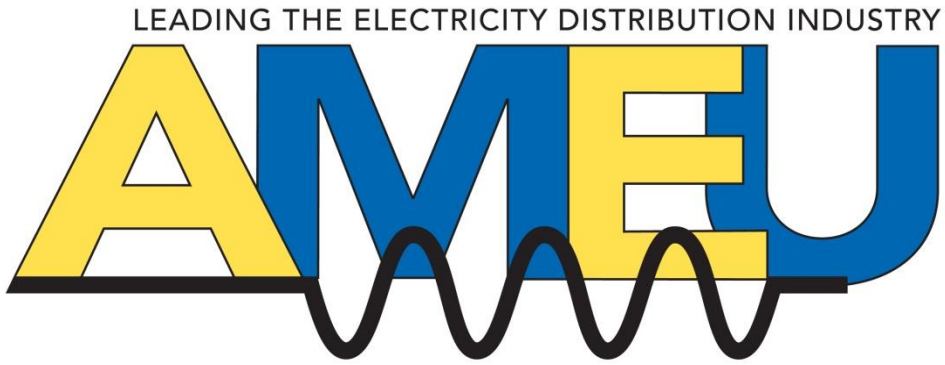

7 – 9 October 2013

The Inter-Relationship between Renewable Generation Reactive Power Capability and Grid Code Compliance

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S&C Electric, United Kingdom

Introduction

- Most renewable energy plant will have the capability to generate and/or absorb reactive power (MVAr)
- However, that does not mean they will be grid code compliant.
- The presentation will explain the relationship between plant reactive power and voltage capability and the grid code.
- I will not cover real power and frequency characteristics in this paper

Why Grid Codes?

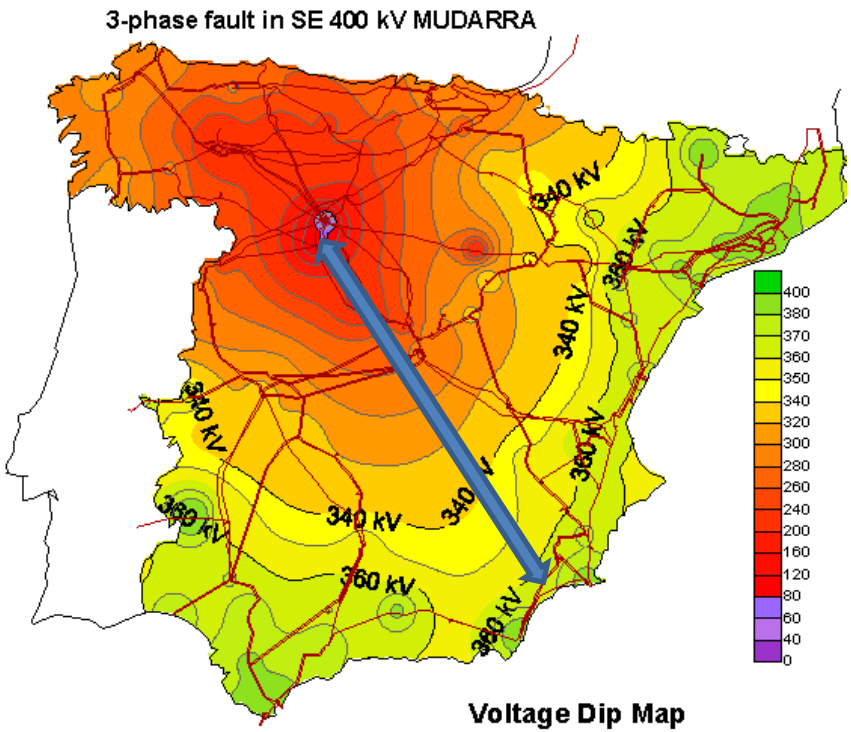
- Permit the development of and operation of an efficient and economical power system whilst ensuring security of the network as a whole.

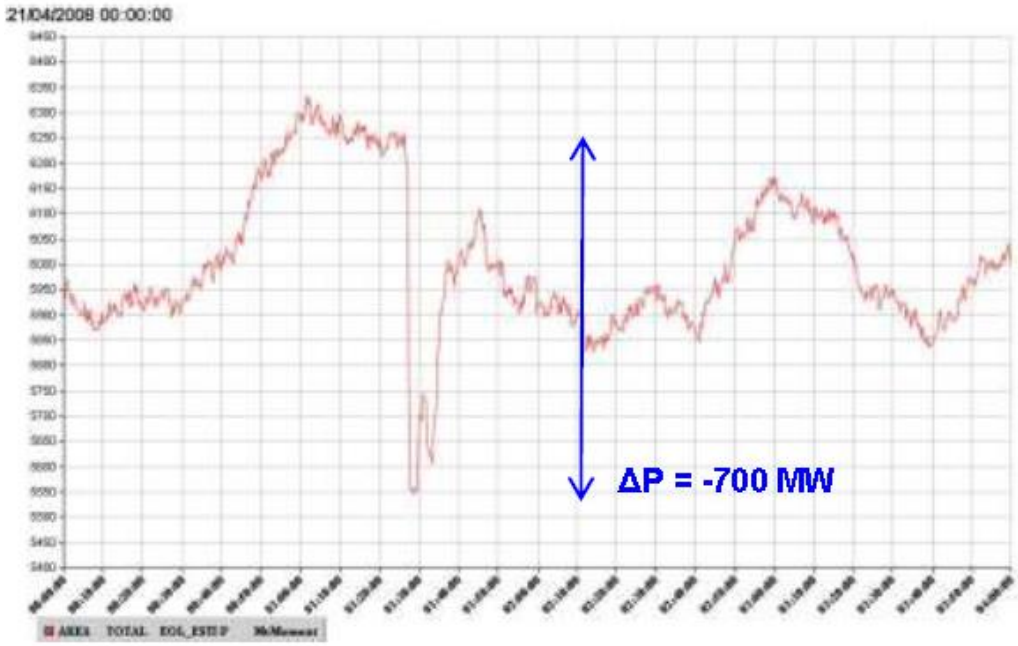
- Since transmission networks in different parts of the World have different characteristics the grid code should be developed to meet the needs of that network.

