

“Addressing Global Wind Farm Interconnection Requirements”

***Sino-German Seminar on Wind Energy
Connection with Power Network
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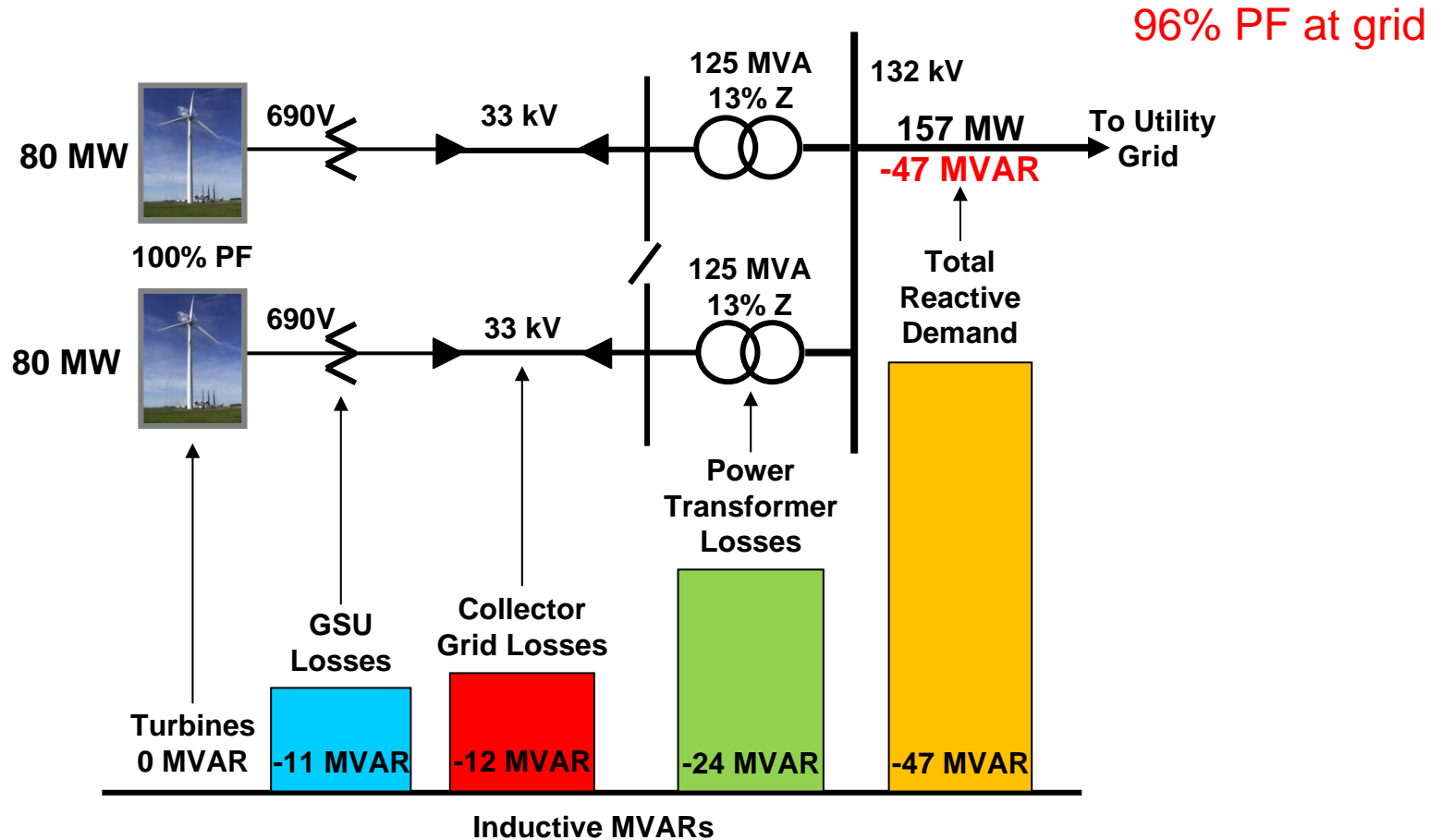
Discussion Topics

