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Electrical Machine Technology: Innovations and Applications

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Photo by Stefan Els

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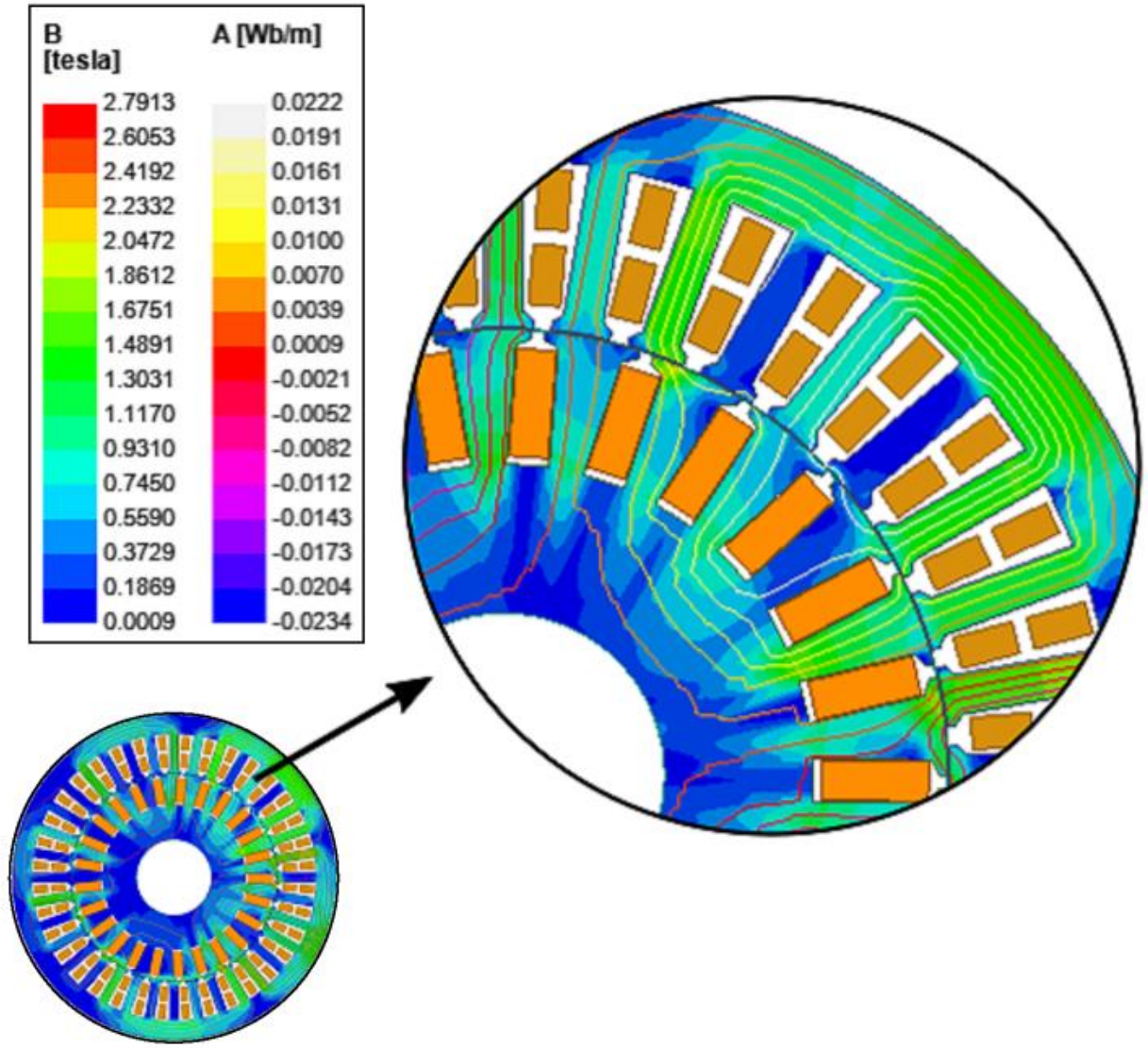
Brushless DFIG

