INTERCONNECTION OF WIND POWER STATIONS TO THE ELECTRIC POWER NETWORK

Jan ŠKORPIL, Emil DVORSKÝ
Department of Electrical Power Engineering and Ecology, Faculty of Electrical Engineering,
West Bohemian University in Pilsen, Sady Pětatřícátníků 14, 304 16 Plzeň, Czech Republic,
tel.: 0420 377634329, 0420 377634321, E-mail: skorpil@kee.zcu.cz, dvorsky@kee.zcu.cz

SUMMARY

Distributed generation (DG) technologies can provide energy solutions to some customers that are more cost-effective, more environmentally friendly, or provide higher power quality or reliability than conventional solutions. Understanding the wide variety of DG options available in today's changing electric markets can be daunting. Some of these DG technologies offer high efficiency, resulting in low fuel costs, but emit a fair amount of pollutants (CO and NOx); others are environmentally clean but are not currently cost-effective. Still others are well suited for peaking applications but lack durability for continuous output.

One of the technologies using in DG applications are wind power stations (WPS). The article aims at providing a basic discussion of the relevant issues related to the wind power interconnection in electric distribution system.

Keywords: *renewable power sources, wind power station, interconnection of the wind power stations*

1. INDRODUCTION

The increasing awareness of environmental issues is pushing the electric power industry toward alternative energy sources such as photovoltaic arrays, fuel cells, biomass, and wind turbines (WT). These energy sources tend to be small units that connect at the distribution level. This will present new challenges for the distribution systems oft the future.

The wind power energy is one of the renewable power sources. The speed and direction of the wind have no periodic quick time changes, especially in the ground atmosphere levels, were the wind power stations operate. For the wind power output, the speed wind changes in very short time intervals are mainly substantial. These facts have the important influence for the power wind energy utilisation and the wind power delivering to the distribution electric power network. Wind generation can cause problems with voltage regulation, flicker and harmonics although these are being significantly improved by power electronics innovations and wound rotor generator configurations. Distributed generation changes the way system protection can be done, and unintentional islanding must be dealt with for safe operation of the distribution network. System planners need to work co-operatively with distributed generators in order to achieve feeder capacity and voltage regulation improvements. Basically the electric power network, where the wind power stations are interconnected, has to have ability to transmit the produced wind output to the power consumption place and the interconnected source cannot has the influences neither on the network nor the interconnected subjects. The interconnection way therefore depends on the power network states and the interconnection power sources type and its operation state.

2. SYSTEM OF WIND ENERGY CONVERTERS

The three main components for energy conversion in wind turbines are rotor, gear box and generator. The rotor converts the fluctuating wind energy into mechanical energy and is thus the driving component in the conversion system (Fig. 1).

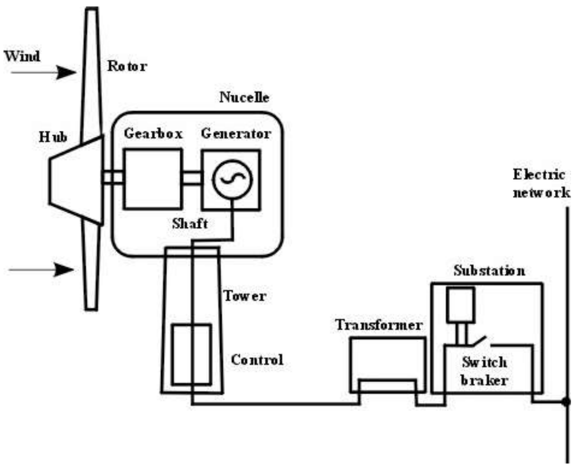

Fig. 1 Basic components of wind power station

Wind turbines are composed of a rotating rotor, with 2 or 3 blades. This rotor is the aerodynamic component of the wind turbine. It captures the energy available in the wind, and transfers it to a rotating shaft, located inside the wind turbine nacelle. The shaft is mechanically connected to the electromechanical converter unit. The generator and possibly an electronic inverter absorb the mechanical power while converting it into electrical energy, fed into a supply grid. The gear box adapts rotor to generator speed. The gear box is not necessary for multipole, slow running generators. The main components for the grid connection of the

WT are the transformer and the substation with the circuit breaker and the electricity meter inside it.

