Design study of a 10 MW MgB2 superconductor direct drive wind turbine generator

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Citation (APA):
A design study of a 10 MW direct drive wind turbine generator based on MgB$_2$ superconducting wires is presented and the cost of the active materials of the generator is estimated to be between 226 €/kW and 84 €/kW, which is lower than the threshold values of 300 €/kW of the INNWIND.EU project. A nacelle structure with a front-mounted generator is presented for further investigation of the integration of such a superconducting generator into offshore turbines with power ratings considerably larger than 10 MW.

**Nacelle and Generator**

**Motivation:**
The INNWIND.EU project is investigating the feasibility of superconducting direct drive generators for offshore turbines ranging up to 20 MW [1]. A king-pin nacelle design is proposed as template for comparing different generators in terms of cost and cost of energy. Features of the drive train are outlined below:

**Nacelle**
- Static King-Pin and two main bearings supporting hub
- \( P = 10 \text{ MW, } T = 10.6 \text{ MNm} @ 9.65 \text{ rpm} \)

**Generator**
- Superconducting field coils and conventional armature winding of Cu
- Air-cooled armature windings and magnetic steel shielding
- Non-magnetic support of rotor coils
- Static superconducting field coils and rotating armature with slip ring
- Static cryostat and cryogenic cooling system
- Full rated power electronics
- \( D = 5.8 \text{ m} \) & \( L = 3.1 \text{ m} \) to match the hub
- 32 poles & \( f = 2.6 \text{ Hz} \)
- \( B_d = 1.5 \text{ T} \), \( A_G = 100 \text{ kA/m} \) & \( F_d = 75 \text{ kN/m}2 \)

**Rotor field coils**
- MgB$_2$ superconducting tape (3.0 mm x 0.7 mm) @ 4 \( \rightarrow 1 \) €/m [2]
- \( T_c = 39 \text{ K} \) & minimum bending diameter = 0.15 m
- Race track coil as stack of 10 double pancake coils (\( D = 0.3 \text{ m} \))

**Conclusions**
A 10 MW superconducting direct drive wind turbine generator based on MgB$_2$ wire has been analyzed in terms of properties, amount of wire needed and expected cost of the active materials. The diameter is 5.8 m and the active length is 3.1 m. A king-pin nacelle concept with the superconducting generator mounted in front of the rotor blades has been proposed, because it is believed to be one of the only ways to support a rotor approaching 250 m for a 20 MW turbine. Finally a cost of capacity analysis of the generator shows that the contribution from the active materials is 226 €/kW, which is lower than the INNWIND threshold of 300 €/kW. Cost reductions imposed by a decreasing wire price indicate that the expenses of the cryogenic cooling systems can be accommodated. This will be further investigated in the INNWIND project and compared with conventional drive trains.

**References**
1. Innwind.EU project web page: www.innwind.eu