Why are Grid Codes Changing

- Why are many grid codes modified to accommodate renewable energy?
  - As the proportion of renewable energy on the system increases conventional generation is displaced.
  - We are therefore displacing continuously available generation with an intermittent generation.
  - It is therefore important that the behaviour of the renewable generation is similar to that of conventional generation when it is generating. Taking into account the characteristics of the technology.
  - If this is not the case then system integrity maybe jeopardized.

Impact of 400kV 3ph Fault in Spain in 2008 without a FRT requirement





640km from fault voltage dropped to 360kV 0.9pu

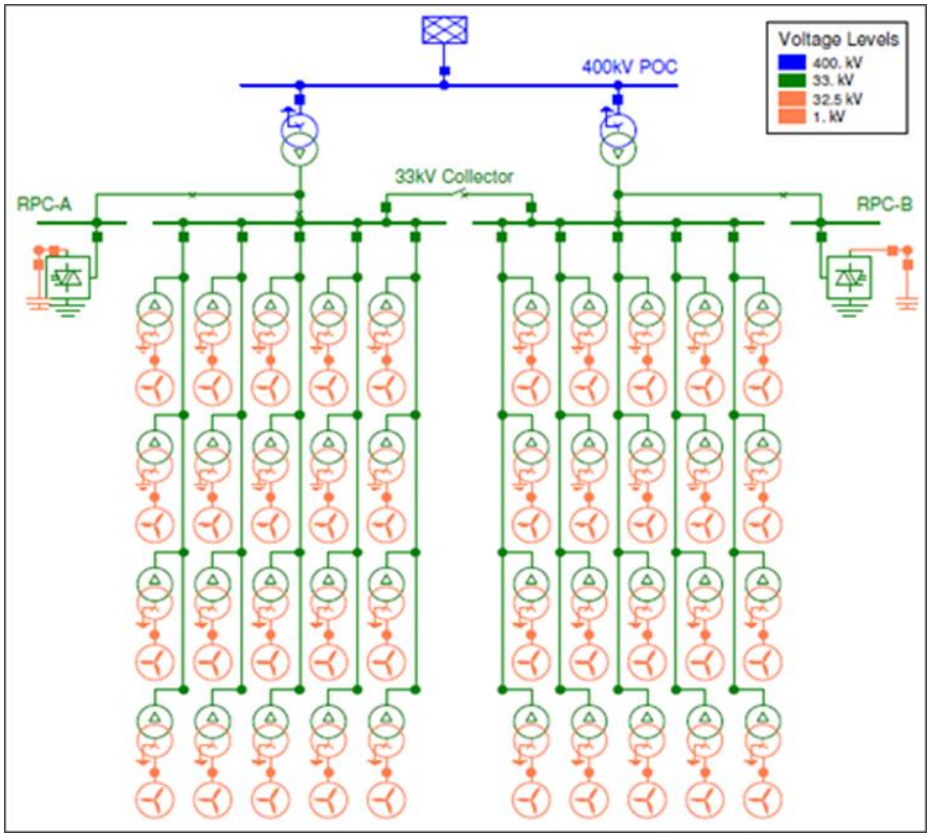
What Aspects of Wind farm behaviour are important?

- Frequency Control – characterised by the real power (MW) output of the wind farm. (this will not be discussed)
- Voltage Control – affected by the ability to control reactive power (MVAr) to maintain a target voltage.
- Supply of reactive power – to support the network.
- Speed of Response (not covered here)
- Low Voltage and High Voltage Ride-through – this is the ability to remain connected to the system following a system event.

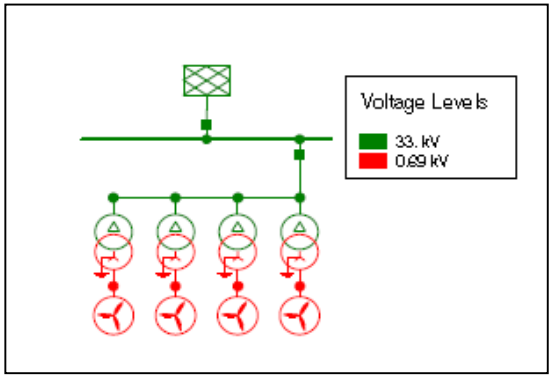
South African Grid Code

- 3 categories of generation
  - Category A: less than 1MVA
  - Category B: 1-20MVA
  - Category C: greater than 20MVA
  - Some of these have sub-categories
- The paper will concentrate on larger generation Category C.

