Paris Session 2022

Selection of LCC or VSC

B4 – DC systems and power electronics

PS 1-1 HVDC Planning, Control, Protection, Operation, Design & Performance

Question 1.3:

• What are the main considerations on technology selection for new and refurbishment of HVDC projects?

Neil Kirby (USA)

New HVDC Planning – LCC or VSC ?

- **DC Conductor Circuit**
  - Investment based on Conductors AND Converters => VSC may use XLPE or MI Cable, LCC only MI
  - Insulated cable Conductor, AND Within VSC rating => VSC solution
- **No Longer New Technology Risk**
  - Increasing Maturity of VSC Driving Utilities/Developers Towards VSC
- **Converter Ratings**
  - Increasing VSC Converter Ratings => Majority of HVDC Systems Proposed Globally Up To ~2000 MW Are VSC
  - Even Up To 3000 MW And Beyond, Trend Towards ±525kV VSC
- **Engineering Complexity**
  - LCC
    - Strong Dependence On AC Systems, Basic Constraints Of p.f., SCL, AC Voltage/Frequency, AC/DC Harmonics, etc..
    - Basic LCC Converter Equipment Well Understood, Complexity Lies In Project-Specific Customization To Meet Performance
    - ⇒ LCC Systems Appear More Constrained, More Operational Risk Perceived By Owners
  - VSC Is The Inverse, Reduced Dependence On AC Networks
    - Basic Converter Management And Control Are More Complex
    - Beneficial Impacts Of MW And MVar Control, And Other Inherent Functionality
    - ⇒ VSC Systems Bring Lower Risk With More Operational Flexibility
  - Late-Stage And In-Service Upgrades
    - LCC Systems : Likely Impact Both Physical Equipment And Software, (e.g. Filters/Shunt Banks, Reactors, Additional Control Functions, etc)
    - VSC Systems : Likely Impacts In Software (Additional Control Functionality)

New HVDC Planning – LCC or VSC ?

- **Operational Flexibility**
  - Benefit Of Controllable MW Through HVDC Compared To AC
  - Dynamical Control Of Mvar in VSC
  - VSC Operates Into Very Weak Or Even Simple Load-Based AC Systems
    - VSC Now So Attractive That Grid Codes Are Being Written Around Them
- **Future Expandability**
  - VSC HVDC Operates At Constant Voltage, Regardless Of Power Direction
  - Prospects For Future Expansion To Multi-Terminal Or DC Grid Systems
  - Individual Converters Operate Autonomously => Addition Of More Terminals Becomes More Manageable
- **Converter Equipment Dimensions**
  - IGBT-Based MMC Submodules Lower Power Density Than Thyristor
  - VSC Converter Valve Structures Larger Than LCC
- **Converter Station Footprint**
  - LCC Systems Require Real Estate For AC Harmonic Filters and Reactive Power Shunt Elements
  - LCC Converter Stations Overall Larger Footprint Than Equivalent Rating VSC

……. Future Trend Is A Preference For, Even Insistence On, VSC For New Installations

Refurbishment Planning – LCC or VSC ?

- **Common Scope Options**
  - Controls
  - Valves + Cooling + Controls (with or without retaining the valve hall building)
  - Total Converter Replacement
- **Outage Duration Permitted**
  - Changeover From Old To New Takes A Finite Amount Of Time
  - Equipment Replacement Must Be Carried Out Safely And Expediently, Often With Continued Link Operation
  - Down-Time Period Without Power Transfer May be Network-Critical or Business-Critical
  - Changeover Outage Allowed May Be A Few Hours, Days, Weeks Or Even Months
    - Longer Outage Permitted => New Building May Occupy Space Occupied By e.g. AC Harmonic Filters
    - ⇒ If Budget Permits, May Allow VSC Through Total Replacement
- **Retention of the Existing Building**
  - Original Valve Hall Dimensions Optimized As Small As Possible For Thyristor Valves
    - ⇒ Larger IGBT Valves May Not Fit
    - ⇒ If Budget Is limited, Remaining Within Existing Building Forces Staying With LCC Converters
- **Total Replacement Option**
  - If Budget Allows, If Adjacent Land Available, And If No Outage Allowed
    - ⇒ May Drive Refurbishment Towards Total Replacement, Building New Link Alongside Existing
    - ⇒ Opens Up Option Of VSC

……Until IGBT MMC Valves Achieve Power Density Equivalent To Thyristor Valves, We Are Unlikely To See Valves + Cooling + Controls Refurbishment Of LCC Using VSC Within Existing Buildings