- Doubly fed induction generators (DFIGs) are the most used generators in medium and large wind turbines.
- Slip ring and brush assemblies provide access to the rotor windings to facilitate the adjustment of rotor current magnitude, frequency and phase angle.
- DFIG based wind turbines currently have the highest operation and maintenance costs
- BDFMs and DFIG drivetrains operate similarly, as they employ the use of fractionally rated converters



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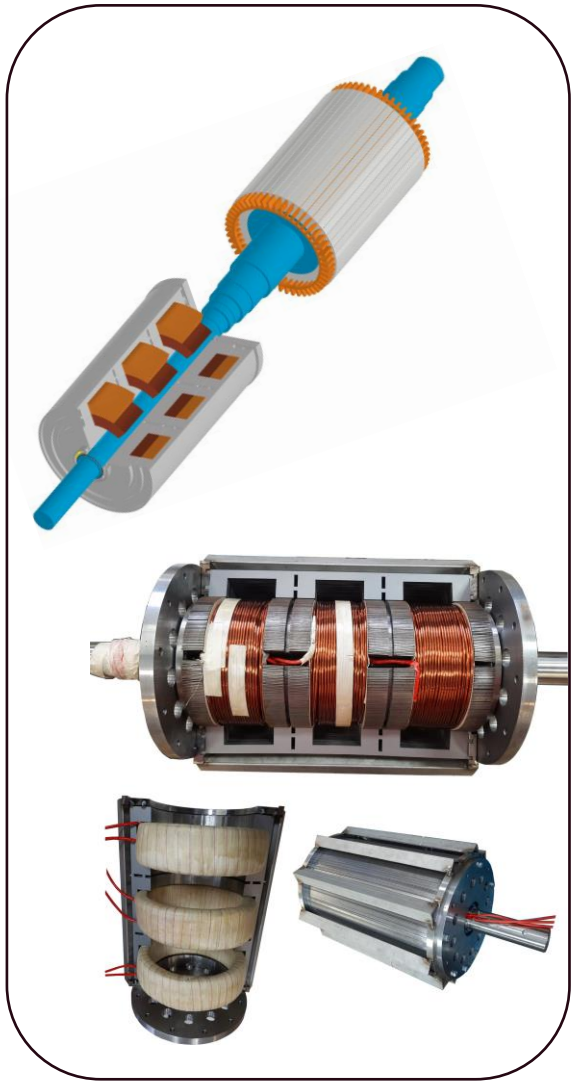
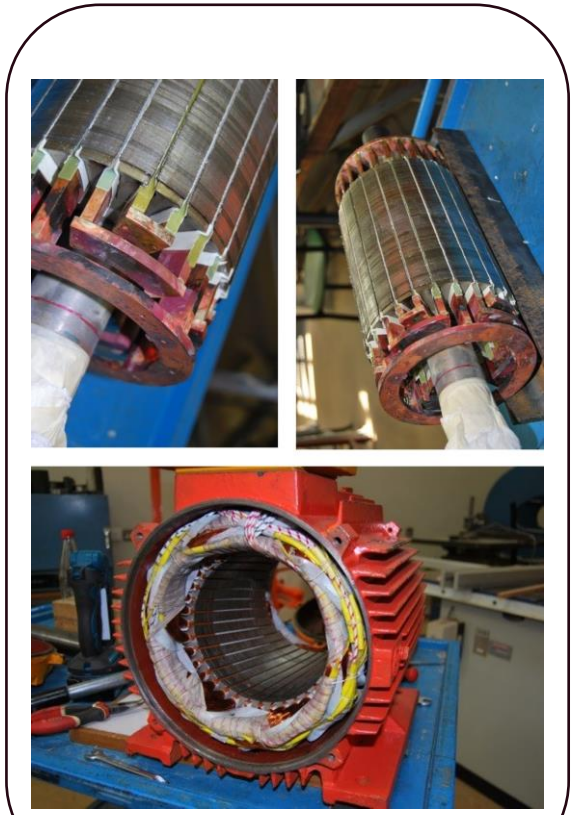
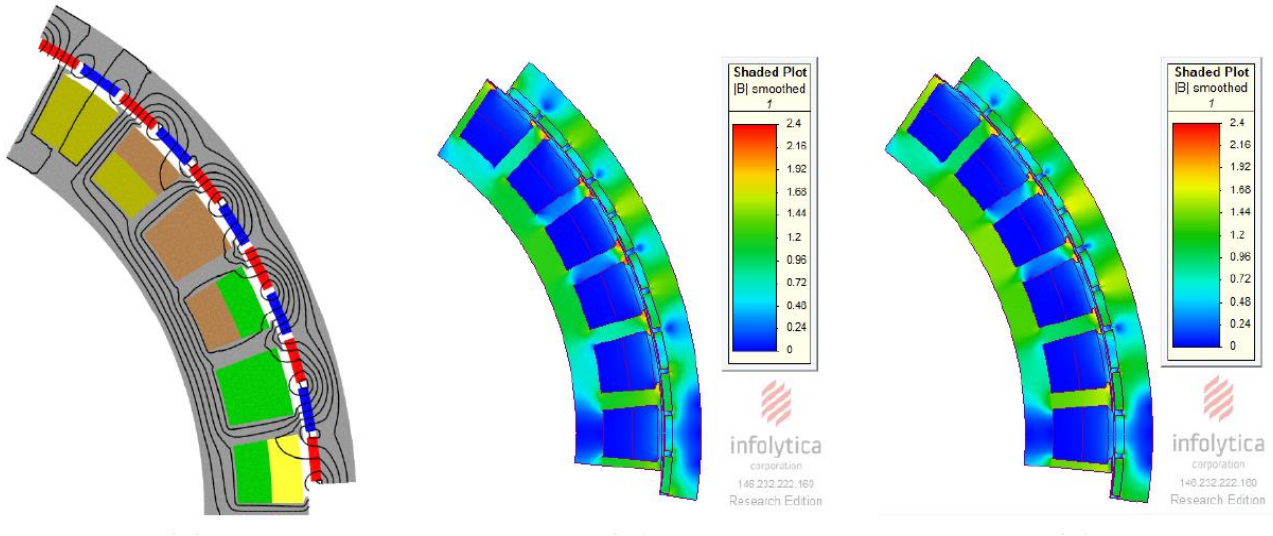