The possibilities, how to get a constant frequency, constant voltage output from a wind electric system are determinated by the aerodynamic system.

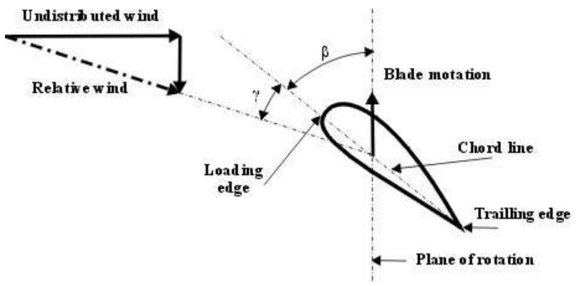

Fig. 2 Definition of pitch angle β and angle of attack γ

The systems of wind energy converters, as regards the possibility of the aerodynamic control, can be divided in to the system with:

- stall control,
- active stall control,
- pitch control.

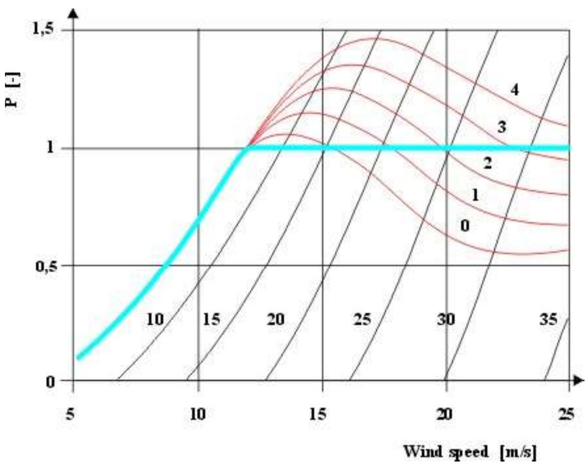

Fig. 3 Aerodynamic power control

The differences are based on the blade pitch angle keeping of the wind turbine. The force developed on a blade is a function of wind speed, turbine rotational speed and the blade pitch angle β (Fig. 2). These three quantities determine the angle of attack γ. The traditional wind turbine used to be a fixed speed turbine with fixed pitch, i.e. a stall-regulated, fixed-speed wind turbine. This wind turbine has blades firmly attached to the hub and no generator speed control. Active-stall controlled systems, also called combi-stall controlled systems, are of the same type; however, they allow the blades to be pitched. This pitching is done within a rather narrow range; a range from 0 to 4 degrees in Fig. 3 corresponds to the active-stall control range for the blade profile used here. The third aerodynamic control strategy for wind turbines is pitch control. The blades are pitched in a broad range, from 0 to 30 degrees in Fig. 3. The red (thick line) in Fig. 3 represents a variable speed, pitch regulate system in which turbine speed and the blade pitch are controlled according to Fig. 2 and Fig. 3, respectively.

The electromechanical part of WT represents equipments which convert mechanical energy to electric with constant frequency and constant voltage output. There are a number of ways how to transform mechanic energy to electric. Today’s trend is to use turbines with the speed control. It is cussed the fact that the variable speed operation gives the potential to reduce mechanical stresses on drive-train components by means of shaft torque control. But more important for the electric power is that the incoming power variations are absorbed by changes in the rotor speed and the shaft torque is smoother, which also gives smoother electric output power. Therefore the systems of wind energy converters, as regards the possibility of the electromechanical parts using, can be divided to two basic systems in depending on the shaft rotating. The systems with:

- constant-speed (fixed-sped) with one or two speeds, directly connecting to the electric network,
- variable-speed, indirectly connected to the electric network.

