VSM Expert Group

Meeting 2

Antony Johnson – Technical Policy
National Grid
May 2018

Agenda

- Introductions and Updates
- Review of Notes / Actions from Previous Meeting
- Presentation by Michael Hirst - DSO Microgrid in southern Sweden
- Summary of Stakeholder feedback from Questionnaire
- Summary of Stakeholder feedback on the proposed Technical Specification
- Stakeholder Experience on VSM Technology
- Common Themes and Conclusions
- Time and Date of next meeting
- AOB

Actions from Previous Meeting

Action	Description	Action Owner	Due Date
1	Industry questionnaire needs completing 1 week prior to next meeting	All	16th May
2	Feedback on technical specification proposal required prior to next meeting	All	21st May
3	Updates to NG slides 13 and 18	Antony Johnson	21st May
4	DOIs from for VSM use in other industries	Andrew Roscoe	21st May
5	CIGRE Task force information	Antony Johnson/Ben Marshall	21st May
6	Circulate information in public domain about May 2016 event	Mike Kay/ Ben Marshall	21st May
7	Update questionnaire – add new groups to list in Q1, add timeframes clarity into Q5E	Can Li	20th April
8	Clarify spec as per above comments received	Ben Marshall/Richard Ierna/Antony Johnson	16th May
9	Post frequency data and simulation info for large and small system responses on website	Ben Marshall/ Richard Ierna/Antony Johnson	23rd May
10	Engage <1MW developers/manufacturers on Questionnaire	Ben Marshall	16th May
11	Seek alignment in dates and arrangements between VSM expert working group on 23rd May and ENTSO-e workgroup on Grid Forming convertor development.	Helge Urdal	16th May

Presentation by Michael Hirst EoN

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- **DSO Microgrid in Southern Sweden**
  - **Control, operation, management and power quality within a zero-inertia microgrid**

Summary of Stakeholder Feedback Response – Questionnaire & Specification

- Responses received from:-
  - Siemens
  - Wester Power Distribution (WPD)
  - Enercon
  - Senvion
  - Turbo Power Systems
  - Enstore
  - National Grid Interconnectors
  - University of Strathclyde
  - Wind Europe
  - Equinor
  - GE
  - Digsilent

General Comments on Questionnaire

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Questions	General Response
Type of Plant	Wind turbines (Onshore/Offshore Types 3 and 4),, HVDC, Energy Storage Systems, SVC's/Statcom's/dynamic compensation equipment, solar,
Experience in VSM based control Systems	Involvement in Joint Industry Working groups and research Early development and research Research undertaken and small scale software / hardware developed as proof of concept Research being undertaken and aware of concepts General concepts applied and tested but numerous question arise from the draft NGET specification with more detail required No experience. Published Papers on VSM / VSM0H have been highlighed

Questionnaire Comments Specification (Question 4)

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Questions	Specification Comments
Specification – Question 4	Specifications should be technology neutral System Studies should be based on transparent studies and established design criteria System studies should be complemented by simulations and real tests The exercise should involve multiple industry players and should not be rushed as it is recognised as complex –ie the timescales are too tight. General cross industry consensus should be reached at the end of the exercise Rename specification to cover inertia, vector shift withstand capability rather than just fast fault current injection The capacity of the energy storage requirements are unclear over a range of different operating conditions and the impact on power quality The short term overload requirements may have an impact on power electronic components Any new specification should consider the interaction of the proposed control behaviour with other Grid requirements. The defect should be highlighted with diagrams to allow manufacturers to develop their own independent solutions The additional energy storage requirements could cause problems for equipment design and make GB a bespoke market resulting in increased costs. Commercial arrangements and hybrid solutions should be considered as an alternative to a hard specification Specification of the overload and storage requirements is unclear and potentially a very expensive component, in particular under various and multiple events The damping requirements are not clear in particular between the speed of power delivery of the frequency / phase disturbance and level of internal control system damping

Questionnaire Comments Specification (Question 4 Continued)

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Questions	Specification Comments
Question 4 Continued	The 10% impedance is unclear. Is this the total impedance between the converter Bridge and System or some other combination (ie turbine transformer, converter reactance etc) unless a virtual impedance type control is required. Concerns over the 0 – 5Hz bandwidth. This will be a problem during system disturbances and faults and the need to limit the fault current. It would be useful to have procedures for compliance tests including LVRT, frequency response, phase angle changes phase imbalance and harmonics The specification will add cost to the equipment and it is not known if this is the most economic or efficient compared with other tools or market arrangements There could be tradeoffs between Onshore and Offshore equipment and how the costs are apportioned between the two. More detail is required particularly in respect of fault ride through events and active power recovery There is significant concern over the overrating and storage requirements which adds significant cost. The overall approach should have greater focus on incentivising the additional functionality The specification promotes VSM functionality rather than a desired converter response The wording requires refinement – eg “instantaneous”, “ahead of any possibility” Clear References and interactions / clarity on existing Grid Code requirements and base quantities Concerns over retrospectivity and there needs to be a clear framework for remuneration for developers – Clause ECC.A.1.2.6

Questionnaire Comments Specification (Question 5)

