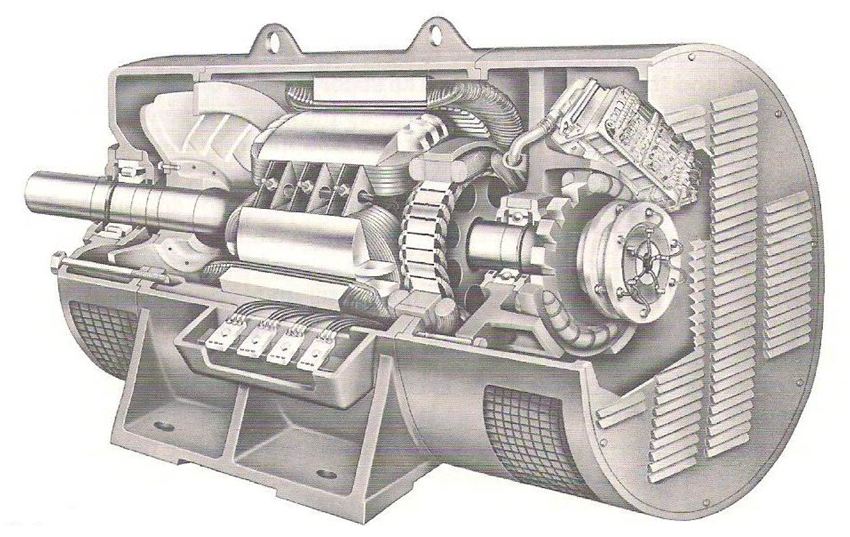
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| Testo di partenza  **NON TRADURRE LE PARTI EVIDENZIATE IN GIALLO** | Testo tradotto dal candidato | Spazio a disposizione del correttore | Penalità |
| **AC Synchronous Generator Technologies** |  |  |  |
| Since the early time of developing wind turbines, considerable efforts have been made to utilize three-phase synchronous machines. AC synchronous WTGs can take constant or DC excitations from either permanent magnets or electromagnets and are thus termed PM synchronous generators (PMSGs) and electrically excited synchronous generators (EESGs), respectively. When the rotor is driven by the wind turbine, a three-phase power is generated in the stator windings which are connected to the grid through transformers and power converters. For fixed speed synchronous generators, the rotor speed must be kept at exactly the synchronous speed. Otherwise synchronism will be lost. |  |  |  |
| Synchronous generators are a proven machine technology since their performance for power generation has been studied and widely accepted for a long time. A cutaway diagram of a conventional synchronous generator is shown in [Fig. 7](https://www.intechopen.com/books/advances-in-wind-power/wind-turbine-generator-technologies#F7). In theory, the reactive power characteristics of synchronous WTGs can be easily controlled via the field circuit for electrical excitation. Nevertheless, when using fixed speed synchronous generators, random wind speed fluctuations and periodic disturbances caused by tower-shading effects and natural resonances of components would be passed onto the power grid. |  |  |  |
| Furthermore, synchronous WTGs tend to have low damping effect so that they do not allow drive train transients to be absorbed electrically. As a consequence, they require an additional damping element (e.g. flexible coupling in the drive train), or the gearbox assembly mounted on springs and dampers. When they are integrated into the power grid, synchronizing their frequency to that of the grid calls for a delicate operation. In addition, they are generally more complex, costly and more prone to failure than induction generators. In the case of using electromagnets in synchronous machines, voltage control takes place in the synchronous machine while in permanent magnet excited machines, voltage control is achieved in the converter circuit. |  |  |  |
| In recent decades, PM generators have been gradually used in wind turbine applications due to their high power density and low mass [[39](https://www.intechopen.com/books/advances-in-wind-power/wind-turbine-generator-technologies#B39)]. Often these machines are referred to as the permanent magnet synchronous generators (PMSGs) and are considered as the machine of choice in small wind turbine generators. The structure of the generator is relatively straightforward. As shown in [Fig. 8](https://www.intechopen.com/books/advances-in-wind-power/wind-turbine-generator-technologies" \l "F8). the rugged PMs are installed on the rotor to produce a constant magnetic field and the generated electricity is taken from the armature (stator) via the use of the commutator, sliprings or brushes. |  |  |  |
| The principle of operation of PM generators is similar to that of synchronous generators except that PM generators can be operated asynchronously. The advantages of PMSGs include the elimination of commutator, slip rings and brushes so that the machines are rugged, reliable and simple. The use of PMs removes the field winding (and its associated power losses) but makes the field control impossible and the cost of PMs can be prohibitively high for large machines. |  |  |  |
| Because the actual wind speeds are variable, the PMSGs cannot generate electrical power with fixed frequency. As a result, they should be connected to the power grid through AC-DC-AC conversion by power converters. That is, the generated AC power (with variable frequency and magnitude) is first rectified into fixed DC and then converted back into AC power (with fixed frequency and magnitude). It is also very attractive to use these permanent magnet machines for direct drive application. Obviously, in this case, they can eliminate troublesome gearboxes which cause the majority of wind turbine failures. The machines should have large pole numbers and are physically large than a similarly rated geared machine. |  |  |  |
| A potential variant of synchronous generators is the high-temperature superconducting generator [[31](https://www.intechopen.com/books/advances-in-wind-power/wind-turbine-generator-technologies" \l "B31); [27](https://www.intechopen.com/books/advances-in-wind-power/wind-turbine-generator-technologies" \l "B27); [49](https://www.intechopen.com/books/advances-in-wind-power/wind-turbine-generator-technologies" \l "B49); [55](https://www.intechopen.com/books/advances-in-wind-power/wind-turbine-generator-technologies" \l "B55)]. See [Fig. 9](https://www.intechopen.com/books/advances-in-wind-power/wind-turbine-generator-technologies" \l "F9) for a multi-MW, low-speed HTS synchronous generator system. The machine comprises the stator back iron, stator copper winding, HTS field coils, rotor core, rotor support structure, rotor cooling system, cryostat and external refrigerator, electromagnetic shield and damper, bearing, shaft and housing. In the machine design, the arrangements of the stator, rotor, cooling and gearbox may pose particular challenges in order to keep HTS coils in the low temperature operational conditions. |  |  |  |
| Superconducting coils may carry 10 times the current than conventional copper wires with negligible resistance and conductor losses. Without a doubt, the use of superconductors would eliminate all field circuit power loss and the ability of superconductivity to increase current density allows for high magnetic fields, leading to a significant reduction in mass and size for wind turbine generators. |  |  |  |



