SC B4 – HVDC and Power Electronics

Presented by

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Chairman SC B4

Presentation Overview

- The Scope of SC B4
- Overview of HVDC Market and Technology
  - LCC HVDC
  - VSC HVDC
- Overview of SVC and FACTS Market
- SC B4 Organisation
- Overview of recent and current WG activities
- SC B4 Strategic Direction

SC B4 Scope – (Abbreviated)

HVDC: economics of HVDC, applications, planning aspects, design, performance, control, protection, control and testing of specialist converter equipment and stations.

Power Electronic for AC systems and Power Quality Improvement: economics, applications, planning, design, performance, control, protection, construction and testing.

Advanced Power Electronics: development of new converter technologies including controls, use of new semiconductor devices, applications of these technologies in HVDC, Power Electronics for AC systems and Power Quality Improvement.

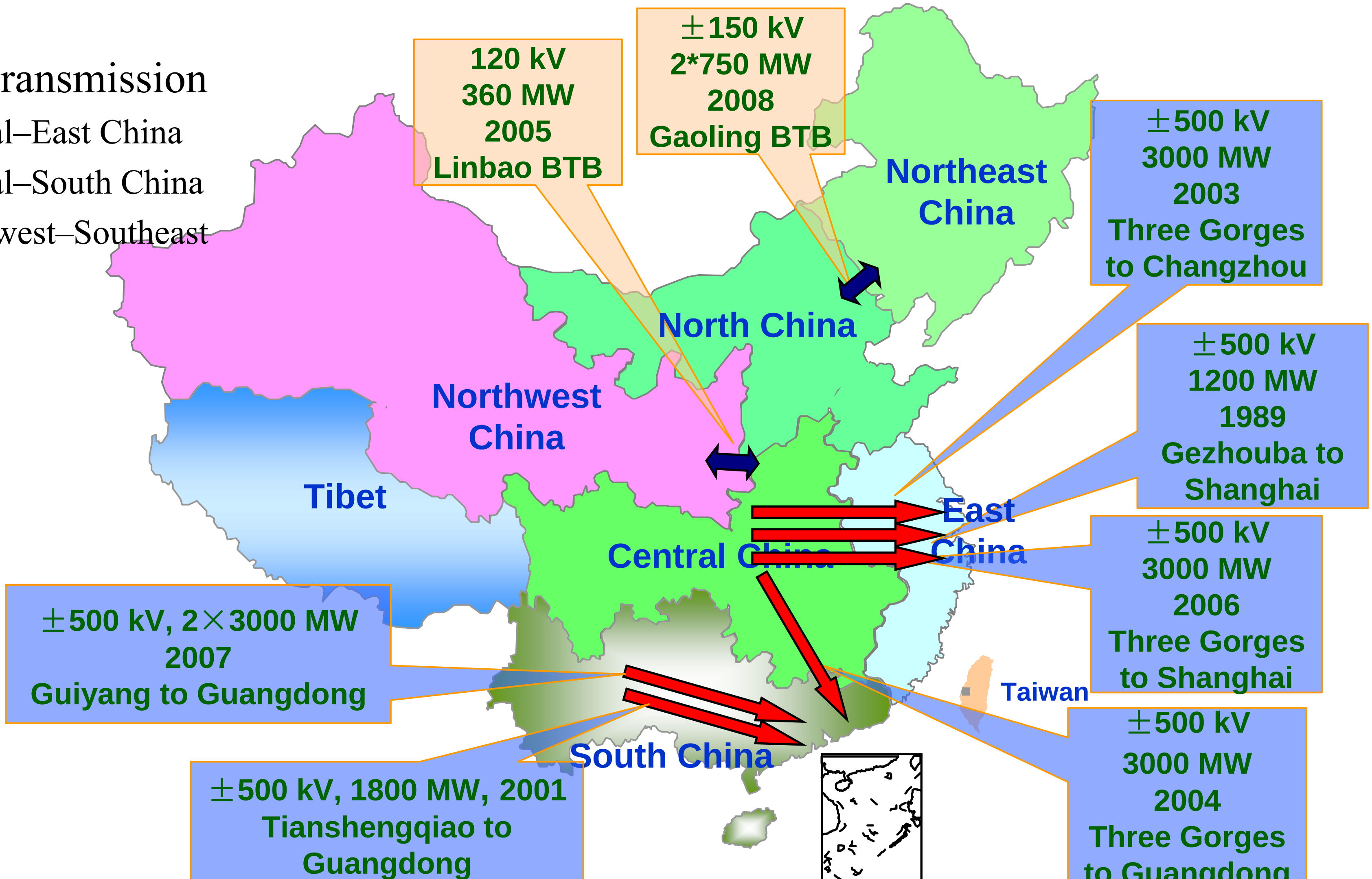
Overview of HVDC

- Gotland, 20MW, 98km submarine cable, first commercial HVDC scheme, commissioned 1954.
- More than 100 schemes with more than 100GW capacity are now in service
- Growth rate is high with > 13 projects totalling > 22GW currently under construction.
- Two different technologies are available:
  - LCC HVDC – Line Commutated Converters based on thyristors
  - VSC HVDC – Voltage Sourced Converters (self commutated) based on IGBTs

