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WG B4.63 Commissioning of VSC HVDC Schemes

Les Brand, Convenor

Objectives / TOR

- Develop a Technical Brochure which provides guidelines for the commissioning of VSC projects.
- VSC = Voltage Source Converter HVDC technology.
- Identify and develop the stages, sequence and structure for the commissioning of a VSC project.
- Develop each stage of commissioning, including development of test objectives, procedure and acceptance criteria.
- Consider requirements for specific applications.
- Consider treatment of issues not prevalent when earlier HVDC commissioning guidelines were published.
- Excludes the DC line/cables and converter equipment testing.

Membership and Activities

- WG approved 10 February 2013.
- 20 regular members and 12 corresponding members
- 15 countries represented.
- Seven “face to face” meetings completed
  - Boston – June 2013
  - Brasilia – September 2013
  - Paris – August 2014
  - Lund – May 2015
  - Agra – September 2015
  - Oslo – April 2016
  - Paris – August 2016
- Completed Technical Brochure due for 60 day review December 2016

Need for Working Group

- Increased interest and adoption of VSC worldwide.
- Current publications focus on LCC HVDC technology.
- Key differences between LCC and VSC technology and capability.
- Current publications are almost two decades old.
- Specific VSC applications present commissioning challenges.
- Evolution of VSC technology – different manufacturer's, different processes and terminology.
- Need to provide some standardisation and structure to commissioning.
- Technical brochure a useful reference to those not on the OEM's side, e.g. owners, developers, system operators, utilities etc.

Voltage Source Converters (VSC)

Key Characteristics

- The valves utilise IGBTs instead of thyristors.
- There is minimal, or sometimes zero, reactive power compensation or AC filtering required, significantly lowering costs and reducing footprint size of converters.
- The converter transformers for a symmetric monopole VSC system are very similar to normal AC transformers (often referred to as “interface transformers”).
- Can supply power to a passive network or to a network with low SCR making them suitable for connecting areas with little or no synchronous generation, such as remote renewable generation.
- Black start capability.
- Ability to control the output waveshape through switching of IGBTs to reduce lower order harmonics.

Voltage Source Converters (VSC)

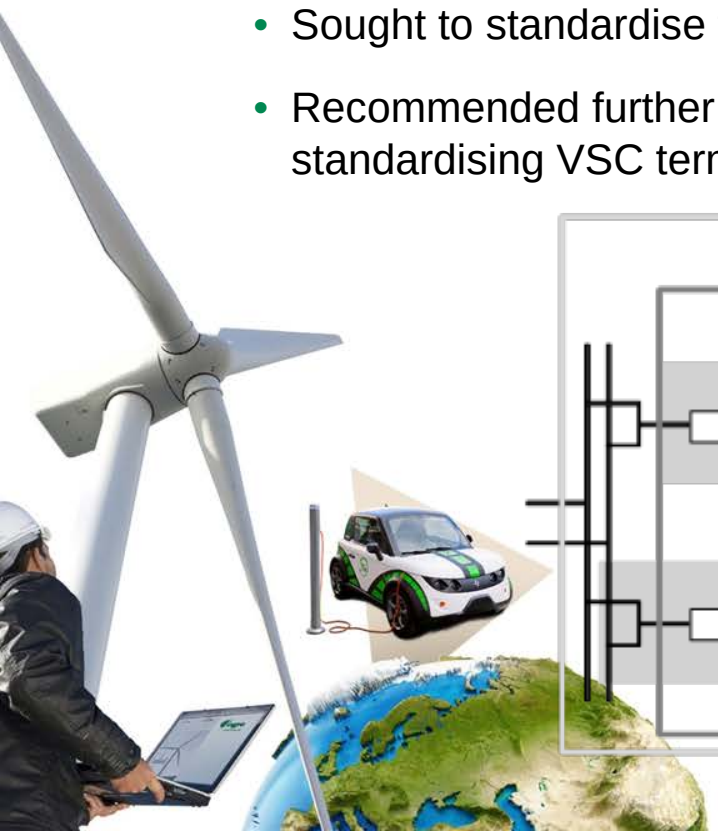
Key Characteristics (cont.)