PM Vernier Machine (PMVM) for Wind Power Applications

- Magnetically geared electrical machines
- They have:
  - High torque density,
  - Potential for less weight and
  - More compactness than conventional permanent magnet synchronous machines (PMSM),
  - Keeps the same structural simplicity



Prototype PMVM(1/6th) FEM simulation results: no-load flux lines, no-load flux density distribution, and full-load flux density distribution.

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Construction and testing of a 15 kW PMVM

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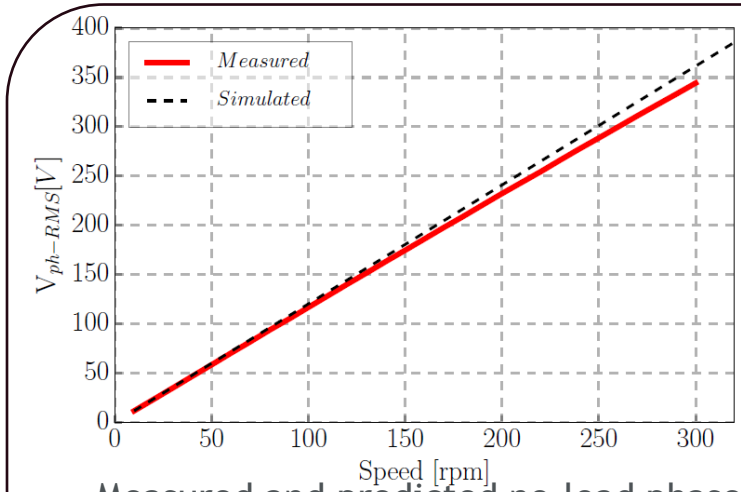
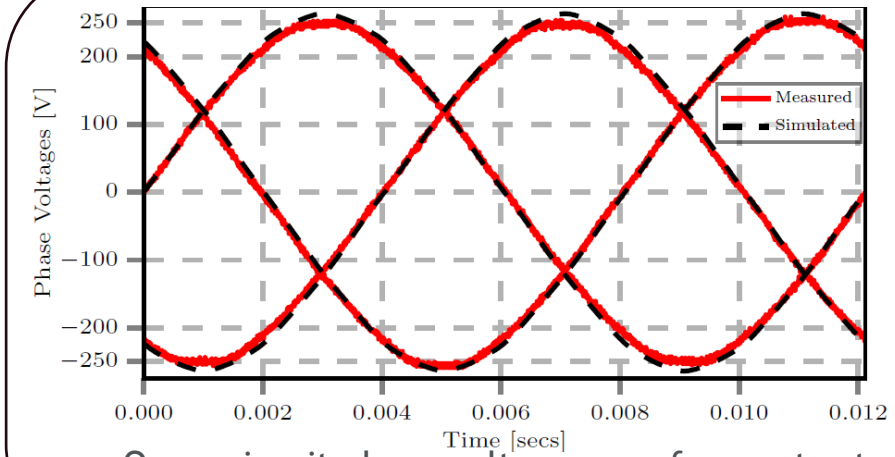