In fixed speed machines the generator (inductive) is directly connected to the mains supply grid. The frequency of the grid determines the rotational speed of the generator and thus of the rotor. The low rotational speed of the turbine rotor is translated into the generator rotational speed generator by a gear box with the transmission ratio. The generator speed depends on the number of pole pairs and the frequency of the grid. The disadvantages of induction generators are high starting currents, which usually are smoothed by a thyristor controller and their demand for reactive power.

In variable speed machines the generator is connected to the grid by an electronic inverter system. Variable-speed systems make use of either induction generators, synchronous generators or dc generators. Each of these systems requires a power electronic converter to obtain torque and speed control. Induction generators with a wound rotor are mainly used. The use of a wound rotor allows a power electronic converter to be connected to the rotor circuit via slip rings. The advantage of this is that variable speed control is obtained using a power electronic converter designed for lower power than nominal power (doubly-fed induction generator), typically about 20 - 30%. Their behaviour concerning reactive power is similar to the behaviour of an induction generator they consume inductive reactive power.

Look at several possibilities of the methods of producing a constant voltage, constant frequency electrical output from a wind turbine in dependence on the aerodynamic and electromechanical system which are presented in Tab. 1. Each has its advantages and disadvantages and each should be considered in the design stage of a new wind turbine system. Some methods can be eliminated quickly for economic reasons, but there may be several that would be competitive for a given application. The fact that one or two methods are most commonly used does not mean that the others are uncompetitive in all situations. The table applies specifically to a two or three bladed horizontal axis propeller type turbine, and not all the methods would apply to other types of turbines. In each case the output of the wind energy collection system is in parallel or in synchronism with the utility system.

Systems 1, 2, and 3 are all constant speed systems with induction generator which differ only in pitch control and gearbox details. The main problem is that a variable pitch turbine is more expensive than a fixed pitch turbine, so a careful study needs to be made to determine if the cost per unit of energy is lower with the more expensive system. The variable pitch turbine with a two speed gearbox is able to operate at a high coefficient of performance over an even wider range of wind speeds than system 1. Again, the average power density will be higher at the expense of a more expensive system.

Rotor	***Transmission***	***Generator***
1) Variable pitch, constant speed	Fixed-ratio gear	ac generator
2) Variable pitch, constant speed	Two-speed-ratio gear	ac generator
3) Fixed pitch, constant speed	Fixed-ratio-gear	ac generator
4) Fixed pitch, variable speed	Fixed-ratio gear	dc generator /dc motor/ ac generator
5) Fixed pitch, variable speed	Fixed-ratio gear	ac generator/ rectifier/ dc motor/ac generator
6) Fixed pitch, variable speed	Fixed-ratio gear	ac generator/ rectifier/ inverter
7) Fixed pitch, variable speed	Fixed-ratio gear	field-modulated generator
8) Fixed pitch	Variable-ratio	ac generator

Table 1 Methods of generating synchronous electric power

Systems 4 through 8 are all variable speed systems and accomplish fixed frequency output by one of five methods. In system 4, the turbine drives a dc generator which drives a dc motor at synchronous speed by adjusting the field current of the motor. The dc motor is mechanically coupled to an ac generator which supplies power to the line. The fixed pitch turbine can be operated at its maximum coefficient of performance over the entire wind speed range between cut-in and rated because of the variable turbine speed. The average power output of the turbine is high for relatively inexpensive fixed pitch blades. The disadvantage of system 4 over system 3 is the requirement of two additional electrical machines, which increases the cost. A dc machine of a given power rating is larger and more complicated than an ac machine of the same rating, hence costs approximately twice as much. A dc machine also requires more maintenance because of the brushes and commutator. Wind turbines tend to be located in relatively hostile environments with blowing sand or salt spray so any machine with such a potential weakness needs to be evaluated carefully before installation. Efficiency and cost considerations make system 4 rather uncompetitive for turbine ratings below about 100 kW. Above the 100-kW rating, however, the two dc machines have reasonably good efficiency (about 0.92 each) and may add only ten or fifteen percent to the overall cost of the wind electric system. A careful analysis may show it to be quite competitive with the constant speed systems in the larger sizes.