China - 19.86GW HVDC In service

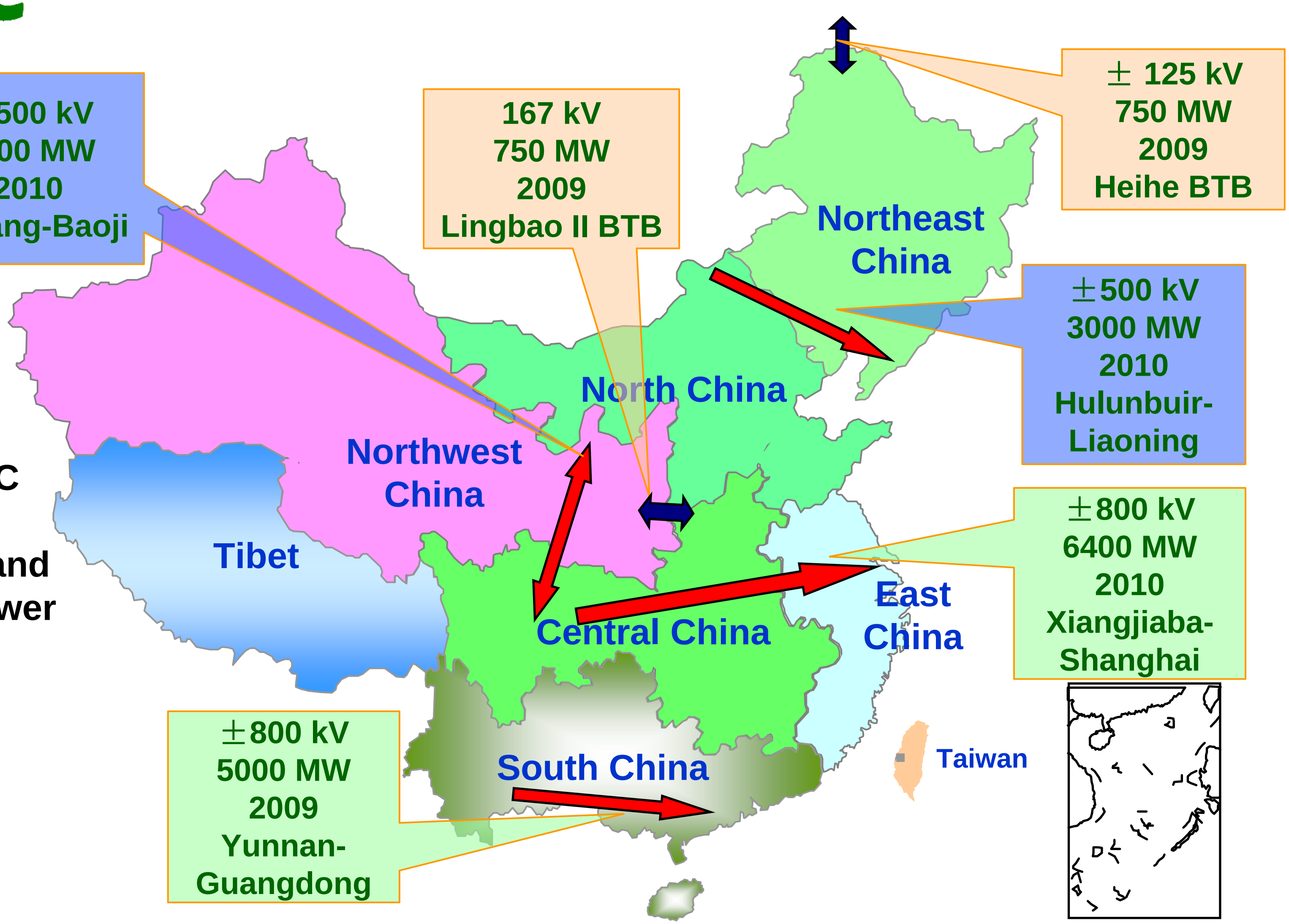
Power Transmission

- Central–East China
- Central–South China
- Southwest–Southeast China



