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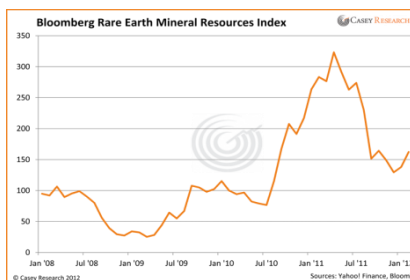
„Biggest supply chain risk in advanced direct drive systems is the rotor material.

Superconductors can be a better alternative to permanent magnets.

Knowledge is here the key difference between business success and failure.”

Facts:

- Market asks for simple drive trains. Thus there is a trend towards direct drive
- This trend calls for permanent magnets or superconductors into the rotor
- 100...400 kg of REM are used per MW of direct drive generator. This materials share is a large chunk of the cost.



2011 Spike of the REM Cost.

Are Rare Earth Metals Jeopardizing the Wind Sector in the Long Run?

The most effective permanent magnets are made of Neodymium/Iron/Boron alloy (NdFeB), of which 27% by weight is Neodymium (Nd). Though being a minor dopant, Dysprosium (Dy), contributes to cost equally. Nd and Dy belong to a class of metals called Rare Earth Metal (REM).

Concerns have appeared in press reports suggesting that production of REMs in China is not sustainable. China has reacted to toughen regulation and closed down illegal mines, thus reducing production to about 20 properly managed facilities. At the same time in mid-2010, China imposed export restrictions of around 60,000 tons/year of REM metal and oxide within a total worldwide demand of about 127,000 tons in this year. Additionally, taxation was added for materials used within China, although this is only US \$5-9 per ton.

China controls 95% of the REM market, which has led to a remarkable spiking of the raw material cost. For a direct drive wind generator, the permanent magnets made of REM contribute to 100...400 kg/MW of the active mass. At the same time generators use about 30% of Chinese REM exports.

While the REM's cost is currently returned to the 2010 level, those figures illustrate the particular vulnerability of the wind sector.

ECO 5 Recommendations for Action

There is no reason such a surge could not happen again. We propose a number of strategies for future risk management and limitation of exposure:

Know about it: This is perhaps the most vital point. In order to manage risk, entities involved in the manufacturing of wind turbines, or in the planning of large wind farms must understand the dynamics of that particular market. The ECO 5 Team can tremendously assist in tailoring practical market intelligence and providing strategic support in finding alternative solutions.

Limit it: A clever magnetic design of a generator can reduce the amount of REM by more than 20% and thus significantly limit vulnerability to pricing fluctuations. We can provide a solid engineering.

Substitute it: On the lower end of the performance range there is the option of using Ferrite or Alnico. In the more powerful range > 2 MW, also superconductors come into play. The ECO 5 Team can provide engineering driven breakeven studies (copper vs. PM vs. superconductors). For superconductors we can manage everything from initial R&D to your channel to supply.

„For the ECO 5 Team magnets are not just random materials—we live magnets. We know magnets from buying to engineering. We are specifically qualified to consult on strategies that involve permanent magnets.”

ECO 5 Team: Engineering Services for Highly Efficient Power Systems

- Rotating Machines
- Coils and Magnets
- Inductive Heating Systems
- Cryo Technology
- Materials Science
- Grid Expansion and Protection.

Why ECO 5?

The ECO 5 Team has a strong strategic and operational heritage; our engineers worked extensively for operating companies and understand the priorities that clients have in the development and delivery of projects.

Within one compact organization, we have an unrivalled range and depth of knowledge and expertise of all aspects that are vital in delivering a sound project.

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As an engineering provider, the ECO 5 Team is specialized in the development of high-efficiency power systems. Our focus is on renewable energy generators for wind, hydro, and wave power. Beyond these fields, core competencies lie in fault protection of high-voltage grids and inductive metal heating. In these areas we contribute highly specialized know-how in the application of industrial-grade superconductors as well as in conventional copper and permanent magnet solutions. Strategic and marketing competencies complement the technical expertise.

We manage customer projects from strategic line-up, feasibility analysis up to prototyping. In technical expertise and tools we cover materials science aspects, multiphysics FEA, and 3D CAD. Supporting these activities, we offer our competence in the areas of cryo technology, plant and process safety, and the analysis of IP rights pertaining to a technological development.

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