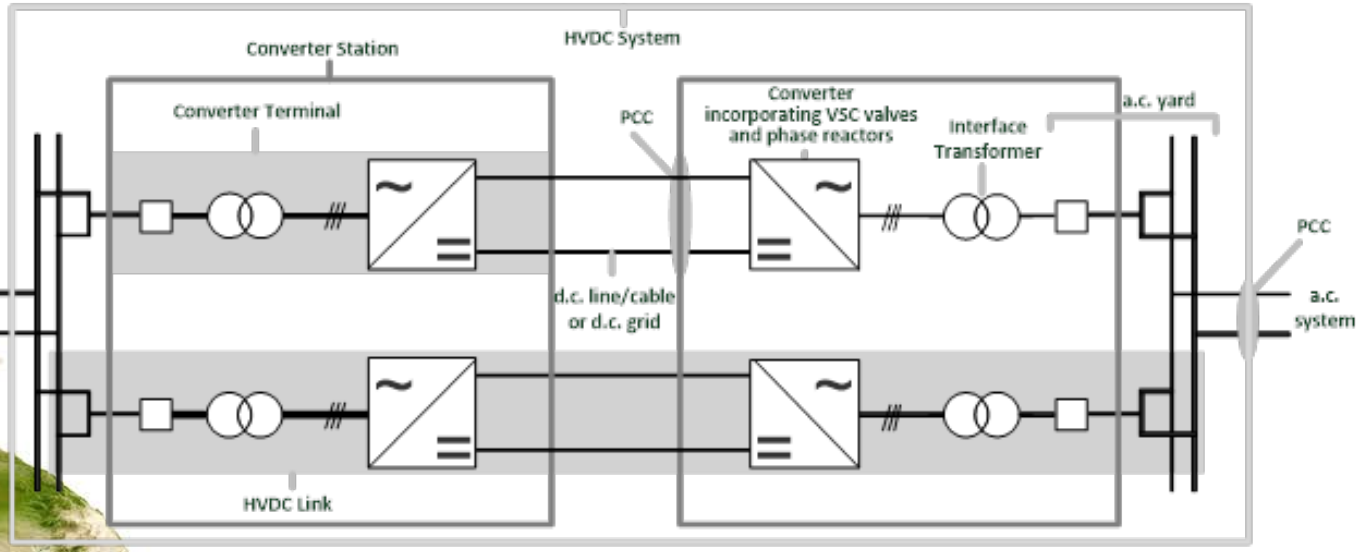
- Controllability of reactive power is independent of active power transfer. Can provide or consume reactive power, at a level directed by the operator.
- Can make use of extruded polymer cables (due to no need to revers polarity of the DC side), which may be more economical than MI cables.
- very little operational experience with the use of VSC using DC overhead lines due to inability to block fault current.
- Although converter station losses are improving, they are still higher than LCC station losses.
- VSC converter station overload capabilities are limited when compared to that of a LCC converter stations.

Voltage Source Converters (VSC)