Typical Windfarm Configuration



Transmission



Distribution

Reactive Power Requirements for Larger Windfarms

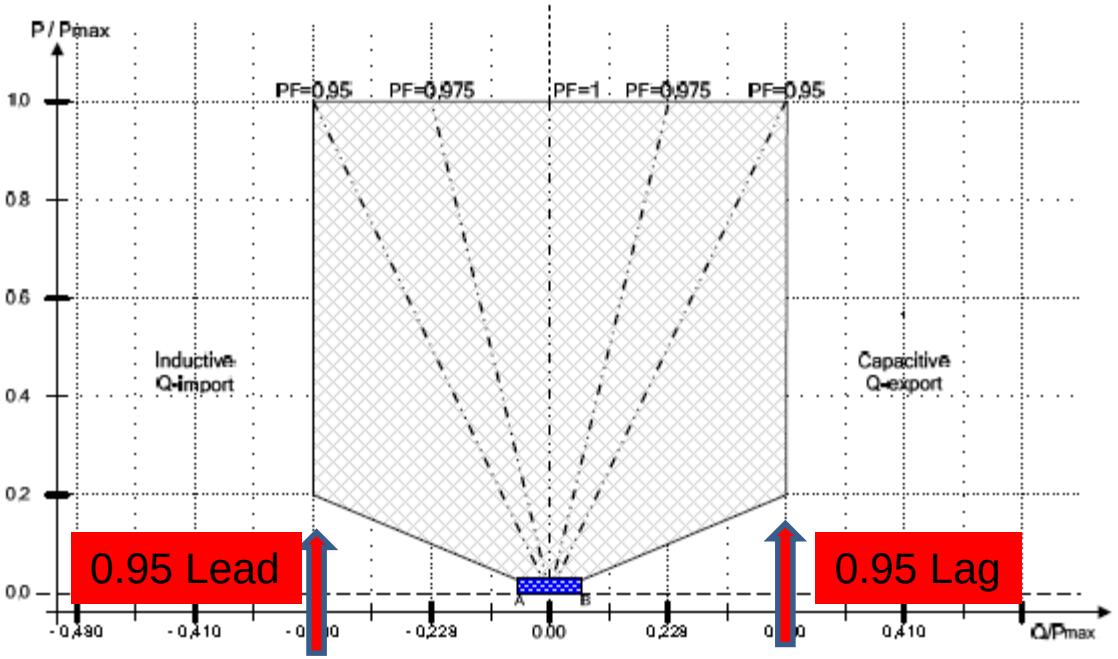
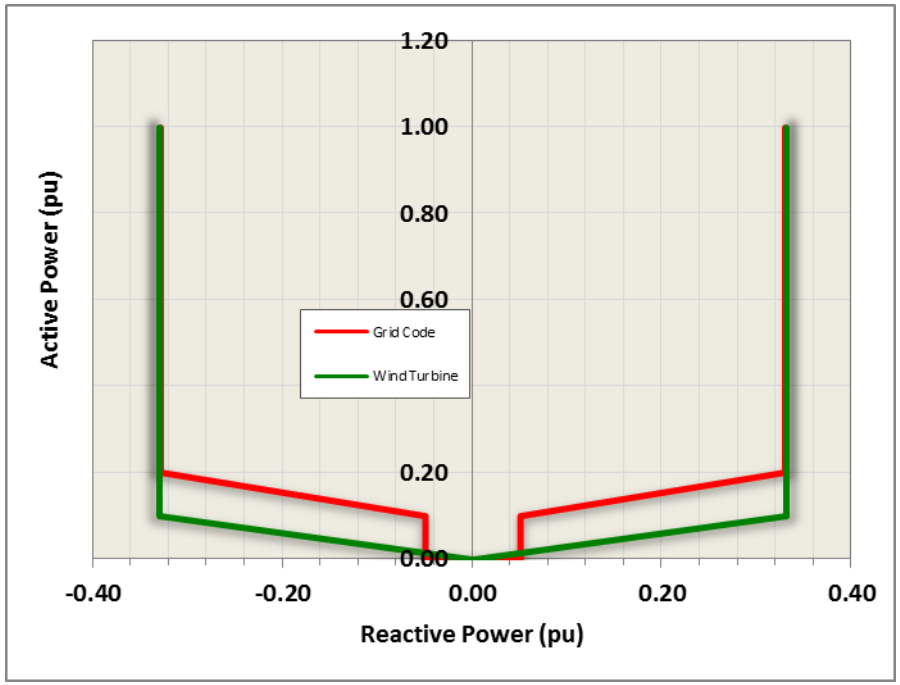
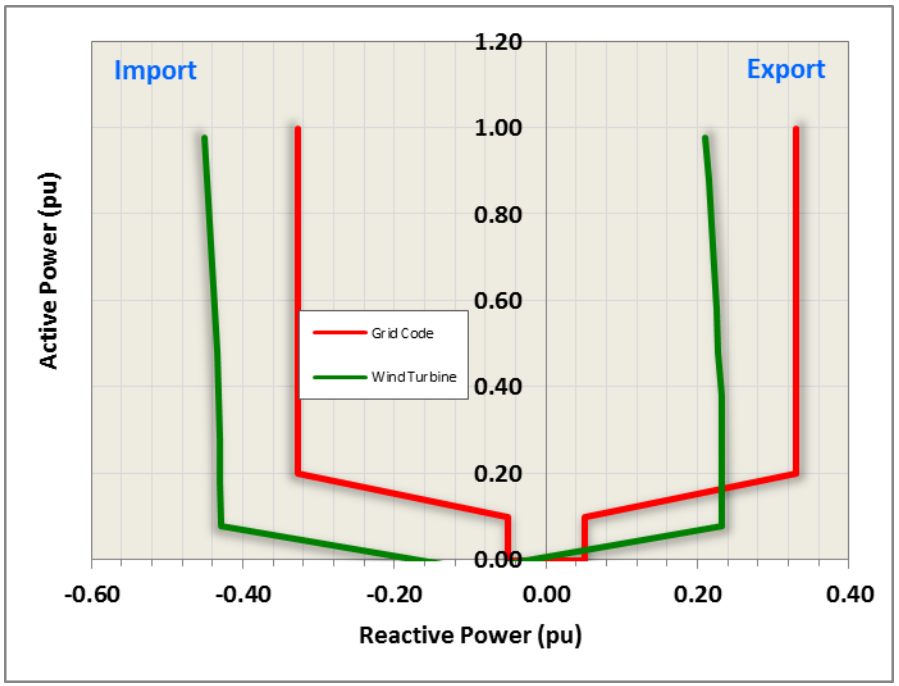


Figure 9: Reactive power requirement for *WEF* with *MEC* equal to or greater than 20MW

Is Your Wind Turbine Grid Compliant?