China-18.9GW HVDC in Construction

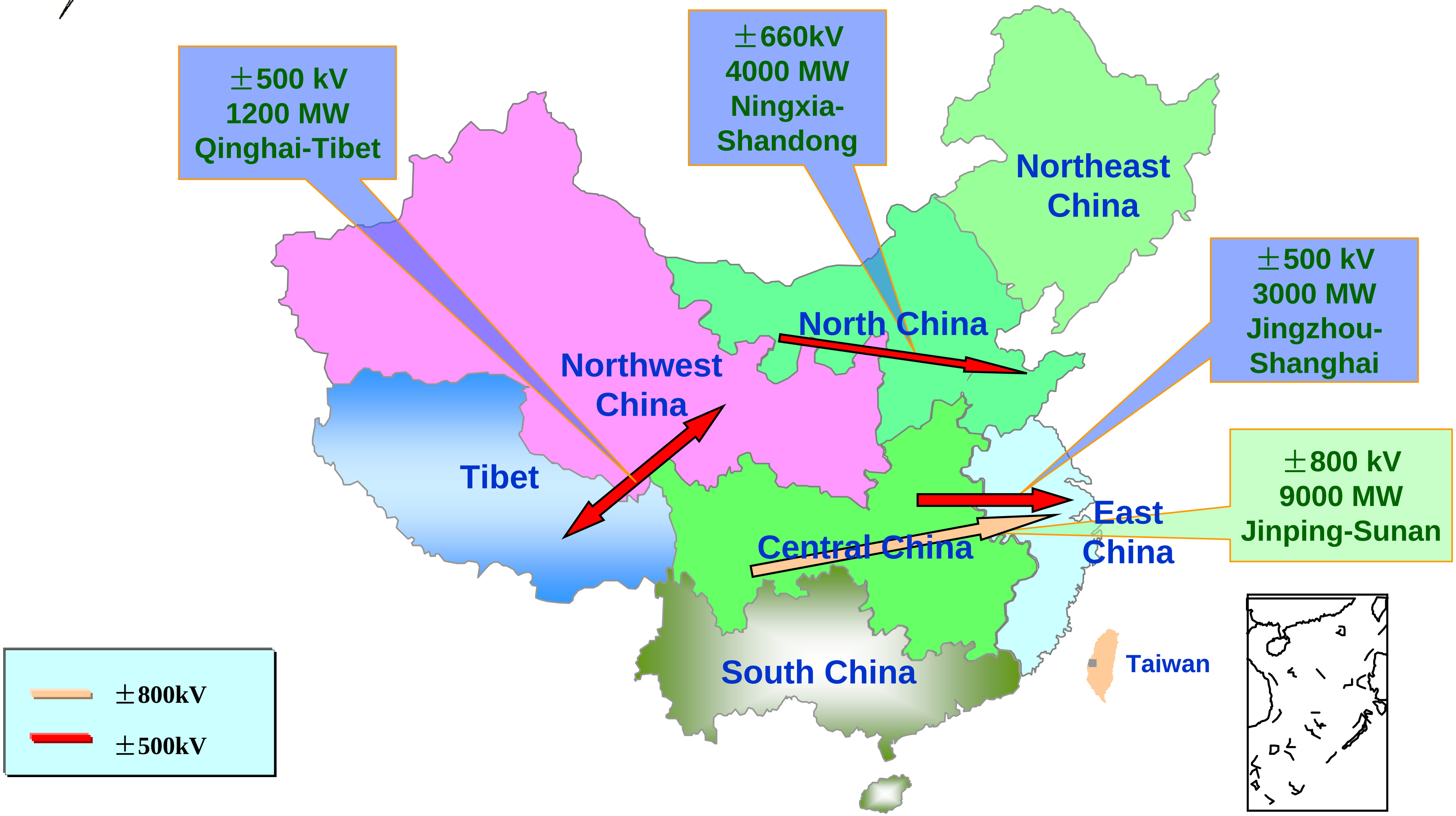
HVDC and UHVDC for grid interconnection and long-distance power transmission