System 5 is very similar to system 4 except that an ac generator and a three-phase rectifier are used to produce direct current. The ac generator-rectifier combination may be less expensive than the dc generator it replaces and may also be more reliable. This is very important on all equipment located on top of the tower because maintenance can be very difficult there. The dc motor and ac generator can be located at ground level in a more sheltered environment, so the single dc machine is not quite so critical.

System 6 converts the wind turbine output into direct current by an ac generator and a solid state rectifier. A dc generator could also be used. The direct current is then converted to alternating current by an inverter. Modern solid state inverters which became available in the mid 1970's allowed this system to be one of the first to supply synchronous power from the wind to the utility grid. The frequency of inverter operation is normally determined by the power line frequency, so when the power line is disconnected from the utility, the inverter does not operate. More expensive inverters capable of independent operation are also used in some applications.

System 7 uses a special electrical generator which delivers a fixed frequency output for variable shaft speed by modulating the field of the generator. The electronics necessary to accomplish this task are rather expensive, so this system is not necessarily less expensive than system 4, 5, or 6.

System 8 produces electricity from a standard ac generator by using a variable speed transmission. Variable speed can be accomplished by a hydraulic pump driving a hydraulic motor, by a variable pulley vee-belt drive, or by other techniques. Both cost and efficiency tend to be problems on variable ratio transmissions.

Over the years, system 1 has been the preferred technique for large systems. This system is reasonably simple and enjoys largely proven technology. Now, it is basically a system 6 machine except that variable pitch is used above the rated wind speed to keep the maximum rotational speed at a safe value.

The list in Table 1 illustrates one difficulty in designing a wind electric system in that many options are available. Some components represent a very mature technology and well defined prices. Others are still in an early stage of development with poorly defined prices. It is conceivable that any of the eight systems could prove to be superior to the others with the right development effort.

3. INTERACTION WITH ELECTRIC DISTRUBUTION NETWORK

The modern electricity supply network is a complex system. The somewhat vague term “power quality” is used to describe the interaction between traditional producers operating fossil fired, nuclear, or hydro power plants and consumers. A distinctive feature of electricity is that it cannot be stored as such - there must at any instant be balance between production and demand. All renewable resources produce when the source is available - for wind power, as the wind blows. This characteristic is of little if any importance when the amount of wind power is modest compared to the total installed (and spinning) capacity of controllable power plants, but it changes into a major technical obstacle as the renewable part (termed penetration) grows to cover a large fraction of the total demand for electric energy in the system. The wind turbines impact is mainly concentrated to **[3]**:

- short circuit power level,
- voltage quality, i.e. the slow voltage variations, flicker, voltage dips.
- harmonics,
- frequency,
- reactive power,
- protection,
- network stability,
- switching operations and soft starting.

Short circuit power level

The short circuit power level in a given point in the electrical network is a measure of its strength and, while not directly a parameter in the voltage quality, has a heavy influence.

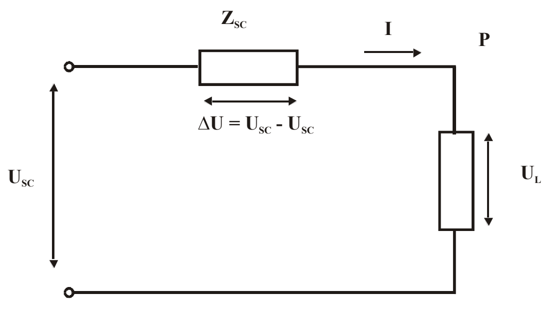

Fig. 4 Aerodynamic power control

The ability of the grid to absorb disturbances is directly related to the short circuit power level of the point in question. Any point (p) in the network can be modelled as an equivalent circuit as shown in Fig. 4. Far away from the point the voltage can be taken as constant i.e. not influenced by the conditions in p. The voltage in this remote point is designated U_{SC} and the short circuit power level S_{SC} can be found as:

$$S_{SC} = \frac{U_{SC}^2}{Z_{SC}} \qquad (1)$$

Where:

Z_{SC} -line impedance.

