

Virtual Synchronous Machines / Grid Forming Converters

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Zero carbon by 2025

What it means

- Carbon free operation of the transmission system for short periods
- We're ready to accommodate whatever amount of zero carbon electricity is being generated by the market at a given time



Key challenges to overcome

- Frequency management
- Inertia and voltage control

Notable records

- **85% zero carbon** on May 23 2020
- **60% share of wind** on Aug 26 2020

Comparison of synchronous machines vs traditional converters vs VSM based converters

Synchronous machines

Provide instantaneous inertia, short circuit current, fast injection/absorption of reactive current and Limit/resist angle change/rocof

Traditional converters (use Phase Locked Loop PLL technology)

Rely on measurements followed by a delay for processing before an appropriate response is delivered. This approach is robust whilst the network is in a steady state. However when the network is disturbed, this approach is limited in its ability to “track” the voltage and frequency.

Grid Forming or Virtual Synchronous Machines based converters

The virtual synchronous machine (VSM) concept allows a converter to act like a voltage source like a synchronous machine. The voltage source behaviour is a critical concept for a converter to respond instantaneously to system changes. Therefore, when the disturbance occurs, VSM can supply fault currents and also contribute the system inertia.

History of Grid Forming / Virtual Synchronous Machines(VSM) in GB

- Papers published in 2013 indicating a major problem with large volumes of Converter based plant displacing Synchronous Generation
- Further research undertaken by National Grid in collaboration with the University of Strathclyde demonstrating the benefits of VSM even under System Split Conditions – Papers Published in Vienna 2016
- VSM Expert Group Established April 2018 to consider feasibility of VSM as a concept and develop specification for possible inclusion in the GB Grid Code
- Stability Pathfinder Work released 2019 to explore long term stability products over the next 10 years which could include VSM
- Further research undertaken with University of Nottingham to develop a 100kW prototype VSM for proof of concept. Additional research undertaken with University of Strathclyde. Research papers on all aspects published in Dublin in 2019
- In GB, one full scale wind farm has been developing and testing the concepts of VSM/Grid Forming

Dersalloch Windfarm

Scottish Power Renewables

- First large scale VSM in GB
- 69MW, 23 Gemesa Turbines
- Black Start – November 2020
- regulated the frequency and voltage of the power from the turbines, essentially forming a stable network island, to keep the electricity system stable and balanced.
- Expect to participate in Stability Pathfinder



Virtual Synchronous Machines (VSM) expert group

- Established in April 2018 to consider if VSM is a feasible concept and develop a specification
- Comprised of interested parties including Developers, Manufacturers, Consultants, Universities etc
- The output of this work has been heavily influenced by the research work undertaken, the feedback received from the Expert Group, and the Stability Pathfinder work

GC0137: Minimum Specification Required for Provision of Virtual Synchronous Machine (VSM) Capability

- <https://www.nationalgrideso.com/industry-information/codes/grid-code-old/modifications/gc0137-minimum-specification-required>
- Modification proposes to add a non-mandatory VSM technical specification to the Grid Code
- The specification will enable converter technologies (e.g. wind farms, HVDC interconnectors and solar parks) to offer an additional grid stability service which will provide the opportunity to take part in a commercial market-based system

Requirements of Grid Forming Invertors in GB

- The Grid Code will need to be updated to reflect the following:-
 - Specification - The ability of the plant to have a Grid Forming Capability
 - ie the ability to operate as a synchronous rotating voltage source behind a reactance and the ability to supply inertia power, phase jump power, damping power and controlled power output. Needs an energy source.
 - Note – The plant is required to have the necessary capabilities and performance but the volume of inertia power, phase jump power, damping power and controlled output power is determined by the developer based on its plant capability.
 - VSM without an energy source, whilst not providing any significant inertia is valuable for fault infeed and provision of synchronizing torque but does not provide a full GB Grid Forming response.

Stability Pathfinder Phase Two

- Recently published EOI for phase 2 in Scotland.
- We want to enable new technology including VSM to participate.
- We have designed a process to allow for a feasibility study where solutions can demonstrate meeting technical specification prior to submitting a commercial tender.
- Feedback on technical specification from Grid Forming technology manufacturers and potential users
 - incorporate this in our final tender specification
- All specifications and requirements can be found here:
<https://www.nationalgrideso.com/research-publications/network-options-assessment-noa/network-development-roadmap>

nationalgrideso.com

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