**Figure 7.** Cutaway of a synchronous generator [22].

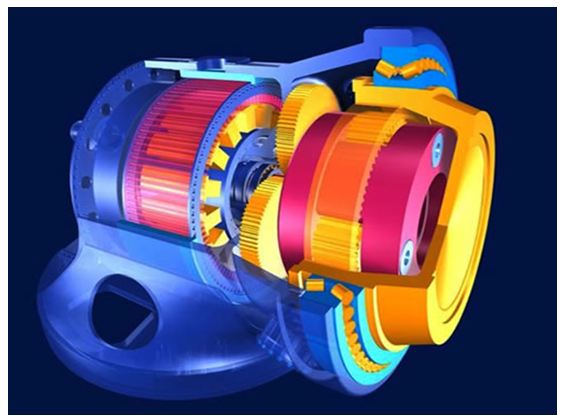


Figure 8 Cutaway of a permanent magnet synchronous generator [18].

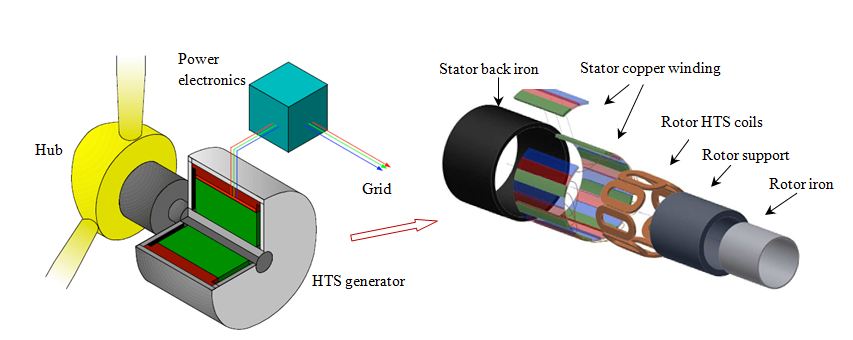


Figure 9. Schematic of a HTS synchronous generator system [11].

Il testo è stato tratto dal sito:

[www.intechopen.com/books/advances-in-wind-power/wind-turbine-generator-technologies](https://www.intechopen.com/books/advances-in-wind-power/wind-turbine-generator-technologies)