Variations in the load (or production) in p causes current variations in the line and these in turn a varying voltage drop (ΔU) over the line impedance Z_{SC}. The voltage in p (U_L) is the difference between U_{SC} and ΔU and this resulting voltage is seen by - and possibly disturbing - other consumers connected to p. Strong and/or weak grids are terms often used in connection with wind power installations. It is obvious from Fig. 4, that if the impedance Z_{SC} is small then the voltage variations in p will be small (the grid is strong) and consequently, if Z_{SC} is large, then the voltage variations will be large. Strong or weak are relative terms. For any given wind power installation of installed capacity P(MW) the ratio $R_{SC} = S_{SC} / P$ is a measure of the strength. The grid is strong with respect to the installation if R_{SC} is above 20 to 25 times and weak for R_{SC} below 8 to 10 times. Depending on the type of electrical equipment in the WT they can sometimes be operated successfully under weak conditions.

Flicker factor

Flicker is an engineering expression for short lived voltage variations in the electrical grid which may cause light bulbs to flicker. This phenomenon may be relevant if a wind turbine is connected to a weak grid, since short-lived wind variations will cause variations in power output. There are various ways of dealing with this issue in the design of the turbine, mechanically, electrically, and using power electronics.

The maximum acceptable voltage changes depend on the frequency of their occurrences (flicker curve) [2], measured curve giving the threshold of visibility for rectangular voltage changes applied to an incandescent lamp. The assessment criterion for this effect is the flicker severity factor P_{st}. Disturbances just visible $P_{st} = 1$ (P_{st} for P short term). Furthermore, a long term flicker severity factor P_{lt} is defined as:

$$P_{lt} = \sqrt[3]{\frac{1}{12}\sum_{j=1}^{12} p_{stj}^3} \qquad (2)$$

Where Pst is measured over 10 minutes and P_{lt} is valid for two hour periods. It can be measured on the real equipment in the common supply point or counted by the preliminary calculations. P_{lt} is function of:

- short-circuit power,
- short-circuit impedance angle ψ_{SC},
- generator nominal output,
- flicker severity equipment's factor c,
- phase angle φ_i, in the case of device's reactive power output examination.

The flicker severity equipment's factor c together with the phase angle φ_i characterised even the specific ability of the equipment to make the flicker. These two values have the great impact on the wind power plants interconnection.

The flicker severity equipment's factor with the generator can be determinate by the flicker measurement on real operate states under switching processes elimination. It is suitable to make this measurement in the electric power network with the resistance-inductive short-circuit impedance in which the self production doesn't cause the voltage changes higher then 3 to 5 %.

The flicker severity c we obtain by the interference flicker rate P_{lt} with the power output and generators current phase angle respecting:

$$c = P_{lt\,m} \cdot \frac{S_{SC}}{S_{rG} \cos\left(\psi_{SC} + \varphi_i\right)} \tag{3}$$

The absolute flicker value c and phase angle φ_i of the complex value c describe the flicker influence of the source self production.

With respect to the short circuit output S_{SC} and the short circuit impedance ψ_{SC} in the suppose common supplying point, we can compute the long-term disturbance ratio of the flicker caused by the power self production:

$$P_{lt} = \left[c \cdot \frac{S_{rA}}{S_{SC}} \cos\left(\psi_{SC} + \varphi_i\right) \right] \tag{4}$$

The flicker severity equipment's factor c depends mainly on the regularity operation of the given equipment which can be affected different parameters:

- generators driven by the turbines (hydraulic, steam or gas) have generally the c value less then 20 and therefore they are not critical from the point of the flicker,
- the flicker value of the reciproting engine depends on the number of the pistons,
- the bigger rotating mass, the lower flickers ratio is,
- there are no measured flicker value c for PV cells and there is no critical flicker influence expected.