Long distance

BTB

China-17.9GW HVDC in Planning



LCC HVDC

- LCC HVDC is available up to ±800kVdc, 6400MW
- AC voltage must be reasonably firm (SCR > 2.5)
- Converter absorbs reactive power – switchable ac harmonic filters used for compensation
- Station footprint is relatively large
- Commutation failures and TOV needs to be considered for integration in ac network
- AC/DC/AC Conversion efficiency is high (≈98.5%)
- Likely to remain the main solution for >500MW for many years

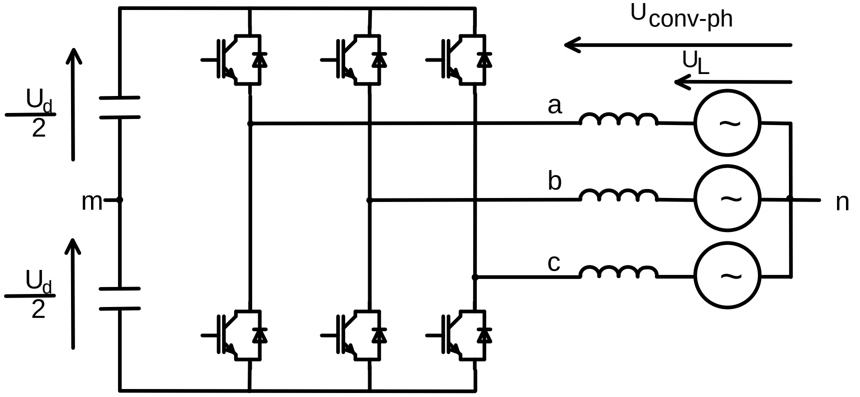
800kVdc HVDC

VSC HVDC

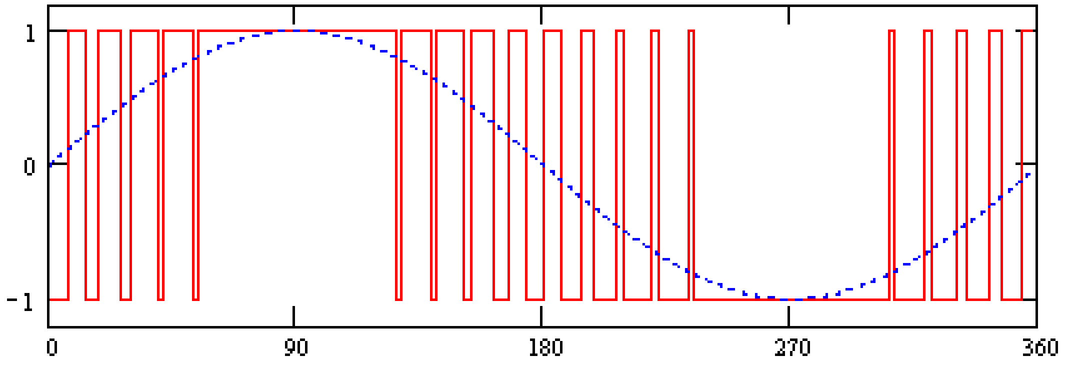
- VSC HVDC up to ±200kVdc, 500MW is under construction
- 2 different technologies are available. Technology development is continuing (lower power loss)
- Converter is self commutating, P & Q can be controlled independently – Black start capability
- Station footprint ≈40% of similar rating LCC HVDC
- No commutation failures and smaller TOV
- AC/DC/AC Conversion efficiency is ≈96.3%
- Likely to take increasing market share <1000MW

VSC HVDC - 2

- First generations of VSC HVDC based on 2 level converters.