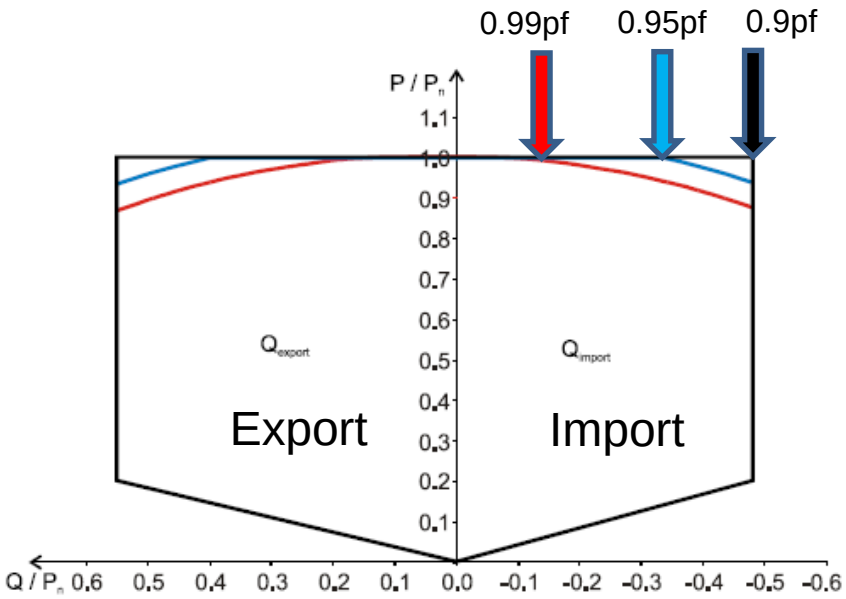
At the Turbine Terminals



At the POC

Reactive Power Capability

Voltage can have a major impact on WTG Capability



Pict. 1: PQ chart as determined by grid voltage

90 % U_n

95 % U_n

100 % U_n

Summarising Steady State Reactive Requirements

- It is important that grid code compliance is demonstrated at the POC.
- It is important that voltage is considered.
  - To ensure there is adequate margin
  - To ensure the WTG capability is available at the required voltage.
  - WTG normally have a limited voltage range outside which they will switch off or reduce their output to protect themselves.

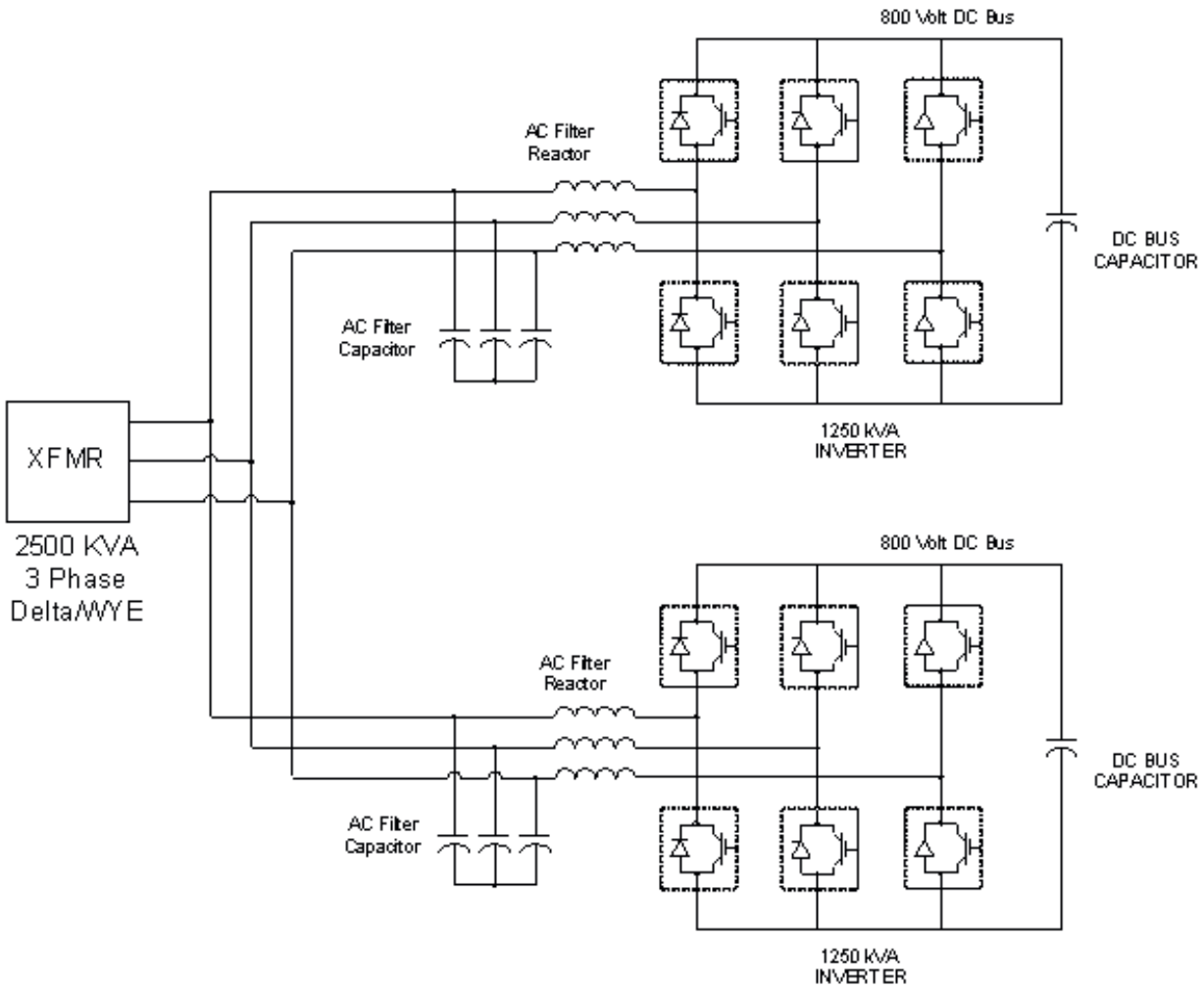
What if the WTG cannot achieve Grid Code Compliance?