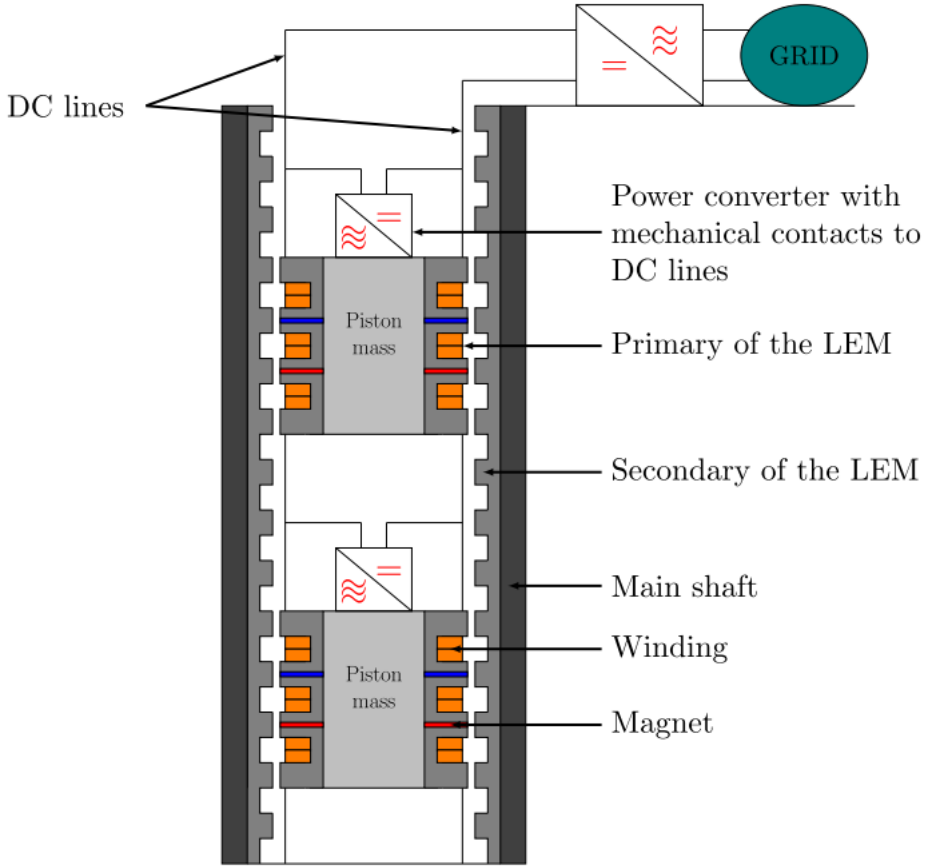
Measured and predicted no-load phase voltage versus rotor speed.