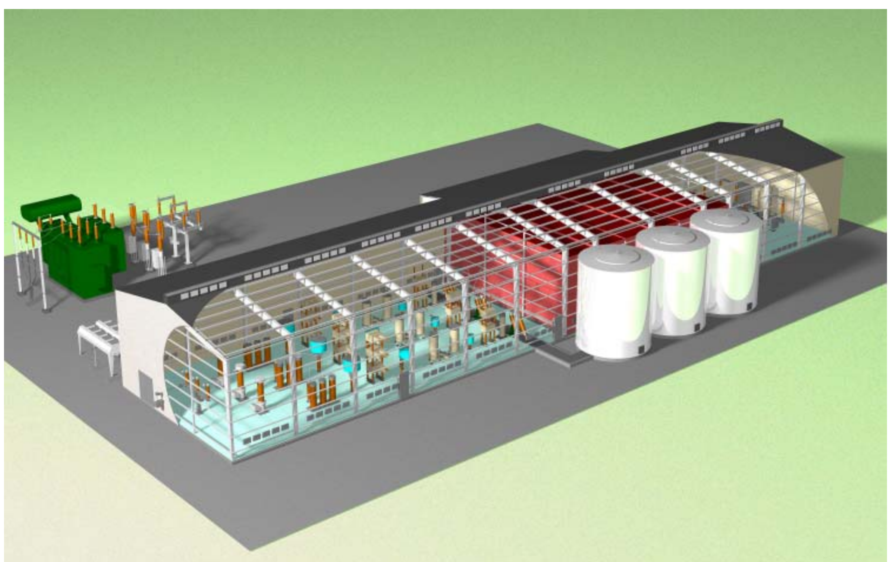


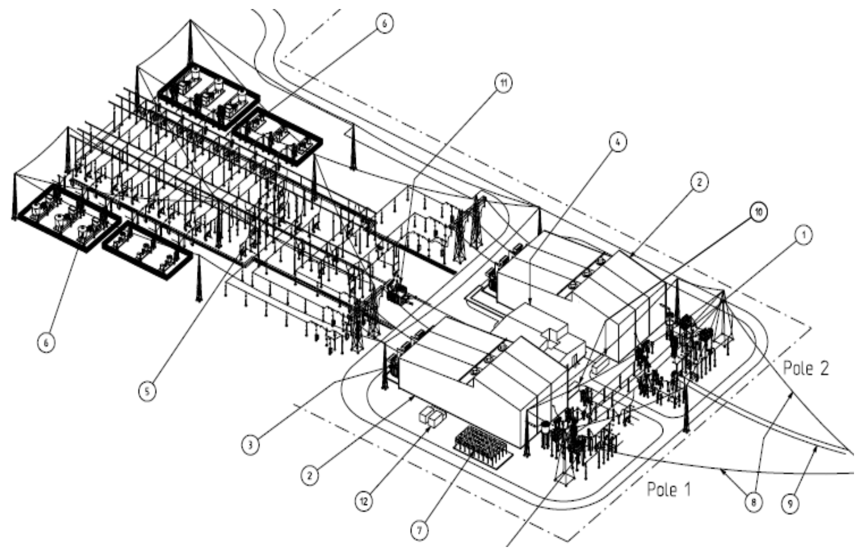
- The resulting waveform requires filtering to remove the high frequency harmonics and Radio Interference