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Questions	Specification Comments
Question 5	The specification cannot currently be met by existing plants Any requirement developed would need to be met at the point of connection There would be implications for energy storage given the tight timescales of working groups Different control strategies may be different for different types of equipment (eg wind generation, storage etc) Assuming that the requirements are clear then a 5 year development window would be required and that more time is required for the discussions and development phase VSM control is not currently used with its development requiring 3 – 6 months research and 6 months for implementation Further confidential discussions required Major areas of concern are equipment rating, overload capability and storage requirements A VSM type control could be considered in principle but the converter would need to protect the converter and converter within a much narrower band than proposed in the specification and limit the amount of active power that the turbine is supporting during Grid Events when curtailed operation is to be avoided. Solutions between Onshore and Offshore may need to be considered separately. Retrofitting to existing plant – particularly wind turbines would need further consideration such as cooling, component design and reliability. New Turbine development – 4 – 5 years from when the requirements are ready and retrofittable 2 – 3 years from when the requirements are ready. These timescales would depend upon when the customers/developers require these capabilities. It is possible to achieve 1.5p.u rating but at additional cost/. This would need to be assessed for all equipment not just the converter not to mention size. Converter control would allow a VSM type response however performance guarantees require industrial application and verification and significant internal checking. This activity is not insignificant A hybrid solution could be considered where a mix of energy storage synchronous compensators and other market based solutions are used but the wider aspects of this – eg space would need to be considered

Questionnaire Comments Specification (Question 5 continued & 6)

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Questions	Specification Comments
Question 5 Continued	Concerns over intellectual Property The control philosophy is fundamentally different to today's requirements The bandwidth could be limited by the switching frequency of the converter bridge and converter equipment and control HVDC are only power transmission devices so any storage requirements applied would increase their cost. Again hybrid solutions using other equipment such as synchronous compensators should be considered but enhanced ratings will only increase the system cost. VSM type functionality has been investigated however it was identified not to be commercially attractive. A three year time window would be required for development notwithstanding the costs and IP issues. There should be no change to the Maximum infrequent infeed loss Regulatory requirements need to be considered which introduces storage to an existing technology such as HVDC
Question 6	A number of comments were received in relation to location of transmission and generation plant, CAPEX and OPEX, technological availability and consenting Numerous developers have said they would be interested in further discussions with National Grid

Summary of Stakeholder Feedback Response – Specification (1)

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- Numerous detailed comments were received on the specification in addition to the questionnaire – Additional points noted include:-
- The requirements should equally apply to Electricity Storage Systems (GC0096)
- More information is required on the energy store and damping requirements
- The overload conditions need to be defined to avoid increasing system rating and cost particularly when exporting reactive current
- Reactive capability in the extended zone for 20 seconds requires special mention
  - Rotary Synchronous Generators do not provide this capability
  - It will add significant cost to the converter
  - The rating needs to be stated
  - With increased ROCOF and storage interactions
- The performance requirements should be specified at the Connection Point to the Transmission or Distribution System

Summary of Stakeholder Feedback Response – Specification (2)

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- Figure 4 from CC.6.3.4 should be added to prevent exporting reactive power during high system voltages
- Use cross referencing where possible to avoid duplicating text
- A full specification is required in respect of power oscillation damping – eg magnitude, frequency and duration of the VSM damping oscillation control so that the associated energy store can be correctly rated
- Impedances should cover the total system – this needs to be clear
- For operation with large ROCOF, the VSM must have the same ability to change phase angles to remain synchronised to the Grid with relative phase angles no more than 90 degrees.
- When a phase change occurs the inverter will produce an increase or decrease in power which will then recover to the pre-disturbed value. The optimal time for this recovery needs to be specified.
- Operation within extended range – wording needs to be changed “increased bandwidth between 5 and 75Hz.

Summary of Stakeholder Feedback Response – Specification (3)

- NGET have received numerous detailed comments and these will need to be addressed on an individual basis.
- The main comments and themes have been summarised in earlier slides but the high level issues are noted below.
  - –eg why have the values specified been chosen –eg are they max or min values, how fast should the controls operate, voltage ranges, transient overvoltage, harmonics / quality of supply, maximum voltage levels, terminology, base quantities, application to Offshore and typographical comments

Experience of VSM Technology

- Presentation by Enstore
- Other’s ?

Common Themes and Conclusions (1) nationalgrid

- Useful feedback received from Questionnaire and Specification
- Major themes
  - Some experience has been gained with VSM technology but it is very much research based and not yet at a commercial level
  - VSM is achievable but there are numerous issues relating to cost, sizing and specification
  - A number of papers have been published
  - The timescales of the workgroup are challenging and require involvement from all industry stakeholders. Ideally a longer development time should be allowed
  - Once a specification has been developed, the lead time is probably in the 3 – 5 year time frame. In one case, an earlier lead time of 3 – 6 months has been chosen. Retrofitting appears possible.
  - Concerns over Intellectual Property
  - The specification should be technology neutral

Common Themes and Conclusions (2)

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- Storage Capacity requirements are unclear
- Equipment rating is unclear as are the costs, sizing and space requirements
- There is appetite for Hybrid solutions, particularly for Offshore Schemes as well as commercial mechanisms
- Consideration needs to be given to the bandwidth requirements
- Clarity required on terminology and base quantities
- Clarification required on the impedance values
- Clarification on damping requirements
- Interaction with other Grid Code requirements
- National Grid need to examine these issues and work with stakeholders in developing a clearer specification

Next Steps

- Refine the specification
- Examine the hybrid approached that can be used and how various options can be fed into the cost benefit analysis
- Time and Date of Next Meeting
- Any other business