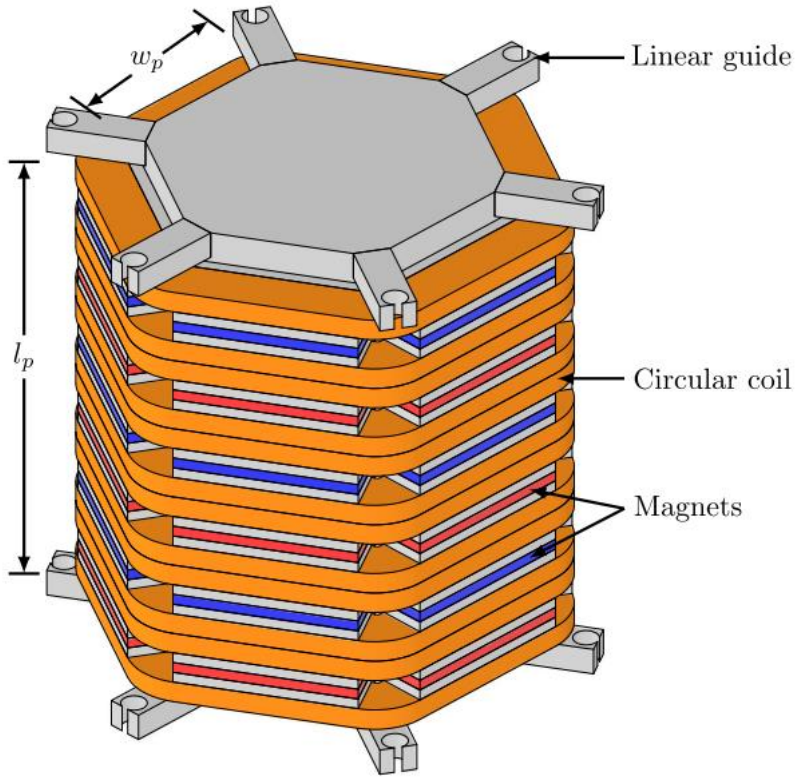


Open-circuit phase voltage waveforms at rated speed.

Linear Electric Machine Gravity Energy Storage System

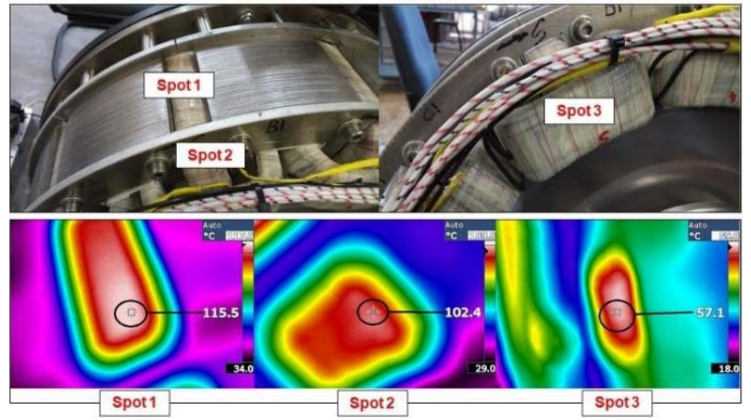
- A mechanical energy storage system
- Operates with multiple piston masses in a single shaft.
- More energy can be stored in a single shaft
- Eliminates the need for gears and other mechanical couplings



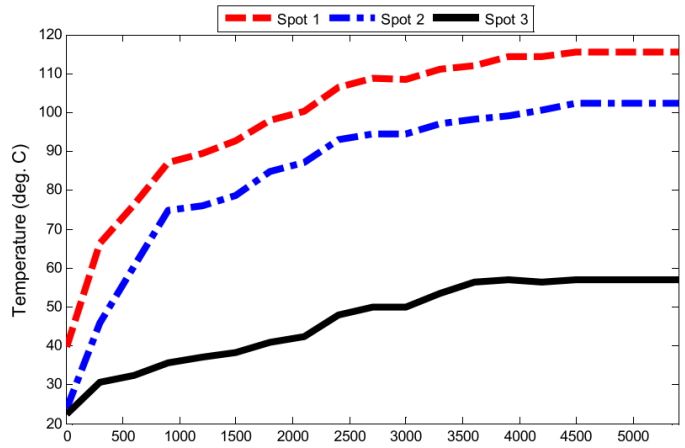


Non-Overlap Wound-Field Converter-Fed and Direct-Grid Wind Generators

- Design, optimize and analyse on non-overlap phase shifting winding WRSM for medium-speed wind power generation
- The design optimisation conducted is to be based on a multi-objective multi-variable optimization algorithm – NSGA-II
- The analysis algorithm is based on an in-house 2-D finite element analysis (FEA) package (SEMFEM)
- **Results**: The different hotspots show the rapid thermal build up in parts of the field coils compared to the armature coils.