VSC HVDC - 3

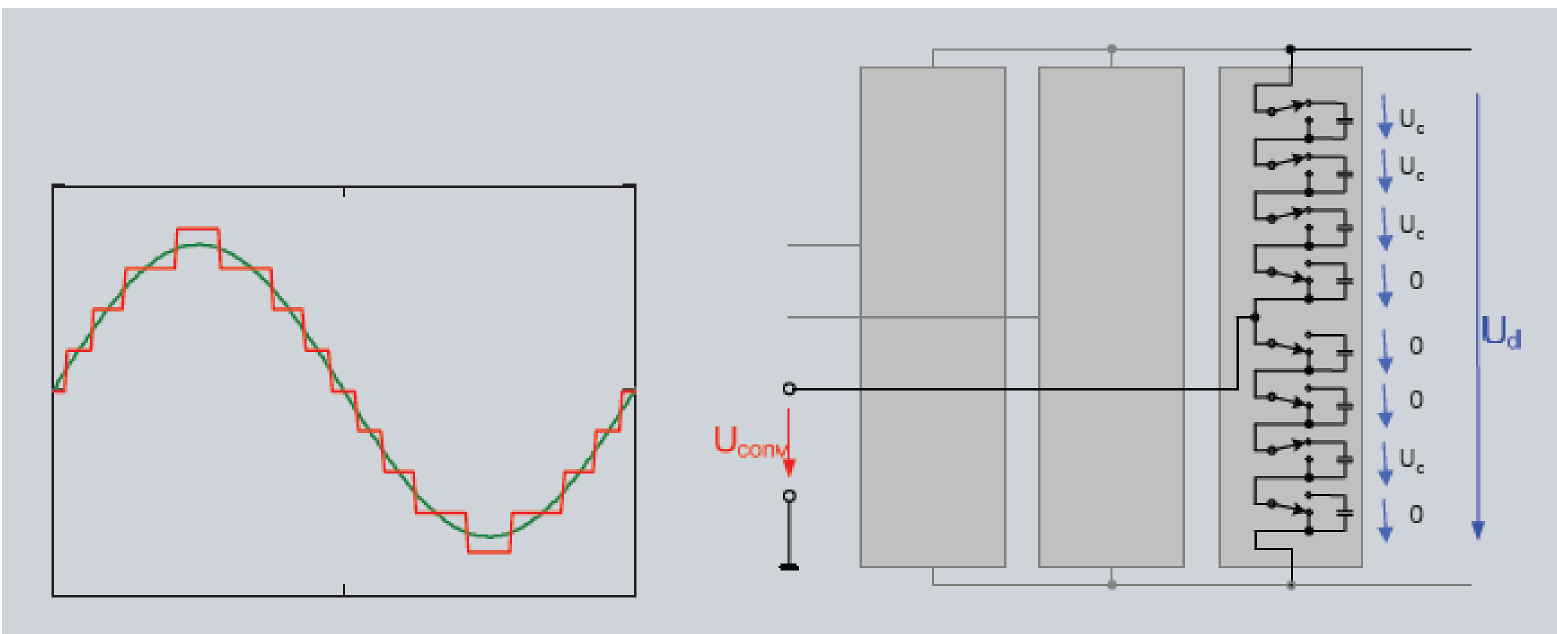
- The first VSC schemes at up to ±150kVdc had the valves in individual enclosures, which facilitated rapid installation.
- At higher voltage this approach is not feasible, and the IGBT valves need to be freestanding, similar to thyristor valves.





VSC HVDC - 4

- Recent developments appear to be moving towards a multi-level approach, which does not need substantial filtering.
- Power losses are reduced, because of fewer switch operations each power frequency cycle.



Where to next for HVDC?

- HVDC is likely to become an integral part of the Network of the Future
  - Controllable power flow in networks– transmission efficiency and security
  - Long distance transmission, OHL and cables – energy sharing, generation optimisation, intermittent generation
  - Connection of intermittent generation (offshore wind)
  - HVDC grid for bulk transport of power
- B4 will help identify the impact on the ac network
- B4 will support the new technology development

Overview of FACTS Market

- FACTS – Flexible AC Transmission Systems, includes SVCs, STATCOM, TCSC, and other, for increased system security and improved power quality.
- Market is large - not as visible to the public as HVDC
- Mainly SVCs for dynamic voltage control in ac networks, driven by different power flows
- STATCOMs used increasingly for support of wind generation
- TCSC - dynamic power control on long ac lines.