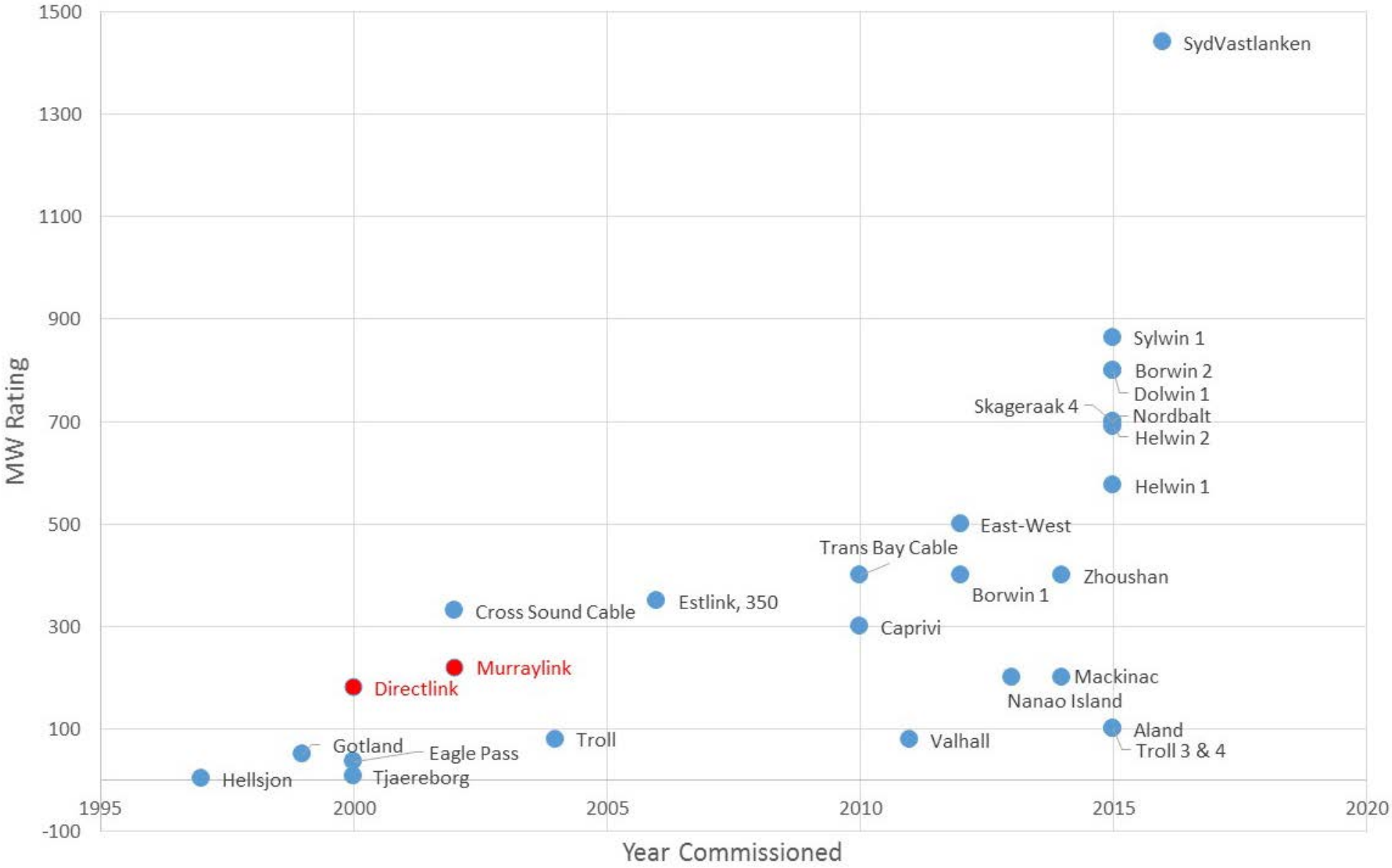
Terminology

- Found different Vendors used different terminology.
- Due to:
  - Evolution of the technology; and
  - Different topologies adopted by the various Vendors.
- Sought to standardise terminology and get all Vendor members to agree.
- Recommended further work, leading to the creation of a new Task Force on standardising VSC terminology in SC B4.