Key thermal hotspots for WF-FSM prototype



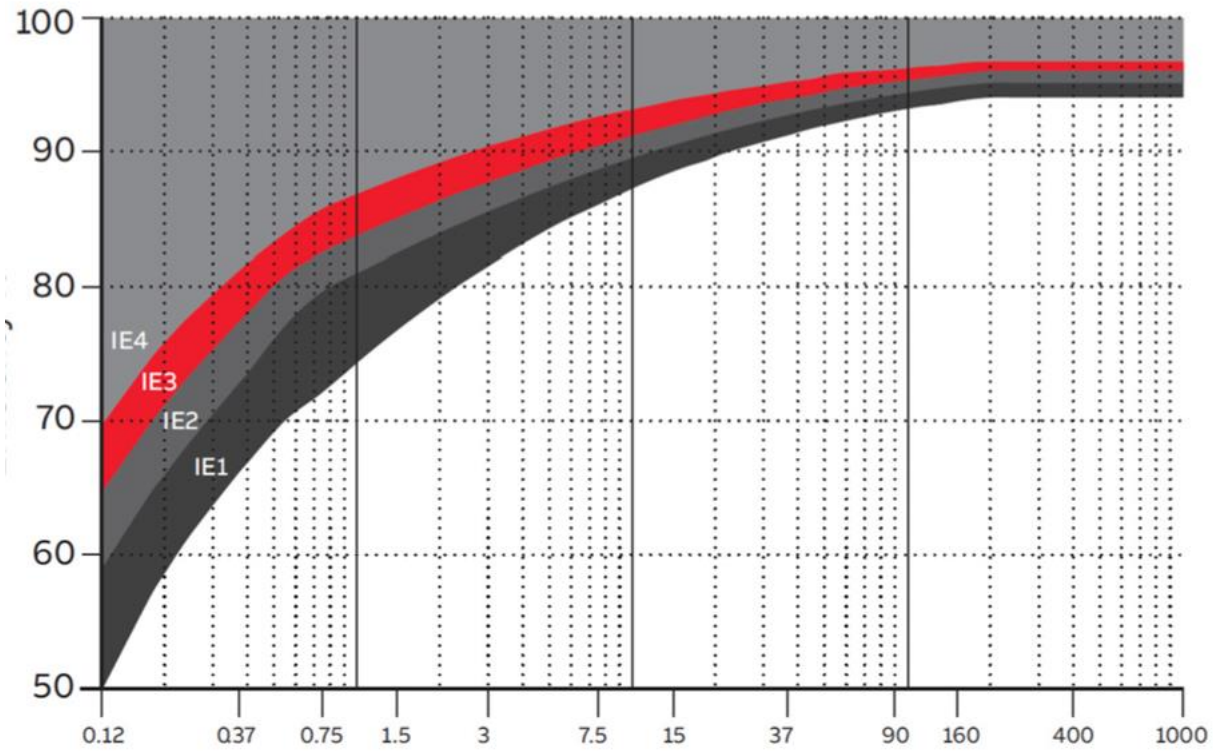
Heat runs under short-circuit condition for WF-FSM prototype

The bigger picture

- Electrical motors and generators are everywhere.
- They drive renewable energy generation, electric vehicles, trains, industry processes, home appliances, etc.
- Electrical motors consume more the 53 % of the world’s total electricity.

