Rui Du, PGGS, ABB, November, 2016

1,100 kV UHVDC Technical presentation

Agenda

- Why 1,100 kV?
- Potential markets
- Challenges
- System design
- Type tested apparatus
- DC yard apparatus
- The full setup
- Production and test facilities
- Summary

Why a new rated UHVDC?

*) Source EIA

Meeting increasing energy demands

- Energy consumption projected to increase by 50 % by 2040*)
- Almost all growth will come in non-OECD countries, more than half from India and China.
- Electricity demand projected to grow by 70% by 2040*)

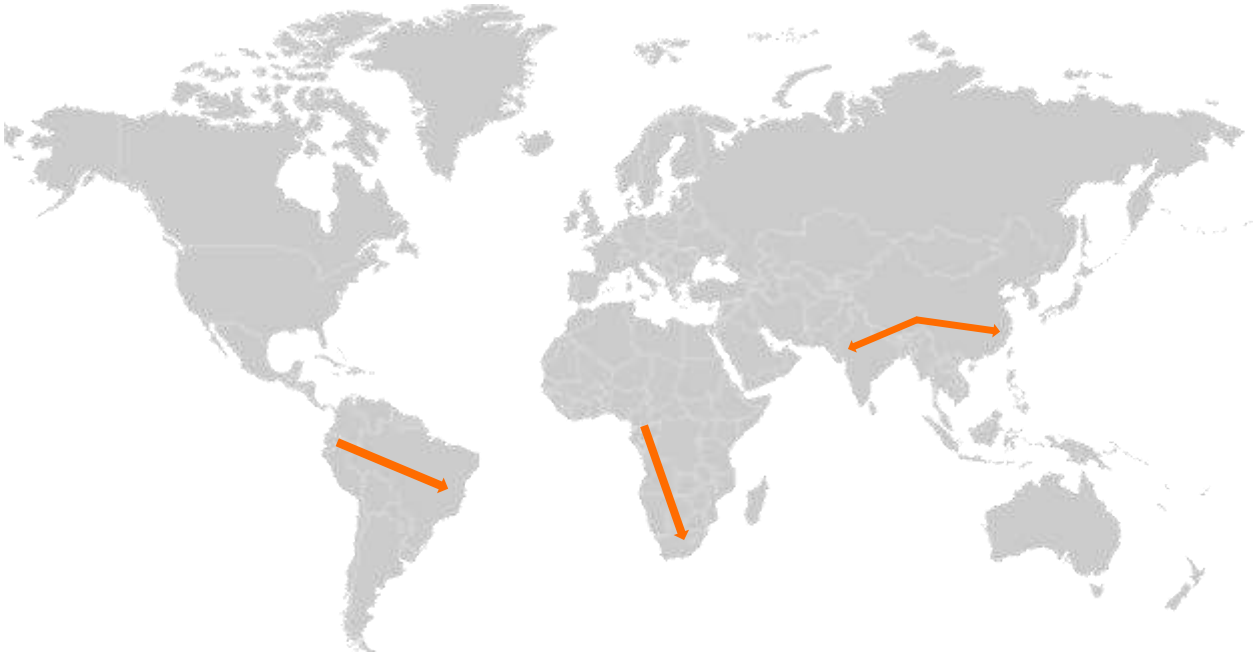
Lowering environmental impact and footprint

- Electric power generation mix moving towards renewables
- Renewable energy sources are often located far from load centers
- Right of Way (RoW) is limited and becoming an environmental, permitting as well as a cost issue.