- Grid Integration Issues
- Global Interconnection Standards
- Meeting Interconnection Standards using Dynamic Reactive Compensation
- Recommended Interconnection Standards

Wind Generation Impacts on the Transmission Grid

- High VAR consumption of induction generators
- Voltage fluctuations due to variable power output
- Inability to regulate voltage within required limits
- Tripping off due to sudden low or high voltage events
- Changes in wind speed can cause sudden power output changes

Typical Wind Farm - Sources of Reactive Demand



Wind farms are large inductive loads that need compensation

Global Interconnection Requirements for Wind Farms

Global Wind Interconnection Requirements for new Wind Farms

<u>Country or Utility</u>	<u>Power Factor Req.</u>	<u>Dynamic Reactive</u>	<u>LVRT/HVRT</u>
1. South Australia	+/-93% at POI	50% of total	Yes/Yes
2. United Kingdom	+/-95% at POI	100% in 1 second	Yes/No
3. USA (FERC/NERC)	+/-95% at POI	Not Required	Yes/No
4. Ontario, Canada	+90/-95% at MV bus	Match conventional	Yes/Yes
5. Alberta, Canada	+90/-95% at POI	50% of total	Yes/No

Retroactive Requirements for Wind Farms

1. Spain – New regulations require LVRT installed on existing turbines
2. Germany – New regulations require dynamic PF capability installed on existing turbines

Requirements vary by country and utility but have a common theme – Wind Power must not decrease grid security

Options to Address these Standards

- Add capability within the wind generator turbine itself
- Add equipment at the collector bus level
- Add a combination of improved turbine capability plus some equipment at the collector bus
- Add equipment at the HV point of interconnection.

A Solution at the Collector Bus has many Advantages

- Less expensive for larger wind installations
- Provides full voltage regulation capability even when wind plant is not generating
- Allows for a more flexible collector grid design
- Allows a wider voltage control range for the utility
- Solution is modular and expandable

Meeting Interconnection Requirements using Dynamic Reactive Compensation

AMSC's Grid Interconnection Solutions

Substation-Level Solution: AMSC's D-VAR® System



Wind Turbine Solution: AMSC's PM3000W



AMSC is meeting interconnection requirements around the world

D-VAR[®] System - Dynamic VAR Device

- Fully Integrated IGBT based STATCOM with proprietary overload capability of 2.67 times its continuous rating
- Provides dynamic reactive capability – both leading and lagging
- D-VAR[®] system can seamlessly switch other capacitors and reactors as part of a larger dynamic solution
- 36 wind farms around the world use D-VAR[®] systems for
 - PF correction
 - Voltage regulation
 - LVRT
 - HVRT
- Modular 4 MVA size