- It is then necessary to provide addition reactive compensation.
- This is normally placed as close to the POC as possible.
- It can come in various forms
  - Fixed switched devices (capacitors or reactors)
    - Not acceptable if continuous or fast voltage control is required.
  - Statcoms
    - Full Inverter, Bias Capacitor or Hybrid system
  - SVC (usually economic only on very large wind farms)

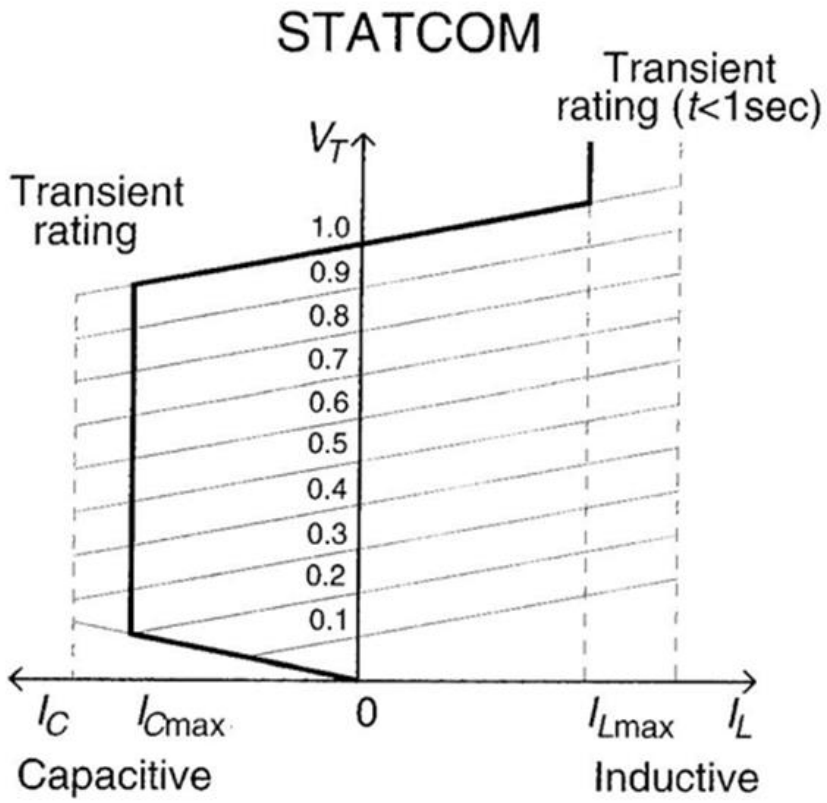
If a Statcom is Required

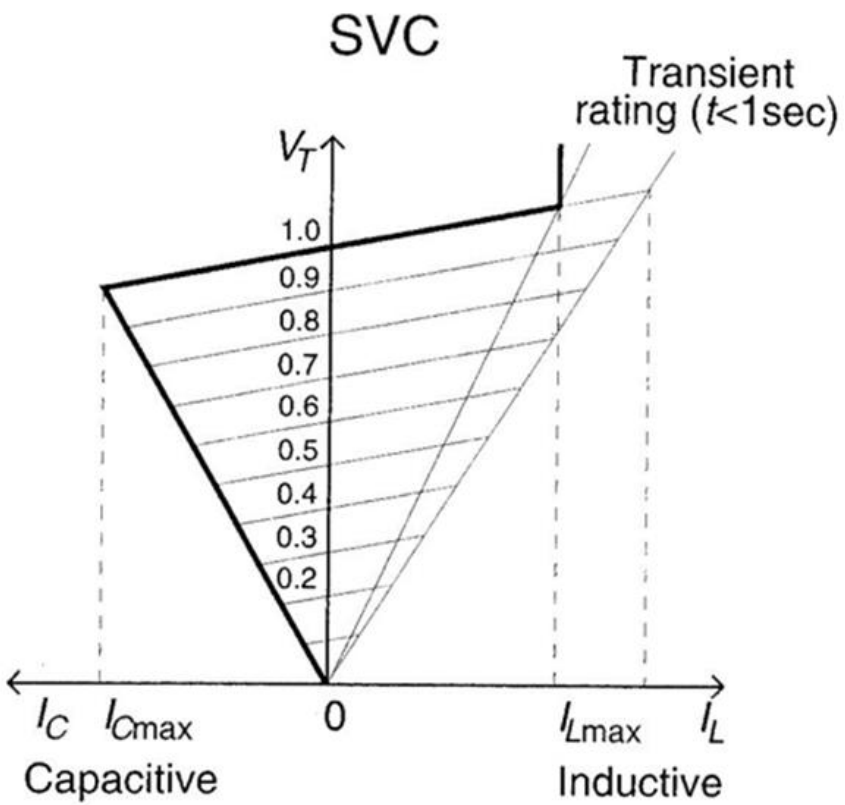
- There 3 basic configurations
  - Full Inverter
  - Inverter + Bias device (usually a capacitor)
  - Hybrid Solution

