ENERGY EFFICIENCY IN INDUSTRIAL SYSTEMS

PRESENTED By

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Need For Grid Integration

- In the recent years, installation of renewable energy system is increasing rapidly. At the same time, the power penetration to the grid due to renewable energy sources has also increased. This increase in the power penetration causes several problems compared to conventional power sources because of scarcity of renewable power sources.
- Wind energy is highly variable and fluctuates with respect to meteorological conditions, variations of wind velocity and direction. Sometime the power output may be zero for a long period. Therefore, it is difficult to predict and connect wind turbine power output to the grids. The connection procedure is different from conventional electricity generation methods.
- Grid integration is the critical problem in the large-scale wind farms. A better interconnected grid will also improve the running cost and the emerging pricing policy. Therefore, it requires a common procedure to connect the system to the grid.

Grid Code

- A **grid code** is a technical specification which defines the parameters a facility connected to a public electric grid has to meet to ensure safe, secure and economic proper functioning of the electric system.
- The facility can be an electricity generating plant, a consumer, or another network.
- The grid code is specified by an authority responsible for the system integrity and network operation. Its elaboration usually implicates network operators (distribution or transmission system operators), representatives of users and, to an extent varying between countries, the regulating body.
- Contents of a grid code vary depending on the transmission company's requirements.
- Typically, a grid code will specify the required behavior of a connected generator during system disturbances. These include voltage regulation, power factor limits and reactive power supply, response to a system fault (e.g. short-circuit), response to frequency changes on the grid, and requirement to "ride through" short interruptions of the connection.

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- The newly developed principles in Germany grid codes are
- All types of generating plants are treated equally.
- Distinguished only by type

Type 1: Generation plants with synchronous generators.

Type 2: Generation plants with other generator types.

The basic requirements are

1. Active power generation :It depends on wind speed, unity power factor, maximum reactive power generation and consumption, reduction of active power generation depend on wind speed and accuracy in frequency control in the power system.
2. Reactive power generation :Maximum values of reactive power (generation and consumption) depending on active power, Control alternatives (power factor, amount, Q-U characteristic) and transition times after control setting.
3. System voltage disturbances

Flicker, Switching operations, Harmonics and Inter harmonics are some of the disturbances considered in certification process

REVIEW OF INDIAN ELECTRICITY GRID CODE (IEGC)

The Indian power system contains the following aspects namely

- Generating stations
- Transmission or main transmission lines
- Sub-stations
- Tie-lines
- Load dispatch activities
- Mains or distribution mains
- Electric supply-lines
- Overhead lines
- Service lines
- Works

Special requirements for solar/ wind generators are

- State Load Dispatch Centres (SLDC)/Regional Load Dispatch Centres (RLDC) may direct a wind farm to curtail its VAr draw/injection in case the security of grid or safety of any equipment or personnel is endangered.
- During the wind generator start-up, the wind generator shall ensure that the reactive power draw (inrush currents in case of induction generators) shall not affect the grid performance.

REVIEW OF INDIAN WIND ENERGY GRID CODE REQUIREMENTS

In many countries in the world, including India has common technical issues and energy policies on the increased penetration of wind energy to the grid

- Voltage and reactive power control.
- Frequency control.
- Fault ride-through capabilities.

Active Power Control

- Active power control is the ability of wind power plants to regulate their active power output to a defined level and at a defined ramp rate (e.g., in the case of active power curtailment requests by TSOs).
- These requirements aim to ensure a stable frequency in the system, to prevent overloading of transmission lines and to minimize the effect of the dynamic operation of wind turbines on the grid (e.g., during extreme wind conditions, at startup/shutdown).
- The ability of wind turbines to control their active power is also important for transient stability during faults. If the power can be controlled effectively as soon as a fault occurs, the turbine can be prevented from overspeeding. Hence, the reactive power needed for remagnetization of the generators is less after the fault is cleared, which helps reestablishing the grid voltage.
- Often, active power generation is reduced temporarily by the control system during the low voltage period. This allows the increase of reactive power generation without exceeding the rated current of the converters. After the fault period, a fast return to normal active power generation is essential to ensure the power balance and stability of the grid

Reactive Power Control

- The voltage levels in a power system must be maintained constant (within a very narrow range) because equipment of the utility and consumers are designed to operate at specific voltage levels.
- Recent adaptations to national grid codes demand from wind farms to contribute to voltage regulation in the system, as conventional power plants do. They must have the ability to generate or absorb reactive power in order to influence the voltage level at the point of common coupling (PCC).
- Under normal operation the voltage at the PCC can be increased by injecting reactive power to the grid and can be decreased by absorbing reacting power. Wind farms should have reactive power capabilities in order to support the PCC voltage during voltage fluctuations and to assist in balancing the reactive power demand in the grid.

Frequency Control

- The power system frequency is an indication of the balance between power generation and load consumption.
- Any deviation from the planned production or consumption moves the system frequency away from its nominal value. In the case of a sudden increase in the load, the frequency of the produced voltage decreases and it is restored back to the nominal when power production is increased by primary control.
- Underfrequency can also occur as a result of an unexpected loss of generation units. On the other hand, over-frequency can occur with a sudden decrease in load or an unexpected increase in generation (e.g., wind gusts) .
- Grid codes require that wind farms must be capable of operating continuously within the voltage and frequency variation limits encountered in normal operating conditions. In addition, they should remain in operation in case of frequency deviations outside the normal operating limits for a specified time and in some cases with a specific active power output.
- By having the ability to remain connected to the grid for a wider frequency range, wind farms support the system during abnormal operating conditions and allow for a fast system frequency restoration. Wind turbines must be designed appropriately, as abnormal frequencies can overheat generator windings, degrade insulation material, and damage power electronic devices

Fault Ride Through Wind Farms

- The grid codes about the wind energy require wind turbine (WT) has the ability of fault (or low voltage) ride-through (FRT). To study the FRT operation of the wind farms, three methods were discussed.
- First, the rotor short current of doubly-fed induction generator (DFIG) was limited by introducing a rotor side protection circuit.
- Second, the voltage of DC bus was limited by a DC energy absorb circuit.
- Third, STATCOM was used to increase the low level voltages of the wind farm.
- The increasing and expansion of wind power has set some new problems to power system. The power system with large scale wind power will involve problems not only in steady state operation but also in contingency condition. FRT requires keep the WTs on the grid during faults so that they can contribute to the stability to the power transmission system.

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- The power system fault will lead to voltage dip on WTs. To maintain the grid stability, wind farm is required to keep connected in the power system for a defined time period under grid fault, this is called FRT.
- Actually, the voltage is not always dip to zero, it can be just a voltage sag. So many researchers put their efforts to deal with the so called low voltage ride-through problem.
- The main differences in FRTs requirement of different countries are the depth of voltage drop, the time period and the boundary where WTs can be tripped.
- New FRT needs not only the WTs keep on grid but also can provide voltage support or generator reactive power to the power system.


Thank you!!!