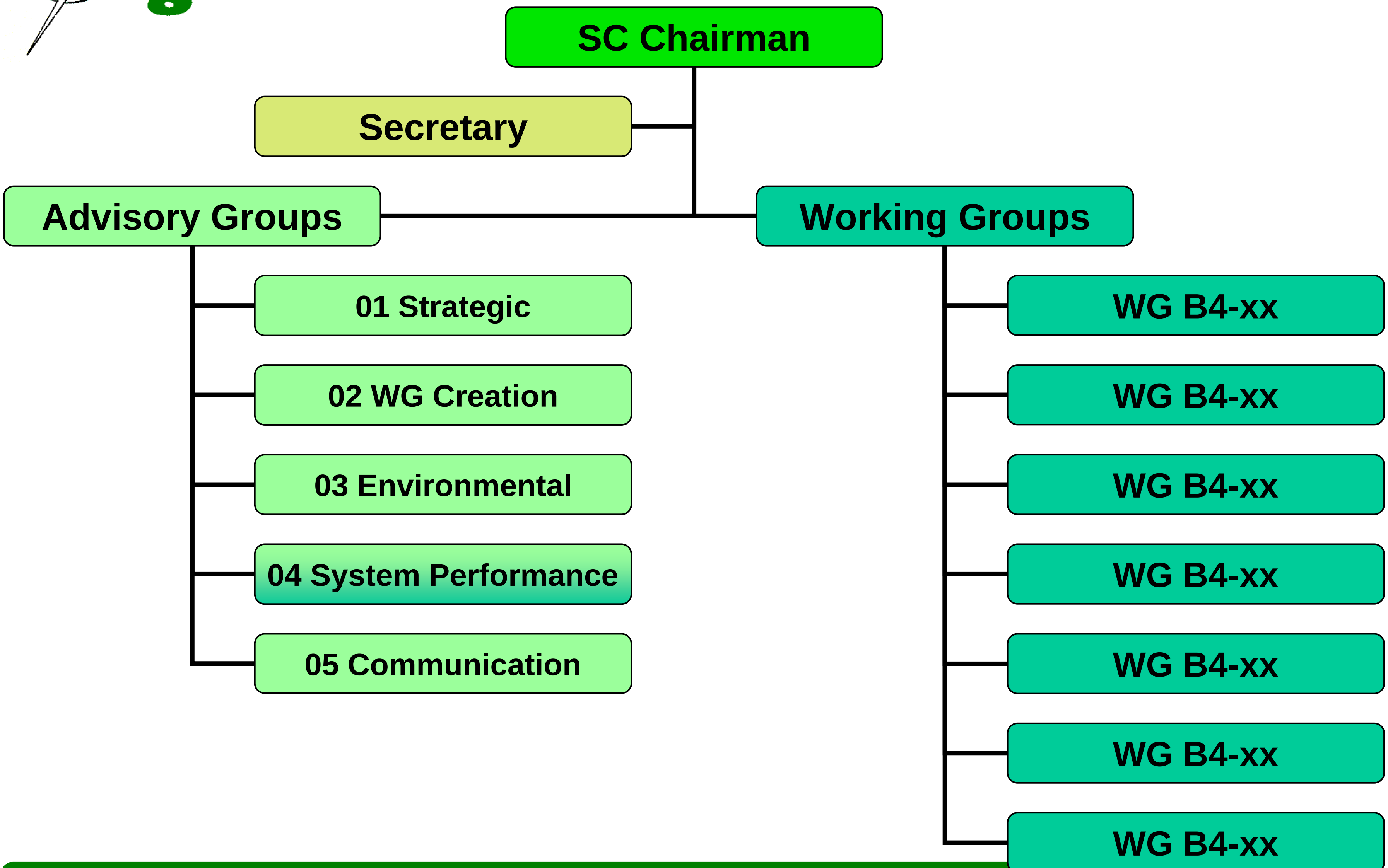
FACTS and PE for the Network of the Future

- Network control – increased utilisation of resources - optimisation of system efficiency
- Achievement of satisfactory voltage quality
- Energy storage – intermittent generation
- Optimisation of energy extraction – variable speed generation
- Network segregation to prevent cascading of faults
- Fault current limitation – fast fault clearance (solid state breakers)

B4 Strategic Direction

- Target Audience for B4
  - Network Operators/Asset Managers, Network planners, Merchant Owners/Operators, Regulators, Manufacturers, Consultants, Academia
- B4 Strategy
  - To support the CIGRE TC Strategic Plan,
  - To promote the use of HVDC and Power Electronics to the benefit of Electric Networks and its users
  - To develop the technology and to support the activities of IEC

SC B4 Organisation



Recently Completed SC Activities

- WG B4.34 Capacitor Commutated Converter (CCC) HVDC interconnections. J. Barros (BR)
- WG B4.39 Integration of Large Scale Wind Power with HVDC and Power Electronics, Convenor B. Andersen (UK)
- WG B4.40 Static Synchronous Series Compensators (SSSC), Convenor A. Edris (US)
- WG B4.41, Systems with Multiple HVDC Infeed, Convenor B. Davies (CN).
- WG B4.43 Increased system efficiency by use of new generations of power semiconductors. D. Westermann (CH)