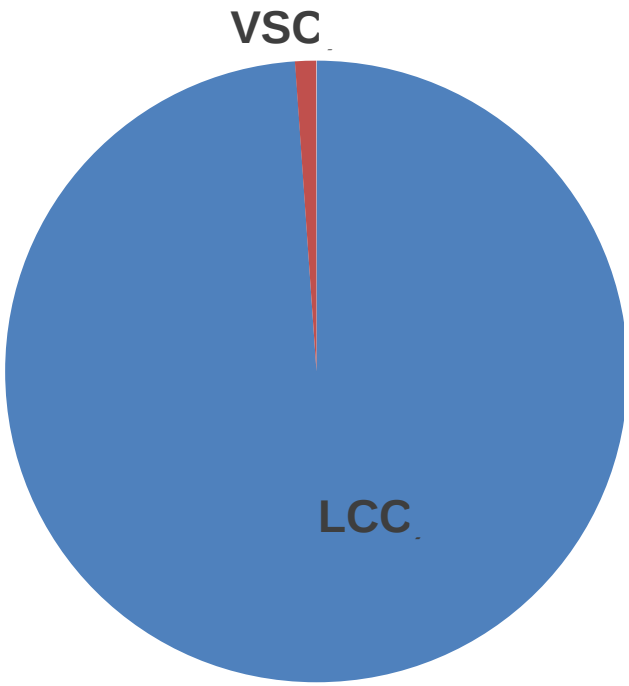
Evolution of VSC Technology



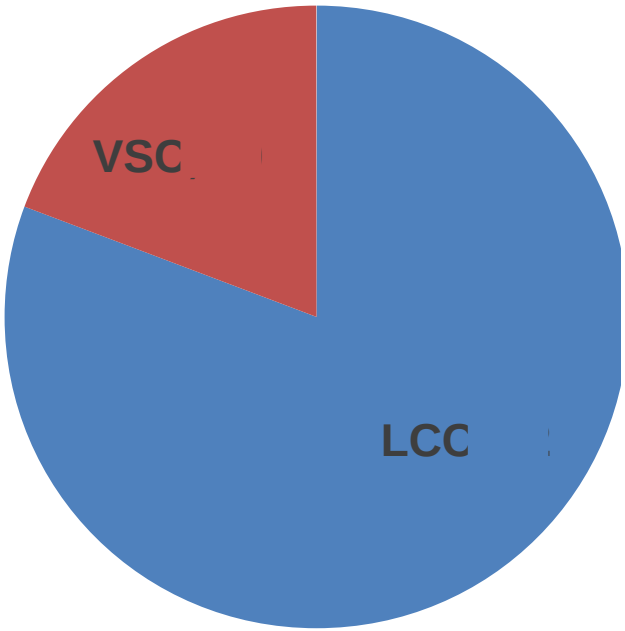
Adoption of VSC

Based on number of projects commissioned

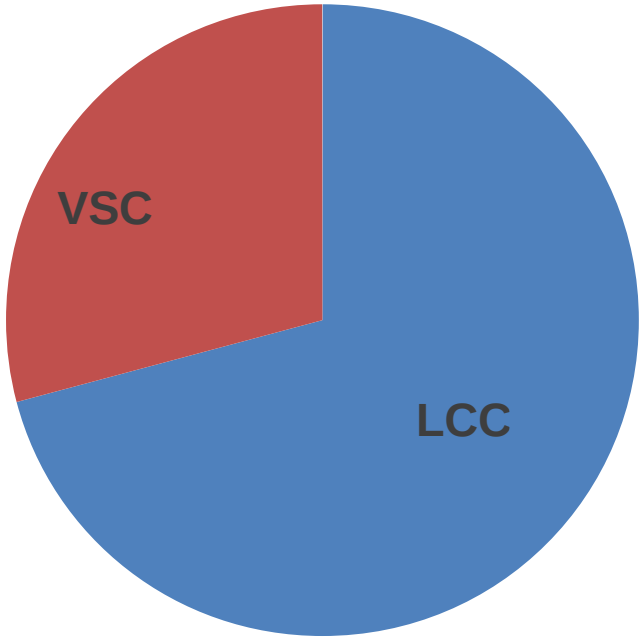
1951-1999



2000 - 2010



2011 - 2014



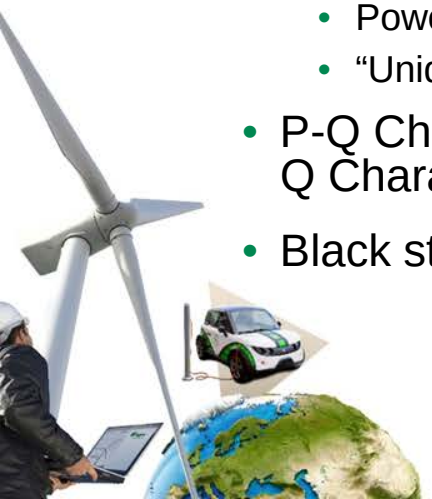
Existing Publications

- Cigre TB97 – “SYSTEM TESTS FOR HVDC INSTALLATIONS”
  - Published in 1995
  - Covers only LCC HVDC systems (some areas applicable to VSC)
- IEC 61975 – “High Voltage Direct Current (HVDC) installations – system tests”
  - Published in 2010.
  - Based heavily (in most cases verbatim) on TB97.
- IEEE Std 1378-1997 – “IEEE Guide for Commissioning High-Voltage Direct-Current (HVDC) Converter Stations and Associated Transmission Systems”
  - Published in 1997
  - Covers only LCC HVDC systems

VSC vs LCC

Key Differences - Commissioning

- New “symmetric monopole” topology.
- Capability to operate in “terminal mode” and to commission controls and equipment with only reactive power initially.