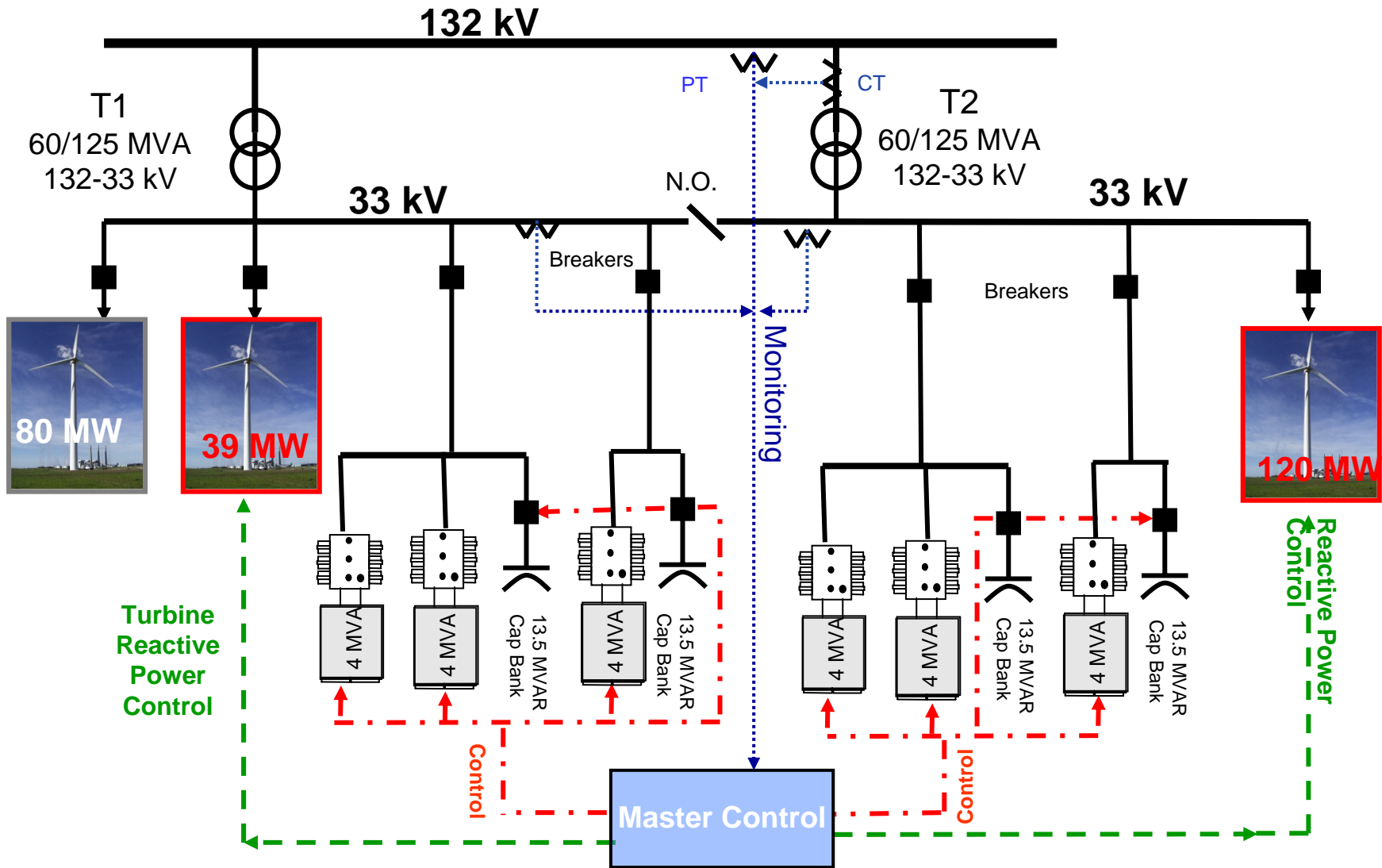


S. Australia Wind Interconnection Requirements

- Capable of +/-93% PF at high side of power transformer at full generation
- Half of PF correction capability shall be dynamic
- Reactive output at least proportional to generation level
- Regulate transmission system voltage
- Avoid tripping wind farm for nearby transmission grid faults and high voltage
- Restore transmission system post fault voltage to a minimum of 90%