Active SC Activities - 1

Type	Number	Title	Name of Convener
WG	B4.38	Simulation of HVDC and FACTS	A. Gole (CN)
WG	B4.44	Planning Guidelines for HVDC Environmental. issues	K.Faugstad (NO)
JWG	B2/C1/B4-17	Impacts of HVDC Lines on Economics of HVDC Projects	J. Nolasco (BR), from B2; B4 liaison J. Graham (BR)
JWG	A2/B4-28	HVDC Converter Transformer Test Procedures, Aging Analysis and Operational Performance	M. Saravolac (FR), from A2; B4 liaison Y. Fu (NL)
WG	B4.45	Technological Assessment of 800 kV HVDC Applications	R.N. NAYAK (IN)
WG	B4.46	Voltage Source Converter (VSC) HVDC for power transmission - Economic Aspects and comparison with other AC and DC technologies	D. Westermann (DE)

Active SC Activities -2

Type	Number	Title	Convenor
WG	B4.47	Special Issues in AC Filter Specifications for HVDC	N. Shore (UK)
WG	B4.48	Testing of VSC System for HVDC applications	T. Guangfu (China)
WG	B4.49	Performance Evaluation and Applications Review of Existing Thyristor Control Series Compensation Devices -TCSC	S. Nilsson (US)
JWG	B4/B2/C3.50	Electric Field and Ion Current Environment of HVDC Overhead Transmission Lines	Jose A. Jardini (BR)
WG	B4.51	Study of Converter Voltage Transients Imposed on the HVDC Converter Transformers	Dr. Yanny Fu (NL)
WG	B5.52	HVDC Grid Feasibility Study	Gunnar Asplund (SE)
JWG	B5/B4.25	Impact of HVDC Stations on Protection of AC Systems	Xi-cai Zhao (China)

B4 Strategic direction

- **The needs of Developing Countries**
  - Re-look at small taps from HVDC lines, taking into account new technology
  - Long distance transmission to small loads assisted by Power Electronics
  - Battery energy storage with renewable power source
- **Environmental Challenges**
  - EMC, Ion flows and audible noise,
  - Visual impact of converter stations and PE equipment
  - Sources of pollution and end of life disposal of equipment
  - Make available impartial advice on the use of HVDC and PE to enable undergrounding of transmission lines

B4 Strategic Direction

- **New and Developing Technologies**
  - – Clearly explain new technology and compare to existing solutions
  - – Develop Application guides (TB) for new types of HVDC and PE systems
  - – Develop Models for network studies, Interactions with the ac network(s) (harmonics, dynamic and transient response, etc)
  - – Determine electrical and mechanical stresses for new PE equipment – to assist development of Standards and operating guidelines.

B4 Strategic Direction

- **System Development and Operation**
  - Feasibility study of DC Grids – enabling developments
  - Conversion of HVAC lines to parallel AC/DC operation
  - Increase the awareness of the capability of FACTS devices to release additional transmission capacity in ac networks
  - JWGs with other SCs to determine the impact of HVDC and PE on the performance of ac network protection and control, and on the overall performance of the ac network.
  - Facilitate the use of Power Electronics in the Network of the future (FACTS, Solid State breakers, short circuit current limitation)

B4 Strategic Direction

- Target Audience for B4
  - Network Operators/Asset Managers, Network planners, Merchant Owners/Operators, Regulators, Manufacturers, Consultants, Academia
- B4 Strategy
  - To support the CIGRE TC Strategic Plan,
  - To provide unbiased information about HVDC and Power Electronics to the benefit of Electric Networks and its users
  - To monitor the performance
  - To provide high quality technical information to support the activities of IEC

B4 Methodology

- Main part of the work will be performed in WGs (or JWGs)
- B4 is able to offer Tutorials and Workshops to the NCs and Regions, to suit particular needs.
- B4 to encourage B4 WG members to offer one day tutorials in association with WG meetings.
- Investigate the possibility of making the website more interactive, including on-line tutorials, webcasts.
- Contact with the Customer Base (surveys and meetings) to be used for getting feedback, to enable continuous alignment with their needs

Thank you for your Attention

We would appreciate feedback on our strategy and direction!

Any Questions?