Typical Statcom Configuration

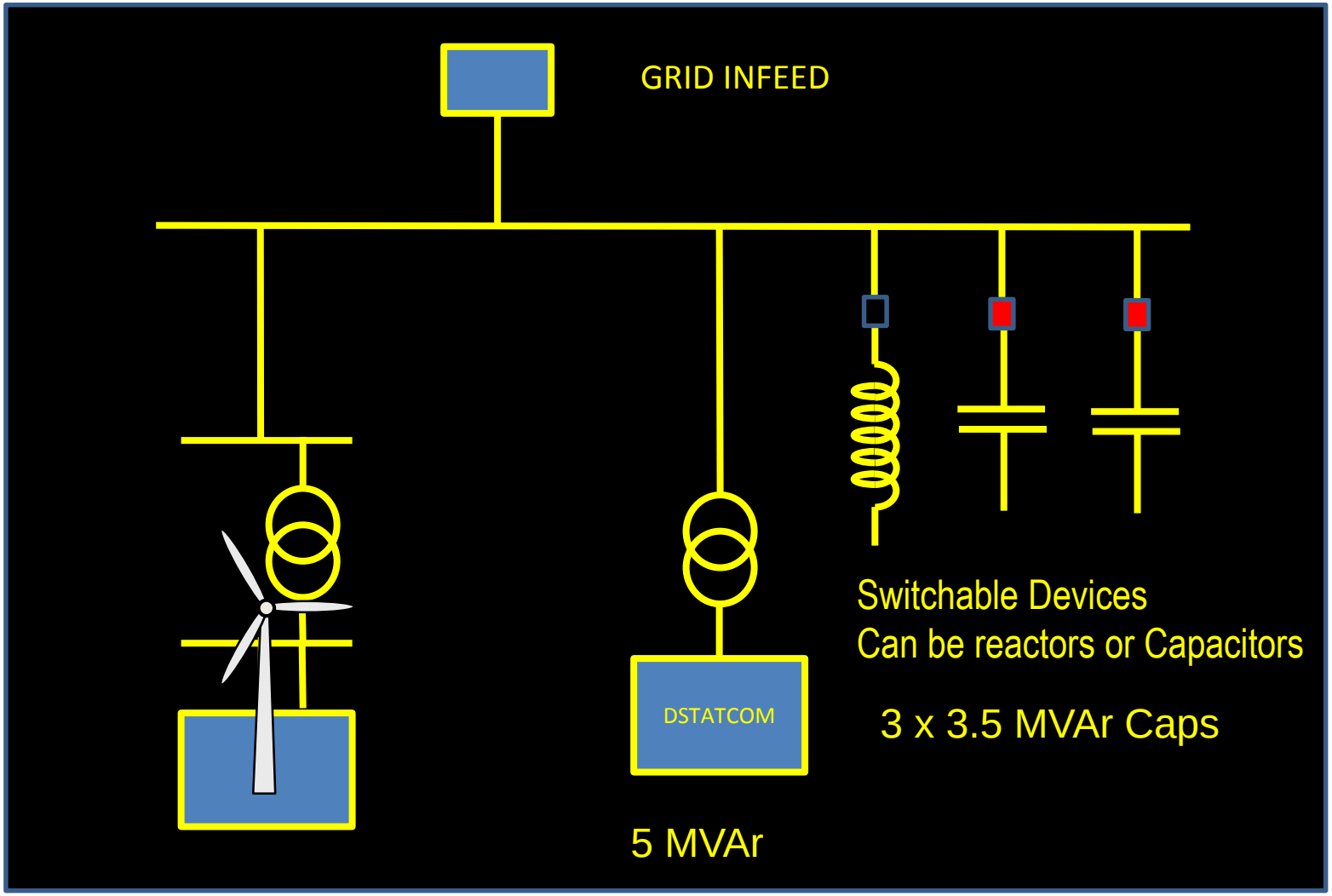


Comparison of STATCOM and SVC Characteristic

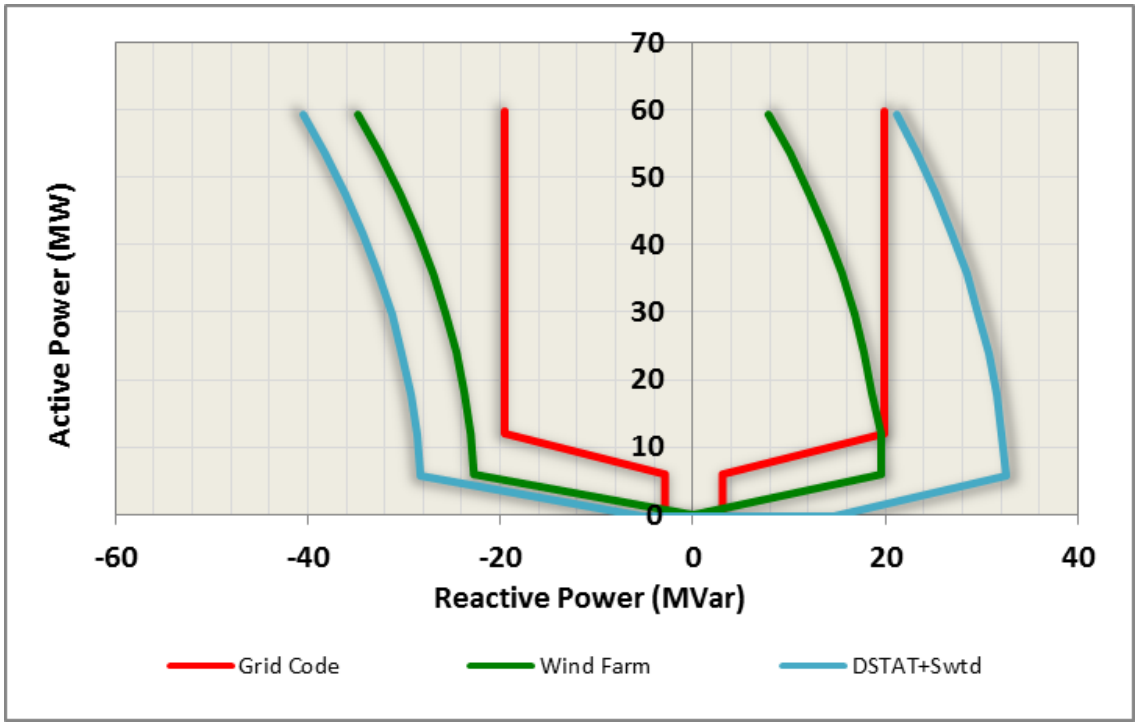




