High Penetration of Power Electronic Interfaced Power Sources focused on

Performance Aspects of Grid Forming Converters

Outstanding questions – future work

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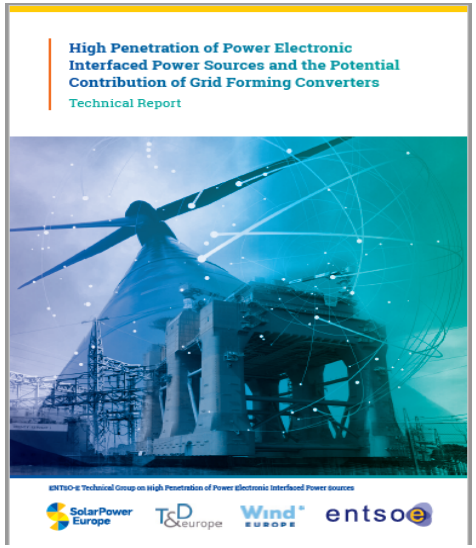
Workshop - Brussels

Summary of earlier WS presentations

- Mario: System challenges ahead as PEIPS increases – even in large CE
- Thorsten & Bernd The seven challenges TG HP focused on
- Antony & Marta The impact on the smaller synchronous areas, GB & Ireland
- Where have industries got to with Grid Forming?
- Thyge Wind Industry – early trials
- Thorsten PV and BESS – main experience is from small systems, e.g. islands
- Thanos Transmission & Distribution equipment with PE Interfaces

- What are the outstanding questions?
- What is the way forward?



Outstanding questions

- **What proportion** of the converter interfaced equipment need to have the seven characteristics in question?
- **Where and when** will the capabilities need to be **available**?
  - **Different urgencies** between small SAs (e.g. GB now) and countries in large SAs (e.g. CE later)
  - **Wind Europe suggest manufacturers need 5 years to prepare even after full spec / codes delivered**
- Are some types of converter interfaced equipment better suited to deliver GFC with these characteristics cheaper and more effective than others?
  - small embedded units versus larger units connected at higher voltages?
  - If a market driven approach is adopted, questions arise as to the **market design.**
  - Would available **capability or utilisation be remunerated**?
  - Markets deliver **comparison of GFC with alternatives**, Synchronous Condensers / Comps?
  - Would payments have to be **location-based**?
  - Could the **entire required range of services (seven covered here) be obtained on the market**?

Way forward

- Where needed
  - Synchronous Area by Synchronous Area?
    - Speed of introduction geared to each need case

    versus
    - Desire for commonality
- Specification / Codes
  - Mandatory vs Non-mandatory?
  - Method to achieve early catch-up in advanced capabilities, where need is already present?
- Incentives
  - Building timely trust in available funding and adequate size of market
  - Focus of markets?
    - Remunerate capability (longer term finance) vs utilisation (day by day income stream)

Additional Material – back-up

GFC cost considerations for wind, PV, Batteries and HVDC

Grid forming converter control is fundamentally different from the control that is commonly employed today and will, considering the general maturity level anno 2019, **require a significant R&D effort from converter manufacturers to develop their technology readiness level to today's level for current control.**

This includes:

- control stability and interaction
- hardware development and re-dimensioning
- development and validation of client user models
- grid compliance testing and certification
- assessment of the wider impact on equipment design
- quantifying any impact to equipment capability across the entire operational envelope
- concept maturing and runtime

Challenges of a possible transition to GFC for equipment suppliers operating in an increasingly competitive markets

- Delivering new capabilities **requires R&D resources** and hence incurs expenditure and time.
- Introducing GFC is a **major change.**
- Ensuring that the **desirable characteristics embedded in existing designs** developed over decades are **not lost** is essential.
- **Added capital cost** in mass manufacture is likely
  - mainly focused on **energy storage and increased converter rating.**

- Offering GFC as well as existing products adds complexity and cost.

- **Manufacturers need commercial incentives to proceed with GFCs,** implying willingness on the part of developers to pay a premium for the new capabilities.
  - Currently, such incentives do not exist (except in some microgrid contexts). They could arise from:
    - Mandatory requirements, such as those in grid codes.
    - Opportunities for additional revenue streams, e.g. ancillary services markets.
      - Compared to existing AS markets, services to deal with the range of issues (e.g. the seven here) arising from weak networks with potential low system strength appear more complicated
  - Negative incentives for non-compliant equipment, e.g. uncompensated constraining off.
  - In **GB the Stability Pathfinder process is in progress, may deliver cost / Effective MVA for alternatives**

Maturity of GFC implementation

Experience with GFC to date is limited, but rapidly expanding:

- From a few MW, so far up to **a 30MW installation in South Australia.**
- So far the most **common adoption of GFC control is associated with BESS facilities** mainly linked to PV installations.
- For wind, the reported installations so far are limited to one 3MW WTG on test.
  - Presented here is a **23 turbine 69MW wind farm on test with GFC for 8 weeks with H up to 8s**
- GFC has so far been established in applications (mainly in microgrids) where it is required to ensure stable system operation already today **GFC has not yet been driven by future proofing large systems with approaching 100% PEIPS penetration.**
- The R&D associated with GFC is rapidly expanding and widening in its coverage with an extensive set of publications being delivered in the second half of 2019.
- **GFCs have not yet been established by the major manufacturers in their mass market converter products.**

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