- Capability to energise from the DC side (e.g. offshore platforms or wind farms).
- Less focus on AC filter commissioning.
- Additional control modes
  - Reactive Power Control
  - AC Voltage Control
  - Frequency Control
  - Power Factor Control
  - “Unique” Controls
- P-Q Characteristic – Combinations of P and Q to test extremes of P-Q Characteristic.
- Black start capability (if applicable).



New Applications and Commissioning Challenges

- Off shore wind farms / platforms.
  - Staged generation/loading.
  - Commissioning without full power/load.
  - Testing of DC choppers to manage excess energy during trips.
  - Testing of energisation from DC side.
  - Practical / logistical issues associated with off-shore commissioning.
- Multi-terminal schemes
  - Testing flows and control interactions.
  - Testing the DC fault response concept.
- DC protections for overhead line applications.

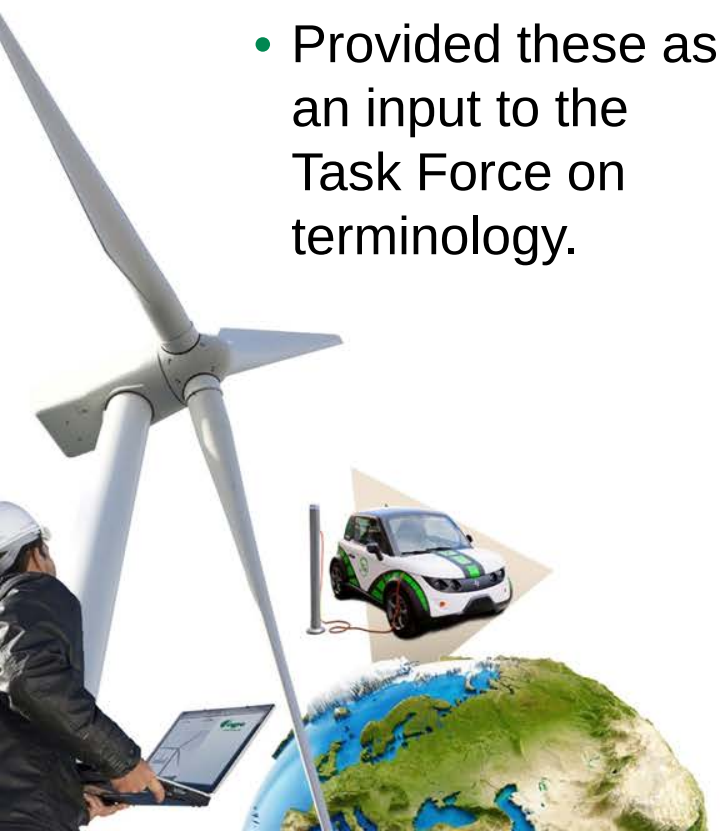
New Applications and Commissioning Challenges

