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
- $P = 10$ MW, $T = 10.6$ MNm @ 9.65 rpm

**Generator**

- Superconducting field coils and conventional armature winding of Cu
- Air-cored 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
- $D = 5.8$ m & $L = 3.1$ m to match the hub
- 32 poles & $f = 2.6$ Hz
- $B_g = 1.5$ T, $A_g = 100$ kA/m & $F_d = 75$ kN/m²

**Rotor field coils**

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

- Cost of active material (SC, Cu & Fe) ~ 226 €/kW [1]
- $\approx 10-15$ K [3]

**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