Environmental impacts

- Demand for energy is rising steadily
- Increase in pressures to reduce energy consumption and carbon dioxide (CO_2) emissions, and provide secure power supplies
- It has been estimated that electric motors account for about 70 percent of the electricity consumed in industrial applications
- Energy consumption depends on the motor's kW rating, the application and the operating hours
- High-efficiency motors can play a significant role in reducing CO_2 emissions

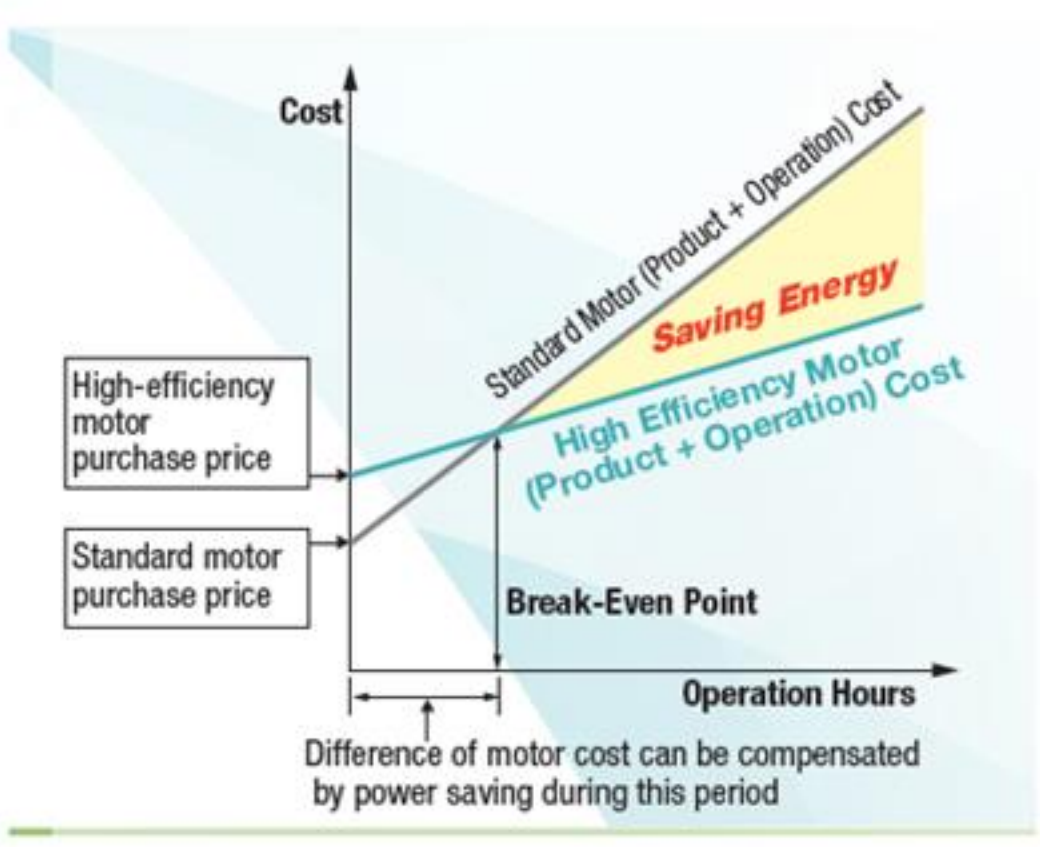


Overview of the nominal efficiency limits defined in IEC 60034-30-1

Mandatory Minimum Energy Performance Standards (MEPS)

- MEPS are regulations that set minimum energy efficiency standards for appliances and equipment to reduce energy consumption and environmental impact.
- Importance
  - Energy Efficiency: MEPS aim to improve energy efficiency, reduce electricity demand, and lower greenhouse gas emissions.
  - Environmental Impact: By reducing energy consumption, MEPS contribute to environmental protection and help mitigate climate change.
  - Economic Benefits: Lower energy consumption leads to cost savings for consumers and reduces the need for energy infrastructure investments.

- Motors sized between 0.75 and 375kW must comply with energy performance standards.



Opportunities

- Electric machine design and prototyping
- Motor Redesigns
- Electric machine testing
- Redesign and retrofitting for improved efficiency
- Electric machine testing
- Electric machines for traction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Thank you
Enkosi
Dankie
Photo by Stefan Els