Grid code Compliance and Renewable Energy Projects

Mick Barlow, Business Development Director, S&C Electric, United Kingdom

14 – 15 May 2013, Cape Town, South Africa
Pre-conference workshops: 13 May 2013 | Site visits: 16 May 2013
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

Voltage Dip Map

ΔP = -700 MW
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
- Low Voltage and High Voltage Ride-through – this is the ability to remain connected to the system following a system event.
Typical Onshore Windfarm
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

Reactive Power Capability

At the POC

www.clean-power-africa.com
This is further affected by POV Voltage Requirements
Voltage can have a major impact on WTG Capability

![Graph showing the impact of voltage on WTG capability](https://www.clean-power-africa.com)
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 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 smooth fast voltage control is required.
  - Statcoms
    - Full Inverter, Bias Capacitor or Hybrid system
  - SVC (usually economic only on very large wind farms)
Speed of Response

Criteria of Assessment

The tests will be regarded as supporting compliance if:

- An appropriate proportion of the full reactive capability of the WEF is delivered within 1 second.
- The change in reactive output commences within 0.2s of the application of the step injection
- Any oscillations settle, to within 5% of the change in steady state reactive power within 2 seconds of the application of the step injection.
- The final steady state reactive value according to the slope characteristic is achieved within 5 seconds of the step application.
- Adjustable slope characteristic, 2 to 7%. NB The slope is calculated in terms of rated Power Factor, for example a 4% droop should result in a 4% change in volts when moving from unity PF to 0.95 exporting or importing.
Speed of Response
This example shows 90% in 1 sec

Figure B.1.3a

After 2 seconds any oscillations should be less than 5% (peak to peak) of the change in reactive power in this time.

90% of the required change in Reactive Capability should occur within 1 second.

0.2s Maximum Dead Time
If a Statcom is Required

- There are 3 basic configurations
  - Full Inverter
  - Inverter + Bias device (usually a capacitor)
  - Hybrid Solution
Typical Statcom Configuration
Comparison of STATCOM and SVC Characteristic

STATCOM

SVC

Transient rating \((t<1\text{sec})\)

Capacitive

Inductive

www.clean-power-africa.com
Full Inverter Solution

GRID INFEED

15 MVAr

DSTATCOM
Full Inverter Solution

Inverter 15MVAR

[Diagram showing active power versus reactive power for different scenarios: Grid Code, Wind Farm, Full DSTAT.]
Bias Capacitor Solution

GRID INFEED

10 MVAr

5 MVAr

DSTATCOM

10 MVAr
What does the Bias Capacitor Do?
Statcom + Bias Cap

Active Power (MW)

Reactive Power (MVar)

-60 -40 -20 0 20 40 60 70

Grid Code  Wind Farm  DSTAT+Bias

Inverter 10MVAR  
Bias  5MVAR

www.clean-power-africa.com
Hybrid Solution

GRID INFEED

Switchable Devices
Can be reactors or Capacitors
3 x 3.5 MVAr Caps

5 MVAr

DSTATCOM
Hybrid Solution

Inverter 5MVAR
Switched 3 x 3.5MVAR Caps
How does this give Continuous Control?
PureWave DSTATCOM Hybrid with Switched Capacitor Banks

**DSTATCOM Output (MVAR)**

Switched Cap Banks

Cap Bank 1

Cap Bank 2

Cap Bank 3

**Total Continuous Output**
Actual Performance of STATCOM at UK Wind Farm

- Var (kV)
- ISS Ds (MVAr)
- DSTAT MVAr

DSTATCOM  Switched shunt device  Voltage
Fault Ride Through
LVRT and HVRT

Must Still Remain Connected

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!

mick.barlow@sandc.com