Electrical Infrastructure and Control Design of MRS Turbines

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What Are Multi-rotors?

Multi-rotor system (MRS) wind turbines are an innovative solution to achieving cost effective large scale wind turbines in the range of 20 MW. The idea is to have a large number of small turbines on one support structure instead of one large turbine, circumventing the square cube law and achieving significant savings in material costs. A recent push for larger rated turbines has lead to conceptual designs of turbines with blades in the range of 250m diameter. The same power level and swept area can be achieved using MRS turbines while saving $(1 - 1/\sqrt{n})$ on blade material and drive train components compared to an equivalently sized single rotor, where n is the number of rotors used in the MRS turbine.

The Project

Although some work has been done on the subject of MRS turbines, there is very little work done on the electrical structure and control strategy. This project aims to address many issues regarding the electrical infrastructure and how to control a multi-rotor array in a manner that optimises performance and provides an enhanced grid interface. A holistic design approach will be used in order to achieve a suitable design of the electrical system and control strategy and will consider the different areas shown below.

Project Aims

- Identify suitable infrastructure for a number of different MRS wind turbines of differing power ratings and individual rotor sizes.
- Development of tools and methods for control design purposes of MRS turbines suitable for grid integration
- Implement a lab-scale prototype of a reduced MRS electrical infrastructure for experimental validation

Benefits

- Reduced cost of blade materials and drivetrain components
- Further savings due to:
  - Standardisation of parts
  - Lower transport costs
  - Lower installation costs
  - Lower O&M costs
  - Improved reliability
- Reduced loading
- Load averaging results in smoother load profile
- Increased reliability due to:
  - Less defects in smaller components
  - only lose $1/n^{th}$ the total power if one rotor fails.
- Improved control capabilities
- Greater annual energy capture due to:
  - Interaction between individual rotors
  - Different solidity compared to large single rotor
  - Individual control of rotors to optimise performance for more localised wind fields.
- Could be utilised in sites previously thought to be to turbulent.

Holistic design approach

Electrical Infrastructure

- Single point or aggregated cluster points
- Choice of hardware
- AC, DC or hybrid collection
- Allow controllability

Control Strategy

- Minimise loads
- Maximise energy capture
- Allow provision of ancillary services
- Minimise outages of rotors

Interaction with the Grid

- Fault performance of individual rotors and whole system
- Achieve power quality standards

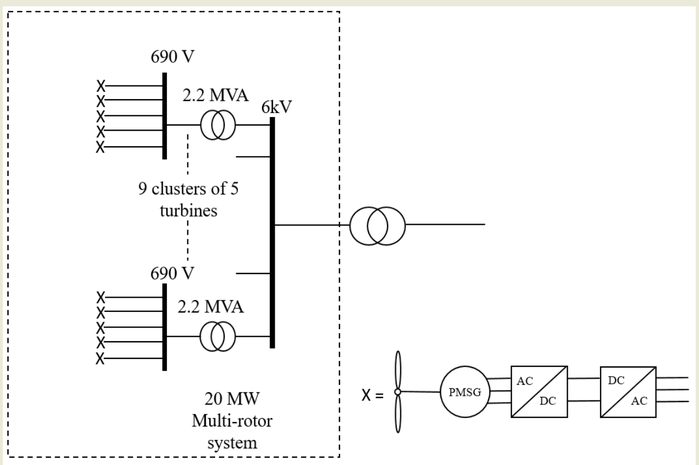
Ancillary Services

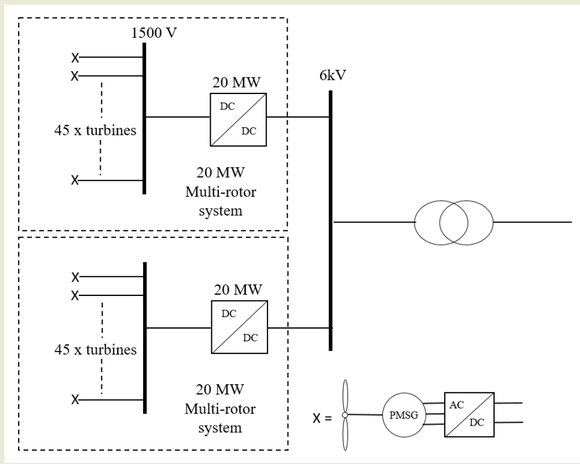
- Emulate synchronous generators by providing synthetic inertia
- Investigate other possible services

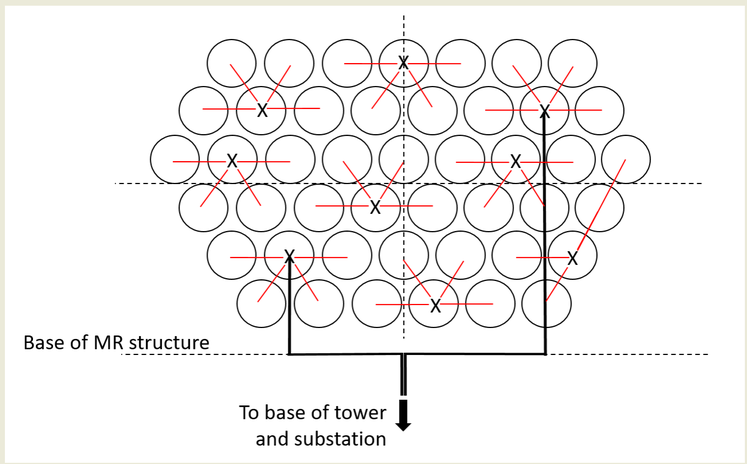
Cost Effectiveness

- Energy capture (including potential energy gains)
- Losses within the system
- Capital costs
- O&M costs

Example MRS Electrical systems







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