The wind power stations play the main role in clicker ratio level. Under experience, their flicker severity c is till to 40 value. For the wind power station stands:

- the more rotate blades number the less flicker severity c level,
- the equipment with invertors tends to have less c value then directly ones which are connected with asynchronous respectively synchronous generator.

If there are more various generators connected to the common supplying point (wind farms), the total flicker value can be counted by:

$$c_{res} = \frac{\sqrt{\Sigma \left(c_i \ . \ S_{rGi}\right)^2}}{\Sigma \ S_{rGi}} \tag{5}$$

In the case of n identical generators, equation (5) is simplified to:

$$c_{res} = \frac{c}{\sqrt{n}} \tag{6}$$

It is noticeable from the equation (6) that for the equipment consisting of the more generators, there is certain flicker compensation effect of the single generators.

Harmonic distorsion

Harmonics are frequencies of voltage or current those are multiples of the fundamental frequency which are present because of variations from a pure sinusoidal waveform at the generator. Harmonics cause resonance with the capacitor banks, large load currents, increased losses, and overheating in motors and generators, and improper operation of breakers, fuses, and relays.

The distortion is expressed as Total Harmonic Distortion:

$$THD = \frac{\left[U_2^2 + U_3^2 + \ldots + U_n^2\right]^{\frac{1}{2}}}{U_1} \tag{7}$$

Before power can be fed to the grid, these harmonics must be filtered out. This can be done by a variety of RLC circuits with varying complexity and effectiveness, depending on the harmonics produced by a given system. Harmonics are generally introduced through the use of power electronics. Highly distorting loads are older unfiltered frequency converters based on thyristor technology and similar types of equipment. It is characteristic for this type that it switches one time in each half period and it may generate large amounts of the lower harmonic. Newer transistor based designs are used in most variable speed WT today. The method is referred to as Pulse Width Modulation (PWM). It switches many times in each period and typically starts producing harmonics where the older types stop, that is around 2 kHz. Their magnitude is smaller and they are easier to remove by filtering than the harmonics of lower order.

It should also be noted that when the power electronics are placed in the rotor circuit for a doubly-fed asynchronous generator, the distortion no longer appears as frequencies of multiples of the fundamental. They become interharmonics that depend on the frequency of the rotor circuit and the harmonic content of either the series 6-pulse converters or the PWM converters. The allowed of the odd harmonic values are determined by the requirements of a distribution network.

Frequency

The frequency of the system is proportional to the rotating speed of the synchronous generators operating in the system and they are apart from an integer even factor depending on machine design - essentially running at the same speed: They are synchronised. Increasing the electrical load in the system tends to brake the generators and the frequency falls. The frequency control of the system then increases the torque on some of the generators until equilibrium is restored and the frequency is 50 Hz again.

The requirements to frequency control in the West European grid are laid down in the UCPTE (Union for the Co-ordination of Production and Transmission of Electricity) rules. The area is divided in a number of control zones each with its own primary and secondary control. The primary control acts on fast frequency deviations, with the purpose of keeping equilibrium between instantaneous power consumption and production for the whole area. The secondary control aims at keeping the balance between production and demand within the individual zones and keeping up the agreed exchange of power with other zones.

The power required for primary control is 3000MW distributed throughout the control zones whereas the frequency control related to keeping the time for electric grid controlled watches is accomplished by operating the system at slightly deviating frequencies in a diurnal pattern so that the frequency on an average is 50 Hz.

Reactive Power

Reactive power is a concept associated with oscillating exchange of energy stored in capacitive and inductive components in a power system. Reactive power is produced in capacitive components (e.g. capacitors, cables) and consumed in inductive components (e.g. transformers, motors, fluorescent tubes). The synchronous generator is special in this context as it can either produce reactive power (the normal situation) when overmagnetised or consume reactive power when undermagnetised. Voltage control is effected by controlling the magnetising level of the generator i.e. a high magnetising level results in high voltage and production of reactive power.