Capacity

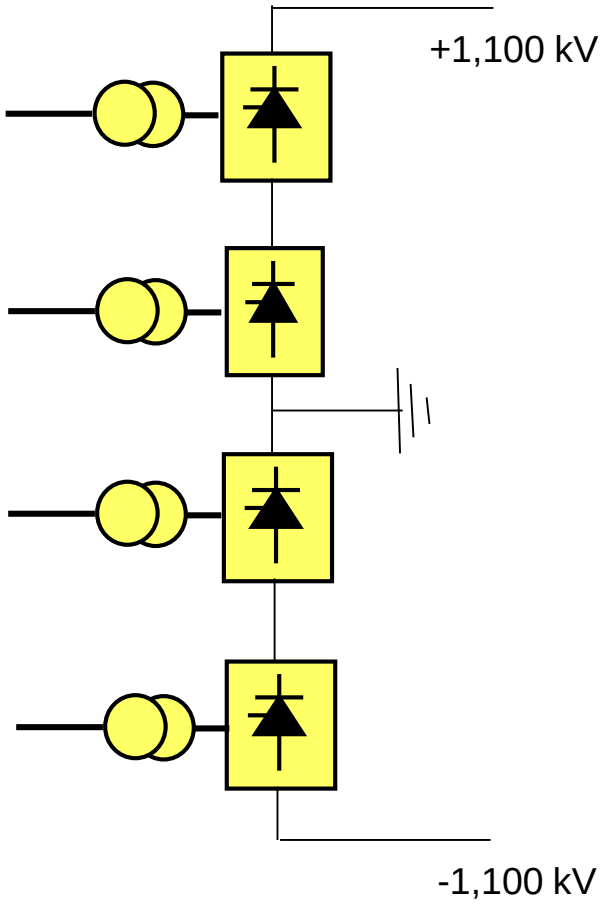
- 1,100 kV UHVDC increases capacity up to 20%, a prodigious upgrade from 800 kV UHVDC
- Opens a new range of voltage levels, above 800 kV.
- Even lower transmission losses over long distances

Potential markets



- UHVDC is the number one choice when it comes to bringing huge amounts of energy from renewable resources, often far away, to large load centers.
- China, India, Africa and the South America are potential markets with these conditions.

System design
Changji - Guquan UHVDC link – technical data



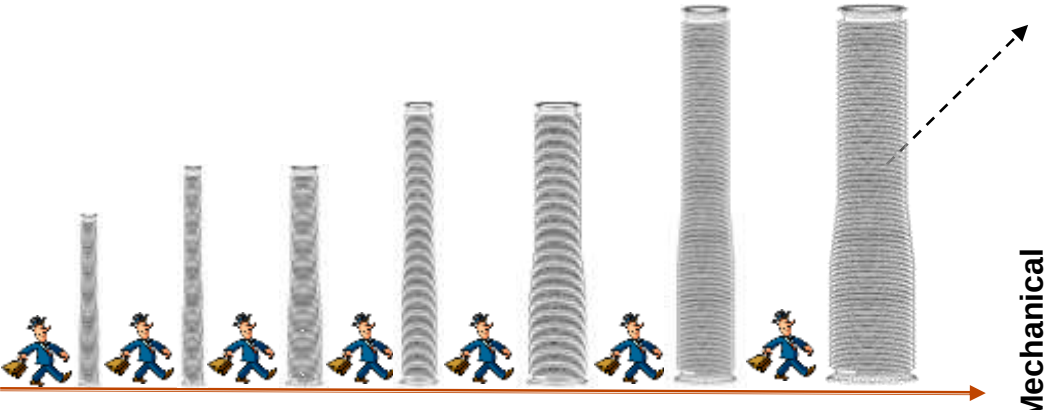
Rated voltage	± 1,100 kV
Rated current	5,455 A
Power rating	12,000 MW
2 hour overload*	12,600 MW
No of converters in series	2
Converter voltage rating	1050/775/510 kV
Reactive voltage drop, dx	10/11 %
Delay angle, nominal	15 degrees
Margin of commutation	18 degrees
Overhead line length	3,284 km

**with redundant cooling*

Challenges
Higher voltage level brings new requirements

- Higher insulation requirement – nonlinearly, length and diameter.
- Higher and larger equipment.
- Increased challenges in mechanical, thermal, valve hall and DC yard design.
- How to avoid a run-away situation?
- New thinking required.

