HVDC Interconnections: Scaling-up Electricity Trade

Agenda:

- Benefits of B2B HVDC;
- Examples of other countries;
- Technology;
- Main features and benefits of ROMOL project;
- Creating opportunities for electricity trade with Ukraine
- Implementation issues

Benefits of Back-to-Back (B2B) High Voltage DC (HVDC) Interconnections

- HVDC is used for efficient transmission of bulk power (e.g. more than 1000 MW) over large distances;
- B2B HVDC is used for interconnection between different synchronous zones (e.g. no need for synchronization between large systems which is very costly and takes long time >10 years);
- Within the same country to connect two different parts – for example, B2B between two parts of Japan's power grid which uses 50 Hz and 60Hz;
- B2B HVDC offers full controllability (i.e. full control of contracted power flows, unlike AC which may create "loop flows" as electricity follows physical laws)
- Power system "ancillary" services (voltage control, overload capability, black-start capability, limitation of short-circuit currents, prevention of cascading faults)

Examples from other countries

Transmission of bulk power

- Agra project in India
- Power rating: 6000 MW
- Distance: 1,728 km
- DC voltage: 800 kV
- AC voltage: 400 kV

Grid support B2B

- Yunnan-Guangxi project, China
- Parallel LCC & VSC B2B converters
- VSC: 350 kV, 1000 MW & LCC: 160 kV, 2000 MW

Interconnection between two systems:

- EU INELFE project (France, Spain)
- Power rating: 2000 MW
- Distance: 65 km underground cable
- DC voltage: 320 kV
- AC voltage: 400 kV

Submarine cables and integration of off-shore renewable energy

- 29 existing HVDC submarine cables and 10 under preparation/ construction
- Integration of off-shore wind

Technology: LCC vs VSC

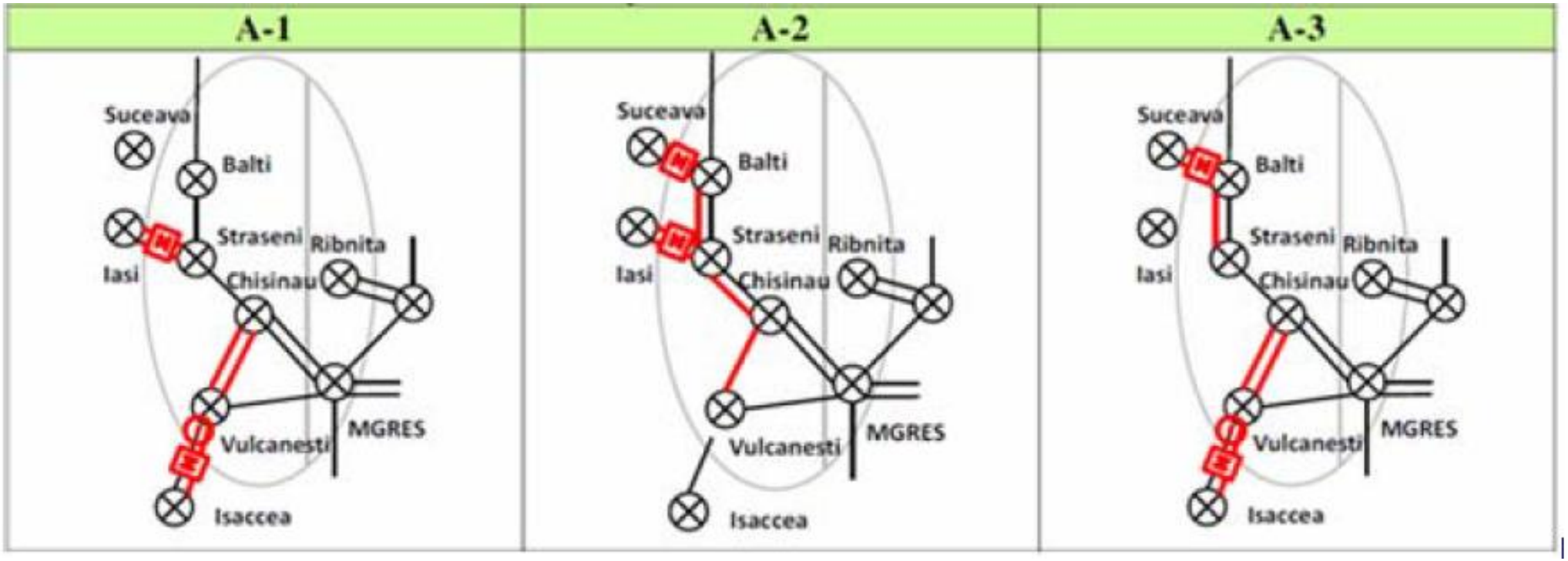
Line Commutated Converters (LCC)

