ACTIVE STATOR - A MORE EFFICIENT DRIVE TRAIN CONCEPT FOR A WIND TURBINE

- The Renewables power train – Introduction
- The active Stator™ Concept
- DC - AC Architecture
- Conclusion
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CONVERTEAM
THE POWER CONVERSION COMPANY

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Converteam – utility scale renewable energy

- Key technology challenges for manufacturers

- **Increase torque density**
  - Maximum density means minimum mass
    - The lightest generator provides two great advantages:
      - The lowest serial production cost
      - The least supporting structural cost
  - Low speed means high torque
    - A low speed generator achieves:
      - Nature’s speed
      - The fewest moving parts
      - The lowest component count

- **Lower component count**
  - Half the components = twice the reliability

MARCH 11

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SWT3.6-107DD, courtesy Siemens Wind Power
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Major Components of Wind turbine

- Blades
- Hub
- Main Shaft
- Gear Box Transmission
- Brake
- Converter
- Generator
- Induction
- Permanent Magnet
- Transformer
- AC Cables
- Nacelle
- Tower
- Medium to High Speed Shaft
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CONCEPT FOR A WIND TURBINE

Eliminate the Gear Box = Direct Drive Train
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Split the Wind Turbine Converter

- Hub
- Main Shaft
- Brake
- Converter
- Direct Drive Generator
- Permanent Magnet
- Nacelle
- Blades
- Medium to High Speed Shaft
- Tower
- DC Cables
- AC
- DC
- Split the Wind Turbine Converter
Many applications look for further nacelle size, weight reductions and systems savings

- Split converter into two major core bridges
  - Rectifier in the nacelle
  - DC Cable down the tower
  - Inverter and other components in tower structure or at the base

- Leading in further advantages in:
  - Total nacelle size and weight
  - Foundations
  - Cables & rotation of nacelle
  - Power system overall topologies
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The Fusion of Wind Turbine PM Generator and Power Electronics

Logical Follow-Up

The diagram illustrates the integration of a Permanent Magnetic Generator and power electronics within a wind turbine structure. The key components include:

- **Hub**
- **Main Shaft**
- **Blades**
- **Nacelle**
- **DC Cables**
- **Rectifier**
- **Active Stator™**

These components work together to enhance the efficiency and performance of the drive train for wind turbines.
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I_{DC}  

V_{DC}  

AS ELECTRONIC COMMUTATOR  

AS MACHINE  

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I_{DC}

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I_{DC}

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Converteam Active Stator™

- Innovative fully integrated electronically commutated machines

- Lowest cost version:
  - Air cooled stators and rotor
  - Liquid immersed stacks
  - Simplest implementation of semiconductors for the control of MW level power

- Highest power density:
  - Liquid cooled stator and rotor
  - Liquid immersed stacks
Converteam Active Stator™

- Large full scale Active Stator™ currently in production
- Two Full scale direct drive machines currently in production
- Will be tested in a Back to back arrangement Q2 2011
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AC Network

![Diagram of AC Network](image)

- AC supply transformer
- Long cable
- Turbine transformer
- Inverter’s reactor
- Capacitor bank
- HV AC supply
- Other inverters
- PWM harmonic filters
- PWM Inverter
- PMG

Offshore Transmissions PC Coupling

Wind Turbine electrical system

![Graph of Gain vs Frequency](image)

Frequency

Gain

100

1

0.001

0.0001

100

1000

10000
DC Networks

- Can operate at a higher voltage than an equivalent AC system using the same insulation
- Operates at unity power factor, more power per mm² of conductor
  - DC typically 22% higher power for a given mm² of copper (earthing conductors not taken into accounts)
- Generators not constrained to operate at the same frequency
  - Wind Turbines can operate at their most efficient operating point
  - Simplicity of reconfiguration
- High integrity & robustness of supply
- Simple to integrate energy storage systems, if necessary
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The Active Stator™ is an innovative variable speed drive topology that exploits and extends the benefits of DC machine technology, enabling significant power density improvements.

- Use of low forward voltage drop power semiconductors and switching frequency to maximise efficiency for a given power density.

- Use of simple, robust, whole wafer, compression mounted power semiconductor devices to maximise the reliability for a given power density.

- The Active Stator™ concept is particularly well suited to the requirements of Direct drive wind turbine generators.

- The Active Stator™ topology concept has been successfully demonstrated.
Thank you for your attention