S. Australia's Interconnection Requirements are Comprehensive

Lake Bonney, South Australia - Reactive Compensation System with D-VAR[®] Device

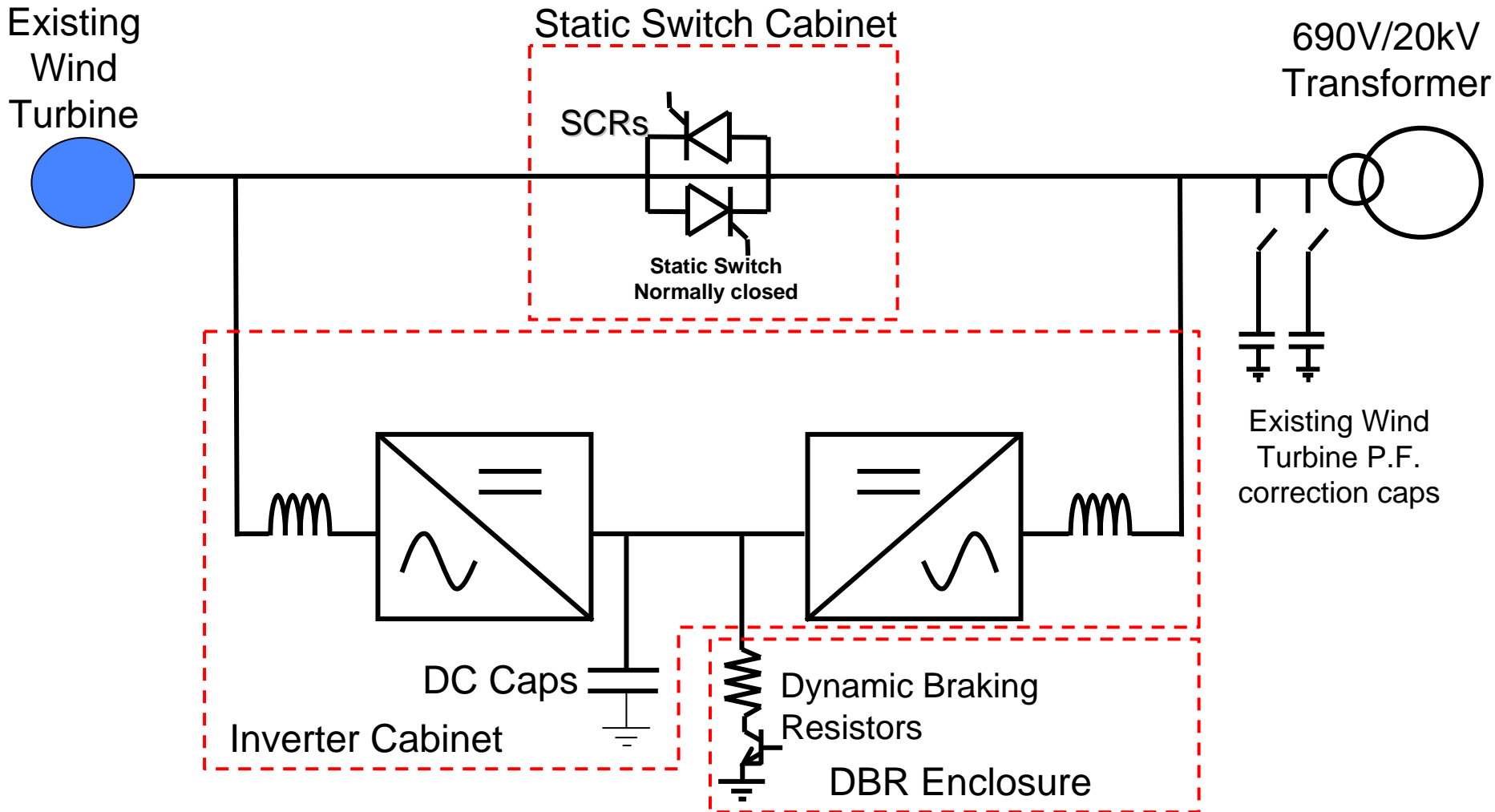


Lake Bonney D-VAR[®] Summary

- D-VAR[®] system solution meets all static and dynamic reactive output requirements
- D-VAR[®] system provides fast, dynamic, continuous voltage regulation at the 132 kV bus
- D-VAR[®] system meets HVRT requirements
- D-VAR[®] system meets post transient transmission voltage recovery requirements
- D-VAR[®] system minimizes costs by utilizing the variable PF capability of the turbines
- LVRT met with internal turbine capability plus D-VAR[®]

D-VAR[®] system fully addressed S. Australia's interconnection requirements

Providing Retroactive LVRT for a Wind Farm



Power electronic equipment will provide Low Voltage Ride Through (LVRT) protection for wind turbines during sag events on the transmission grid

Recommended Wind Generation Interconnection Requirements

- Wind Power generation should be held to the same interconnection standards as conventional electric power generation
- Wind Interconnection standards should include:
 - Ability to regulate the transmission grid voltage
 - Able to meet a +/-95% power factor at the POI at full generation level
 - 50% of the total reactive compensation must be dynamic
 - Ability to ride through low voltage and high voltage situations on the transmission grid without tripping off line
- Meeting these interconnection requirements will allow wind power to advance China's national energy policy and contribute significantly to overall grid security

These requirements will help China's wind industry achieve it's full potential

Questions?



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