- Using **Thyristor** valves
- In commercial use since 1972
- Voltage up to 800 kV
- DC power up to 7000 MW
- Reactive power requirement up to 60% of its MW rating at each terminal
- AC system strength: critical
- Losses: 0.6 - 0.7%
- Black-start: limited capability
- Footprint: large due to filtering & reactive power support

Voltage Source Converters (VSC)

- Using Insulted Gate Bipolar **Transistors**
- In commercial use since 2000
- Voltage up to 500 kV
- DC power up to 2000 MW
- Does not consume any reactive power and each terminal can control Q-flow
- AC system strength: not critical
- Losses: 0.8 – 0.9%
- Black-start: fully capable
- Half the size of similar rating LCC

Romania – Moldova (ROMOL) Interconnection



- Option A1: B2B in Straseni and Vulkanesti (& additional 400 kV line)
- Option A2: B2B in Balti and Straseni (& additional 330 kV and 400 kV lines)
- Option A3: B2B in Balti and Vulkanesti (& additional 330 kV and 400 kV lines)

ROMOL Interconnection: Cost and Benefits

Benefits:

- 600 MW (2 x 300 MW) B2B in Vukanesti increases energy security and power market competition in Moldova;
- Advanced technology (VSC) saves AC costs in the power grid through full controllability of power flows, before and after the synchronization;
- Provides voltage control and ancillary services
- Defers investments in power generation

Cost estimate and financing plan:

- B2B station at Vulkanesti:
  - Cost of LCC: 210 Euro/kW
  - Cost of VSC: 300 Euro/kW
- AC costs:
  - Transmission line: Euro 45 million
  - Substations: Euro 25 million
- Total project cost: Euro 250 million
- Financing plan:
  - EC grant: Euro 40 million
  - EBRD, EIB and WB each Euro 70 million

Scaling-up electricity trade with Ukraine

Option 1: HVDC Link with ENTSO

- Can be established at different locations (existing substations);
- Partially uses existing or refurbished transmission lines;
- Requires agreement with ENTSO and neighboring TSOs (cross-border project);
- Reliability (N-1) criteria may require significant up-front investments.

Option 2: Interconnection of Burshtyn

- B2B for the re-integration of Burshtyn with the Ukraine power grid;
- Uses existing AC power grid to a greatest extent/ differs AC investments;
- Does not require formal clearances from ENTSO and neighboring TSOs (domestic project);
- Reliability (N-1) criteria may be less costly to meet.

Implementation Issues

- Feasibility work required (or updating of existing studies to meet international / ENTSO requirements)
- Coordination with ENTSO and neighboring TSOs requires establishment of a high-level implementation committee with representatives of ENTSO and relevant TSOs
- Mobilization of project financing:
  - Option A: 100% public project implemented and operated by UE
  - Option B: Public-Private Partnership with UE representing the public sector
  - Option C: Tolling option (concession) with 100% private investment
- Development and adoption of necessary regulations, legal and contractual framework
- Signing of Electricity Trade/ Offtake Agreement(s) and financing agreements
- EPC contracting, construction and commissioning