Hybrid Solution



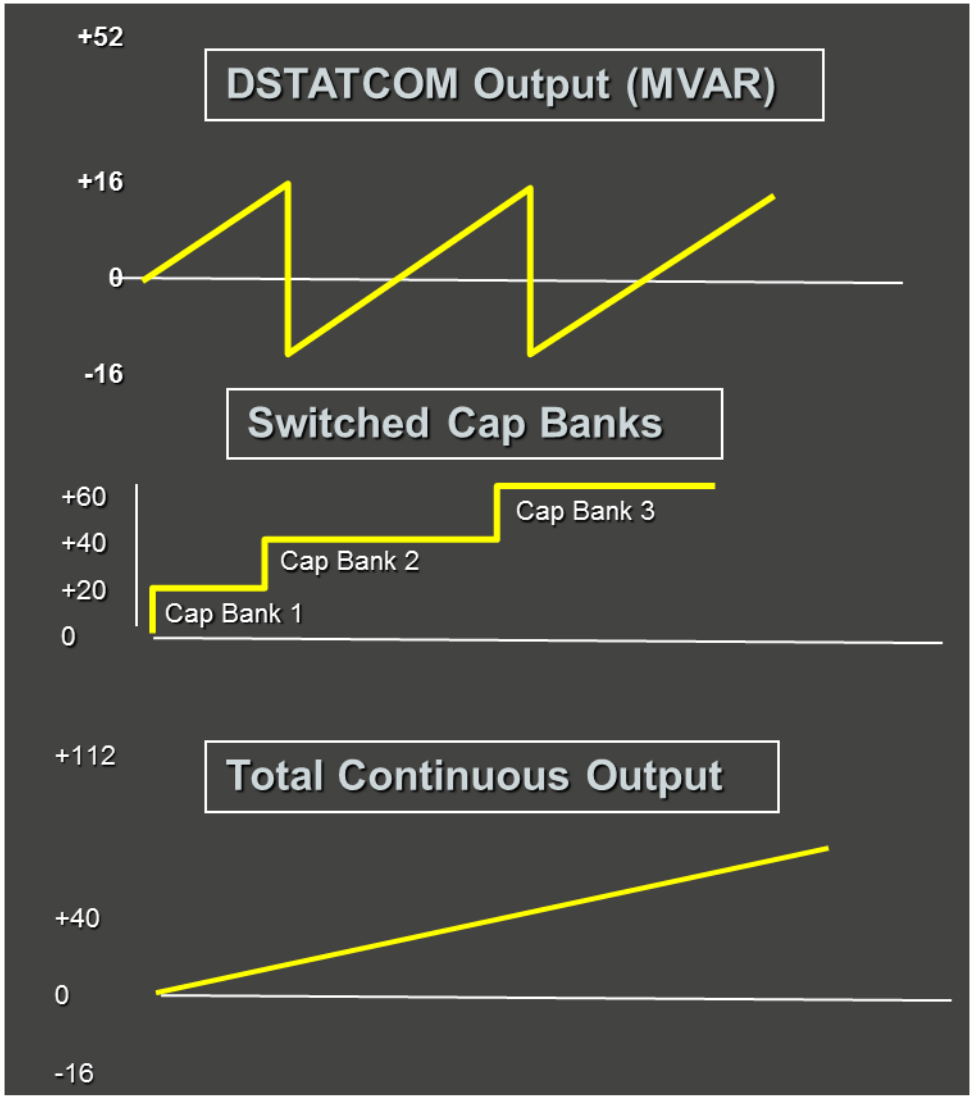
Hybrid Solution



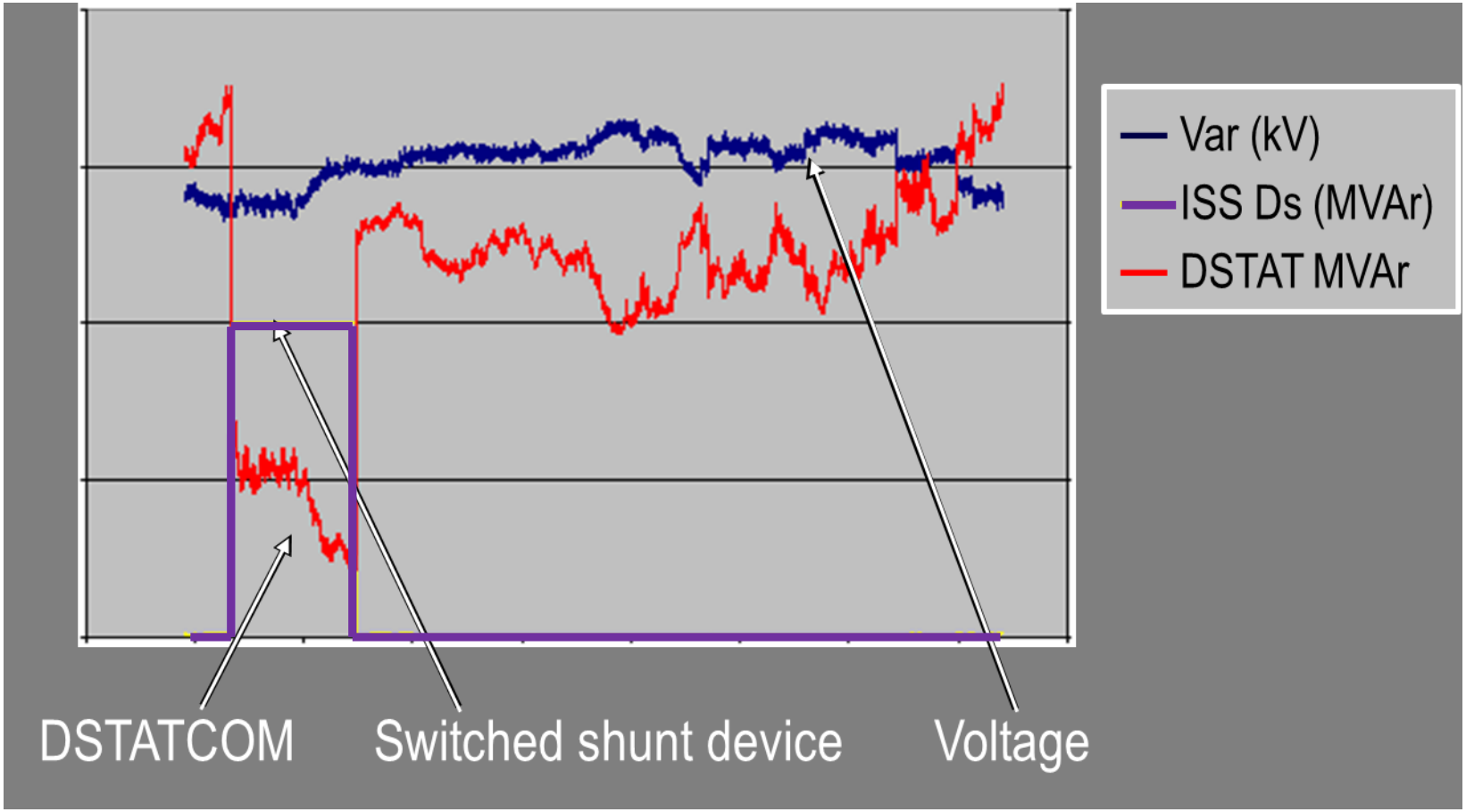
Inverter 5MVAr
Switched 3 x 3.5MVAr Caps