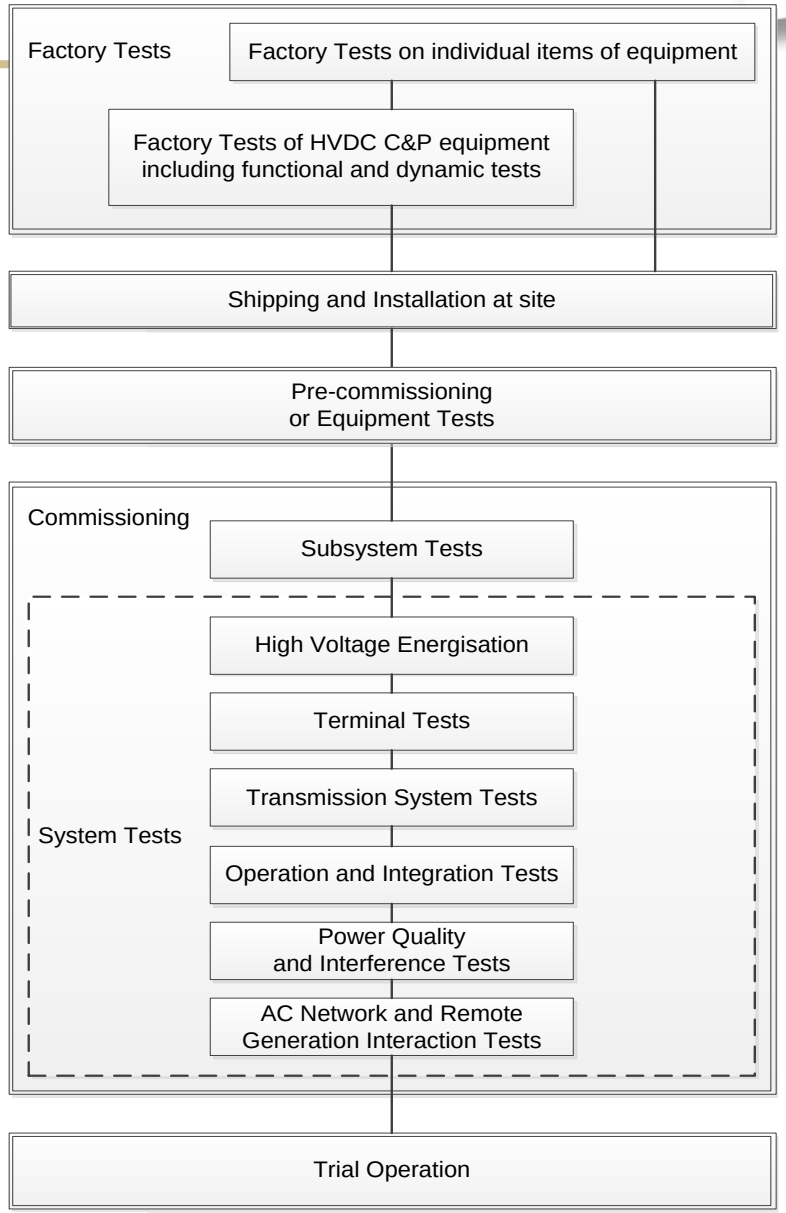
(Continued)

- Commissioning in a constrained and/or market environment
  - Demonstrating compliance when full power flows (P and/or Q) cannot be dispatched due to market or AC network constraints.
  - Coordination of test energy.
- Commissioning Management, Documentation and OH&S during commissioning in the modern world.
- Specific guidelines on off-site testing, in particular:
  - factory testing of control and protection systems; and
  - dynamic performance testing and modelling.

Overall Commissioning Process

- Similar issues with getting Vendors to agree on these terms.
- Provided these as an input to the Task Force on terminology.





Technical Brochure

- Due for submission to 60 day review end of December 2016
- Expected publication – March/April 2017

TESTING AND COMMISSIONING OF VSC HVDC SCHEMES

WG B4.63

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