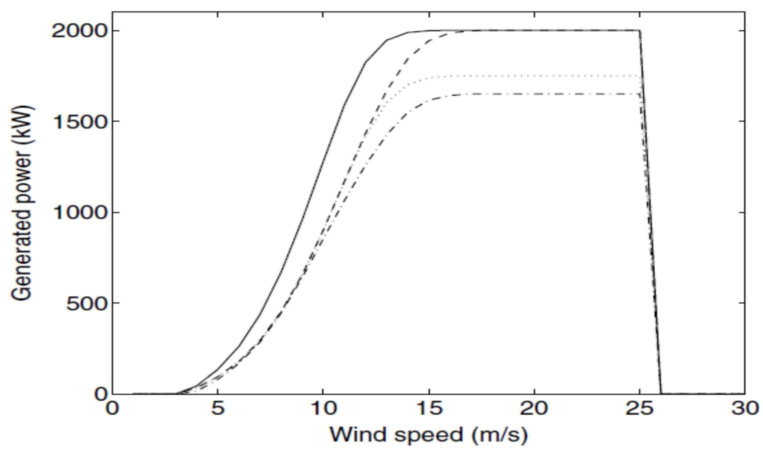

Figure 2.21 Power curves for four different turbines: 80 m, 2 MW (solid); 66 m, 2 MW (dashed); 66 m, 1.75 MW (dotted); and 66 m, 1.65 MW (dash-dotted).

6. Briefly explain status and properties of solar power.

The amount of energy that 1m2 of earth receives from the sun varies strongly between locations. Without clouds, it is highest near the equator and lowest near the poles. Including the impact of clouds, the amount is highest in the deserts. But a solar panel can be tilted toward the sun to compensate for the curvature of the earth. At optimal angle, the amount of energy reaching a solar panel is between 1000 and 2000 kWh/m2 per year for most locations. In Europe, the best parts are in the south of Spain with insolation above 1900 kWh and the worst parts are in the north of Scandinavia with values somewhat below 1000 kWh. Building giant solar power installations in desert areas could supply the whole world with energy. Using concentrating solar power, a 1000 × 1000 km2 in the desert would be needed That is not a small size (much more than the "two football fields in the Sahara" that the authors have heard mentioning during informal discussions), but still something that is technically achievable. The energy from the sun can be used in a number of ways. The most visible use today is in the form of solar panels, often installed on the roof of a building. A big advantage of this type of solar power is that it is produced where it is needed, as electricity consumption is also taking place mainly in buildings. In some countries (like Germany and the Netherlands), this type of installation is getting rather common.

A solar panel will only transfer part of the solar energy that falls on it into electrical energy. For the current generation of series-produced solar cells, the efficiency is between 6% and 15%, but individual cells can have higher efficiencies up to 20%

Large photovoltaic (PV) installations have been built recently, including 40MW installations in Germany and Portugal The large solar power installations are not based on photovoltaic but on concentrating solar thermal plants, where the energy from the sun is focused using large arrays of mirrors. The concentrated sunlight is used to boil water that in turn powers a turbine like in a conventional thermal power station. The largest of such installations to date is a 350MW installation in California. Plans for much larger installations exist. A 72MW photovoltaic plant is planned in northeastern Italy , said to be Europe's biggest. The plant was expected to be completed by the end of 2010.The amount of power produced by a solar power installation depends on the location of the sun in the sky and on the amount of cloud cover. The variations and predictability in cloud cover are similar to that of wind speed. The location of the sun in the sky shows a predictable daily and seasonal variation caused by the rotation of the earth on its axis and around the sun. This will likely make solar power more predictable than wind power, but there is limited experience with prediction for solar power to verify this. Solar power installations based on photovoltaic have limited economics of scale. The costs per kilowatt remain about the same with increasing size because the cost mainly varies with the solar panels. This makes rooftop installations for domestic or commercial installations an attractive solution. Such small installations are also easy to set up and connect to the grid, although rules on connection vary between countries, and contacts with the local network operator are in almost all countries compulsory. Small rooftop installations are by definition close to the consumption of electricity and they will, therefore, reduce the power transport through both the transmission and the distribution networks. With thermal solar, large installations are much more attractive than small installations. As a result, they are more likely to be built at remote locations. Very large installations are likely to occur at locations far away from consumption centers, such as Nevada, the Gobi Desert, and Northern Africa. The daily variation in solar power production indicates that the daily peak falls around noon. This is in most countries not the highest consumption, but certainly a high consumption. It has been suggested to have solar panels tilted and facing southeast or southwest (in the northern hemisphere) so that the peak production corresponds closer to the peak consumption. The seasonal variation indicates that the annual production peak occurs during summer, where the consumption due to cooling also has its peak in countries with a hot climate. Unfortunately, the daily peak in consumption falls in the afternoon and the annual peaks in consumption falls 1 or 2 months past the date where the sun reaches its highest point in the sky. Despite this, solar power is still expected to offer some contribution to the peak load. Again, an optimal tilt can be chosen to maximize the contribution of solar power to the consumption peak. The most recent developments point toward storage of molten salt at high temperatures. The salt could be kept sufficiently hot for several hours to still produce steam and thus electricity. This would compensate for any fluctuations in cloud cover on a timescale up to several hours and significantly increase the predictability of the production. It would also allow the energy to be available to cover the evening peak in consumption.

7. Discuss photovoltaic and different methods used for MPPT calculation.

There are many MPPT algorithms that could be implemented, but generally three techniques are commonly used

1. Perturb and observe

The algorithm perturbs the operating point in a certain direction and samples dP/dV, if positive indicates the right direction toward the maximum power point (MPP) and vice versa. The algorithm keeps adjusting the required operating voltage through using extra electronic hardware referred to as a chopper or DC/DC converter,

This method is easy to implement; however, it has slow response time and may track in the wrong direction in case of rapidly changing atmospheric conditions. Moreover, oscillations around the MPP may result during steady-state operation.

2. Incremental conductance

This algorithm uses the incremental conductance dI/dV to calculate the sign of dP/dV:

$$\frac{\mathrm{d}P}{\mathrm{d}V} = I + V \times \frac{\mathrm{d}I}{\mathrm{d}V}$$

Then, the voltage is adjusted accordingly as with the previous algorithm. This method provides faster response than the perturb and observe method; however, it can produce oscillations in case of rapidly changing atmospheric conditions.

3. Constant voltage method

By assuming that the ratio of cell voltage at maximum power Vm to its corresponding open-circuit voltage Vc is relatively constant throughout the normal operating range,

$$\frac{V_\mathrm{m}}{V_\mathrm{c}} = K$$

The constant K assumes a value of 0.76, which is an approximate value that is related to the material used for the solar panel. The open-circuit voltage is obtained using an unloaded pilot cell near the array. This method is fast and simple; however, the accuracy could be questioned since the atmospheric conditions could be different for the pilot cell and the array.