How does this give Continuous Control?

PureWave DSTATCOM Hybrid with Switched Capacitor Banks



Actual Performance of STATCOM at UK Wind Farm



Fault Ride Through
LVRT and HVRT

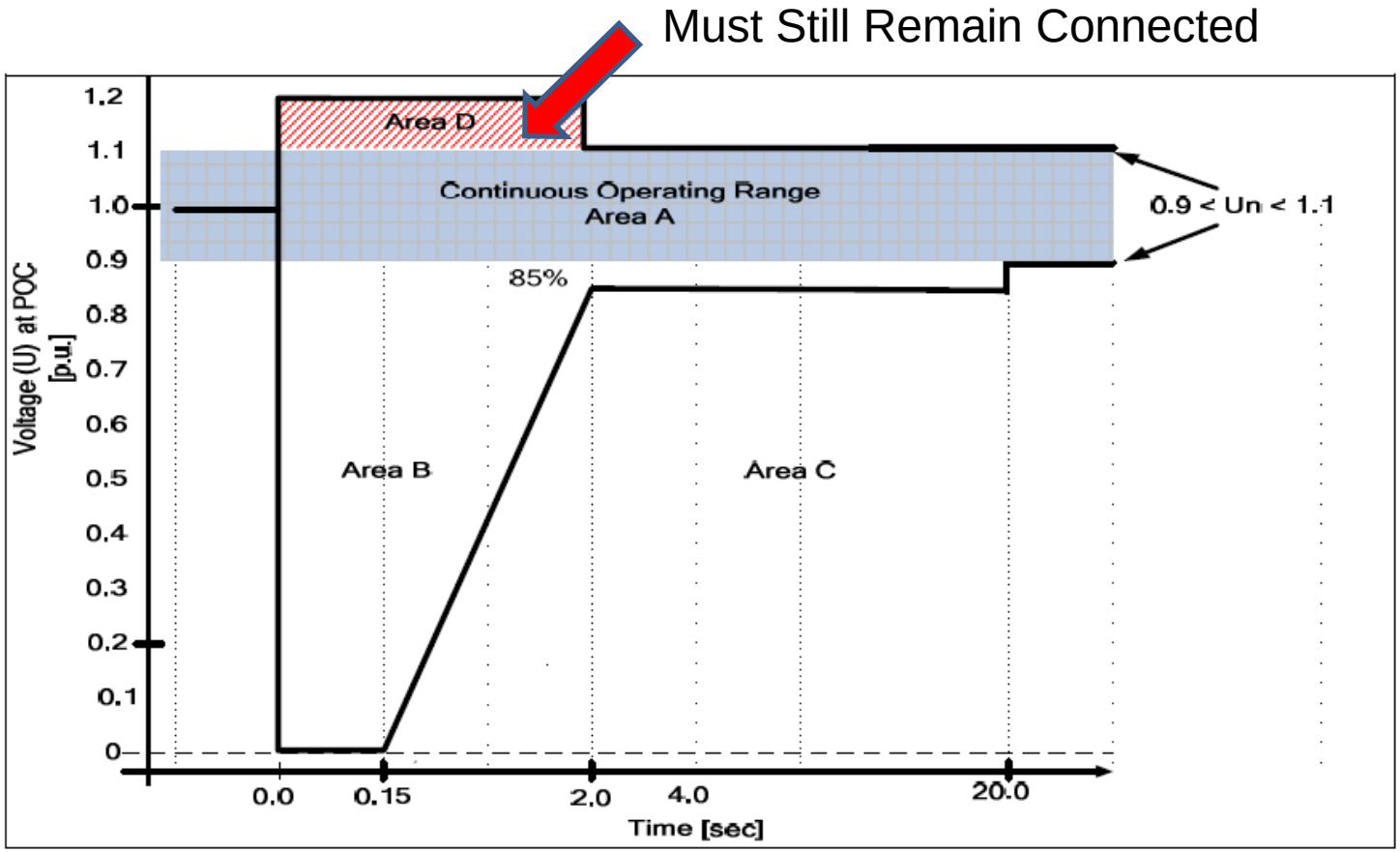


Figure 3: Fault Ride Through Capability for the WEF

Conclusions

- The Grid Code makes significant demands on wind farms.
- It is important that these requirements are fully understood if the wind farm is to be connected without issues and to budget.
- If additional equipment is going to be required to achieve compliance this should identified early in the project planning.
- If additional reactive compensation is required this may have to be coordinated with the wind turbines.

Thank you!

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