To minimise the losses it is necessary to keep the reactive currents as low as possible and this is accomplished by compensating reactive consumption by installing capacitors at or close to the consuming inductive loads. Furthermore, large reactive currents' flowing to inductive loads is one of the major causes of voltage instability in the network due to the associated voltage drops in the transmission lines. Locally installed capacitor banks mitigate this tendency and increases the voltage stability in area.

Many WT are equipped with induction generators. The induction generator is basically an induction motor, and as such a consumer of reactive power, in contrast to the synchronous generator which can produce reactive power. At no load (idling), the consumption of reactive power is in the order of 35-40% of the rated active power increasing to around 60% at rated power. In any given local area with WT, the total reactive power demand will be the sum of the demand of the loads and the demand of WT. To minimise losses and to increase voltage stability, the WT are compensated to a level between their idling reactive demand and their full load demand, depending on the requirements of the local utility or Distribution Company. Thus the power factor of WT, which is the ratio between active power and apparent power, is in general in the range above 0.96. For WT with pulse width modulated inverter systems the reactive power can be controlled by the inverter. Thus these WT can have a power factor of 1.00. But these inverter systems also give the possibility to control voltage by controlling the reactive power (generation or consumption of reactive power).

Protection

The extent and type of electrical protective functions in a WT is governed by two lines of consideration. One is the need to protect the WT, the other to secure safe operation of the network under all circumstances.

The faults associated with first line are short circuits in the WT, overproduction causing thermal overload and faults resulting in high, possibly dangerous, over voltages, that is earth faults and neutral voltage displacement.

The second line can be described as the utility view, which is the objective is to disconnect the WT when there is a risk to other consumers or to operating personnel. The faults associated with this line are situations with unacceptable deviations in voltage and/or frequency and loss of one or more phases in the utility supply network. The required functions are given:

- Under frequency (one level delayed)
- Over voltage (one level delayed,
- one level instantaneously
- Under voltage (one level delayed)
- Loss of mains (instantaneously)
- High overcurrents (short circuit)
- Thermal overload
- Earth fault
- Neutral voltage displacement

Depending on the WT design, that is if it can operate as an autonomous unit, a Rate Of Change Of

Frequency (ROCOF) relay may be needed to detect a step change in frequency indicating that the WT is operating in an isolated part of the network due for example to tripping of a remote line supplying the area.

Network stability

Three issues, all are largely associated with different types of faults in the network, are central in the discussion:

- tripping of transmission lines (e.g. overload),
- loss of production capacity (e.g. any fault in boiler or turbine in a power plant),
- short circuits.

Permanent tripping of transmissions lines due to overload or component failure disrupts the balance of power (active and reactive) flow to the adjacent areas. Though the capacity of the operating generators is adequate large voltage drops may occur suddenly. The reactive power following new paths in a highly loaded transmission grid may force the voltage operating point of the network in the area beyond the border of stability. A period of low voltage (brownout) possibly followed by complete loss of power is often the result.

Loss of production capacity obviously results in a large power unbalance momentarily and unless the remaining operating power plants have enough so called “spinning reserve”, that is generators not loaded to their maximum capacity, to replace the loss within very short time a large frequency and voltage drop will occur followed by complete loss of power.

Short circuits take on a variety of forms in a network and are by far the most common. Many of these faults are cleared by the relay protection of the transmission system either by disconnection and fast reclosure, or by disconnection of the equipment in question after a few hundred milliseconds.

In all the situations the result is a short period with low or no voltage followed by a period where the voltage returns. A large WT (wind farm) in the vicinity will see this event and disconnect from the grid immediately if only equipped with the protection described above. This is equivalent to the situation “loss of production capacity” and disconnection of the wind farm will further aggravate the situation. Up to now, no utility has put forward requirement to dynamic stability of WT during grid faults.

