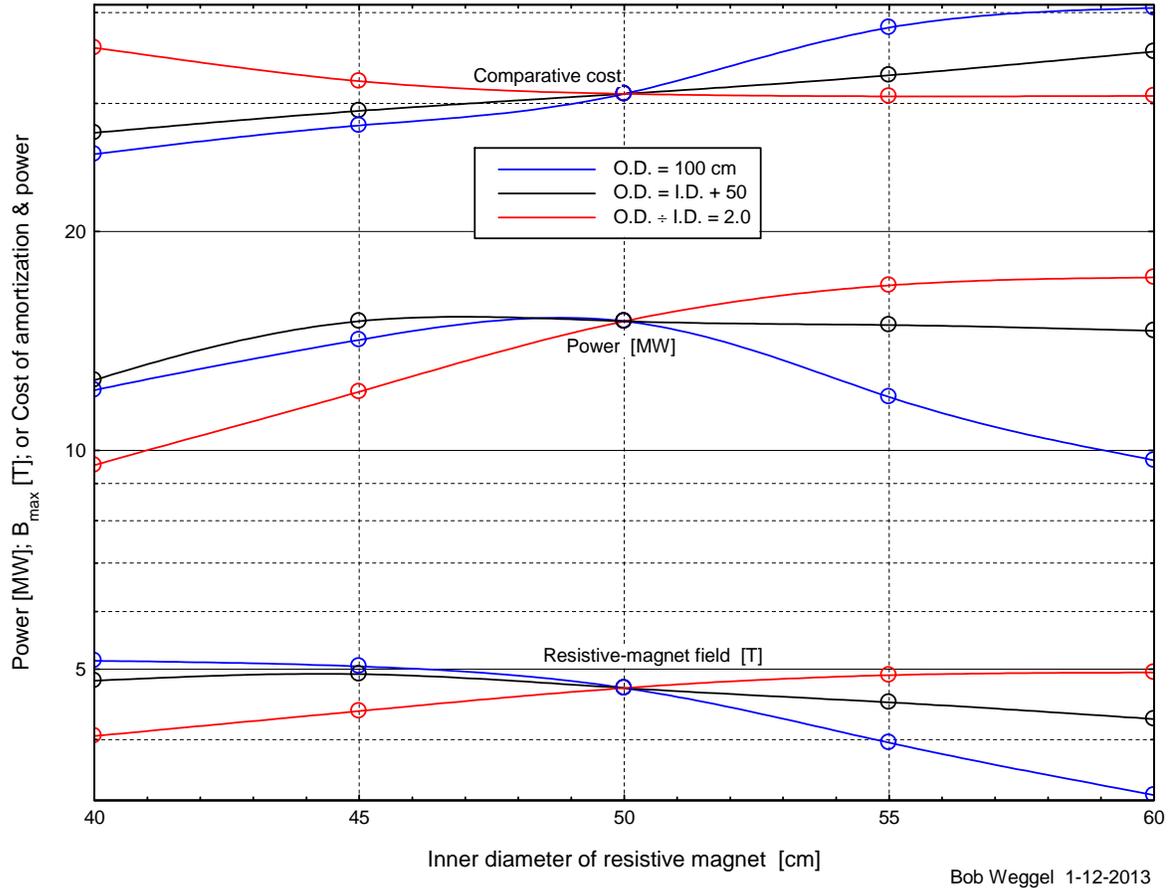Performance of IDS120k vs. Resistive-Magnet Inner & Outer Diameter

Bob Weggel 1-12-2013

Kirk McDonald requested that I design one or more Target Magnet systems in which the inner diameter of the resistive-magnet insert is as much as 60 cm. The above figure plots parameters of thirteen designs optimized to minimize total annual cost—power plus capital amortization—while satisfying all constraints on every coil and maintaining an on-axis field profile similar to that of "IDS120k3_30.docx".

The blue curves apply for a constant O.D. of 100 cm. Each increase in inner radius of the insert adds shielding but subtracts winding depth. An optimized system with an insert I.D. of 60 cm instead of 40 cm consumes 20% less power (9.7 MW instead of 12.1 MW), but generates 35% less field (3.36 T instead of 5.14 T), requiring the superconducting coils to generate more field and thereby increasing the estimated comparative cost of the Target Magnet system by 59%.

The black curves apply for a winding depth that is constant (25 cm); the shielding depth is constant, too. An insert I.D. of 60 cm instead of 40 cm implies an O.D. or 110 cm instead of 90 cm. Its optimal power consumption is 17% higher (14.6 MW vs. 12.5 MW); its field contribution is 11% less (4.27 T vs. 4.82 T); the estimated cost of the Target Magnet system is 29% higher.

The red curves apply for inserts of constant aspect ratio, O.D./I.D. = 2. Increases in I.D. imply increases in winding depth but decreases in shielding. With an I.D. of 60 cm instead of 40 cm (and hence an O.D. of 120 cm instead of 80 cm), the optimum power consumption is 81% higher (17.3 MW vs. 9.5 MW); the field is 22% less (4.95 T vs. 4.05 T); and the estimated system cost is 14% lower.

RJ Weggel, Jan 13, 2013