Switching operations and soft starting

Connection and - to a smaller degree - disconnection of electrical equipment in general and induction generators/motors especially, gives rise to so called transients, that is short duration very high inrush currents causing both disturbances to the grid and high torque spikes in the drive train of a WT with a directly connected induction generator.

In this context WT fall into two classes. One featuring power electronics with a rated capacity corresponding to the generator size in the main circuit and one with zero or low rating power electronics in a secondary circuit - typically the rotor circuit of an induction generator. The power electronics in the first class can control the inrush current continuously from zero to rated current. Its disturbances to the grid during switching operations are minimal and it will not be discussed further here. Unless special precautions are taken, the other class will allow inrush currents up to 5-7 times the rated current of the generator after the first very short period (below 100 ms) where the peak are considerably higher, up to 18 times the normal rated current. A transient like this disturbs the grid and to limit it to an acceptable value all WT of this class are equipped with a current limiter or soft starter based on thyristor technology which typically limits the highest RMS value of the inrush current to a level below two times the rated current of the generator. The soft starter has a limited thermal capacity and is short circuited by a contactor able to carry the full load current when connection to the grid has been completed. In addition to reducing the impact on the grid, the soft starter also effectively dampens the torque peaks in the air gap of the generator associated with the peak currents and hence reduces the loads on the gearbox.

4. CONCLUSION

The wind power stations output and design are changing rapidly. In half eighties years of the last century the output was on 250 kW value and after ten years on 600 kW. There were the asynchronous generators with short-circuit armature and the gearbox between rotor and generator used. This type of the power stations had the great influence on the power network due to the flicker.

Now, we can find the wind power station with the power output more then 2 MW. Vestas company has designed **[1]** the wind power station prototype with 3 MW power output and near Magdebug the power station with 4,5 MW output was installed, for the scientific purpose mainly. The construction design and operate states are changing too. The present conception with the generator constant rotate speed is changing to the operation state with the variable rotation speed in dependence on the wind speed. The electric current with the variable parameters is then transform and frequency adjust to the network parameters by the power electronic. This design enables the maximal wind power utilisation opposed to the generators with the constant rotate speed which can reach the maximal wind power only under one wind speed. The flicker value of the new wind power stations is going rapidly down, (usually in interval from 3 to 10) and there isn’t the main interconnection problem of the wind power stations.

Although distributed generation presents challenges to the distribution network, if these challenges can be met, there is potential for the distribution network operator to benefit from the presence of distributed generation. Wind generation particularly offers challenges to the distribution network operator in the areas of voltage regulation and harmonic content, but technology advances in the power electronics field have allowed the network impact of wind generators to be significantly reduced. Although distributed generation may make distribution planning more difficult, if the network operator and generator operator cooperate, system operation may be improved, perhaps to the point of the distribution network being able to operate independently of the transmission network when necessary.

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BIOGRAPHY

Jan Škorpil was born on 18. 8. 1941. In the 1964 he received the M.Sc. (Ing.) degree with distinction at the Technical College in Pilsen, at the Department of Power machinery engineering. Then he worked as a plant engineer at the power and heating station of Chemical plant in Záluží. Since 1966 to 1971 he was a senior lector at the department of Power machinery engineering at the Technical College in Pilsen. Since 1971 to 1981 was a special worker for teaching technology, since 1981 he works at Power engineering department of Electric Engineering Faculty of West Bohemian University in Pilsen. He finished PhD (CSc) study in the field of technical teaching in 1989. Since 1991 he is associate professor (Doc), his thesis title was from area of Power engineering. His branch area is power station equipment, renewable energy sources and environmental protection.

Emil Dvorský was born on 11.12.1955. He finished his university study at 1980 in the specialisation of Electrical Power Engineering. Then he worked as a engineer in West Bohemia Power Enterprise. Since 1984 he works at Department of Power Engineering of Electric Engineering Faculty of West Bohemian University in Plzen. He finished his Ph.D. study in 1988 and since 2003 he is associate professor at the same department. His specialisation is power production and distribution, management and economy in this area.