From 800 kV to 1,100 kV
Difference mechanical design



From 800 kV Design

Creepage

Insulator length Increases

Mechanical

Insulator diameter Increases

Wet Withstand Performance

Pollution/Rain withstand decreases

Creepage

Insulator length Increases

Mechanical

Insulator diameter Increases

Wet Withstand Performance

Pollution/Rain withstand decreases

Creepage

Insulator length Increases

Mechanical

Insulator diameter Increases

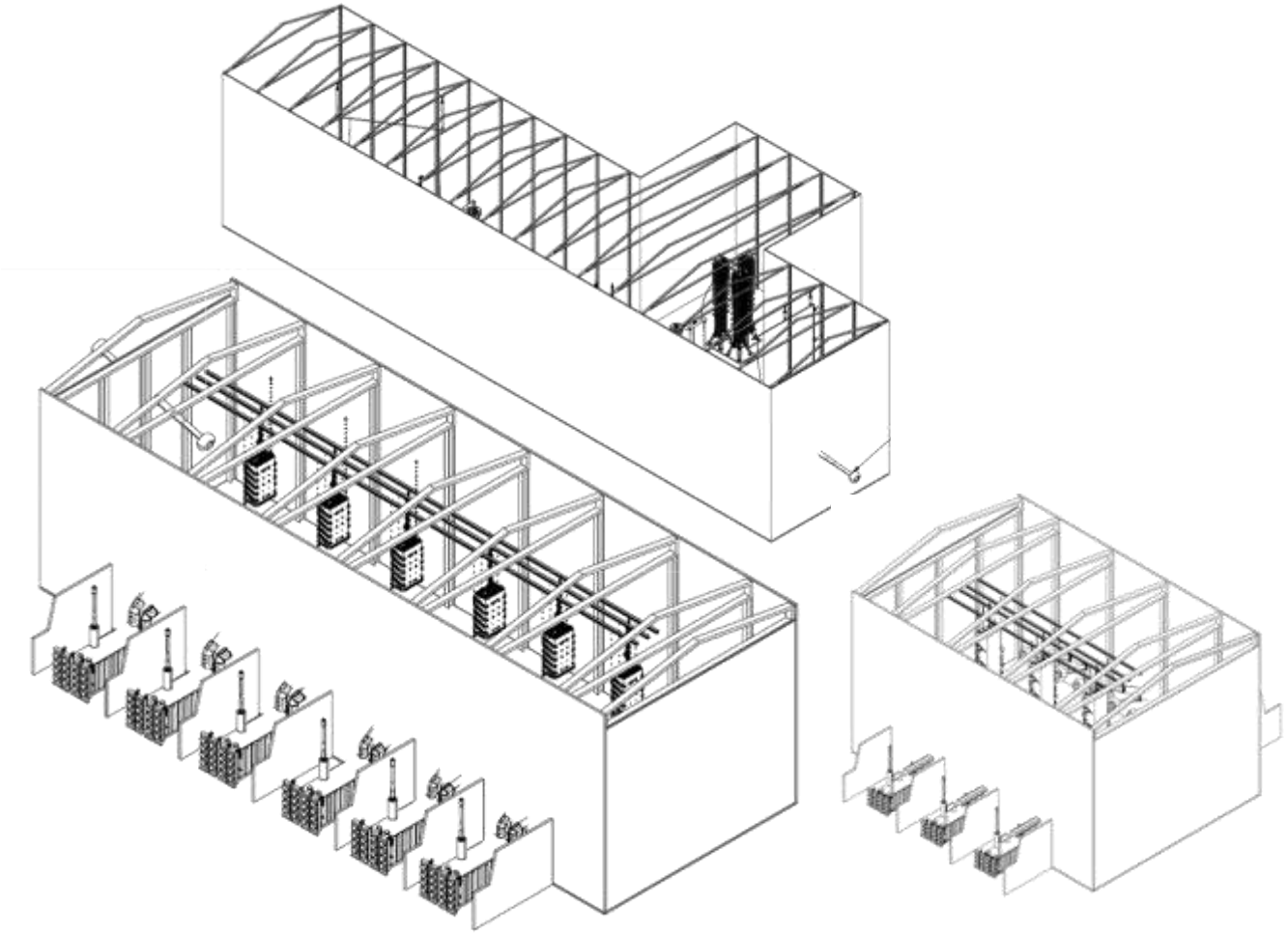
Wind load ↑ → Insulator diameter
Bus bar diameter ↑ → …. ↑
Possible run-away situation!

From 800 kV to 1,100 kV
Solutions to avoid a ”Run-away situation”

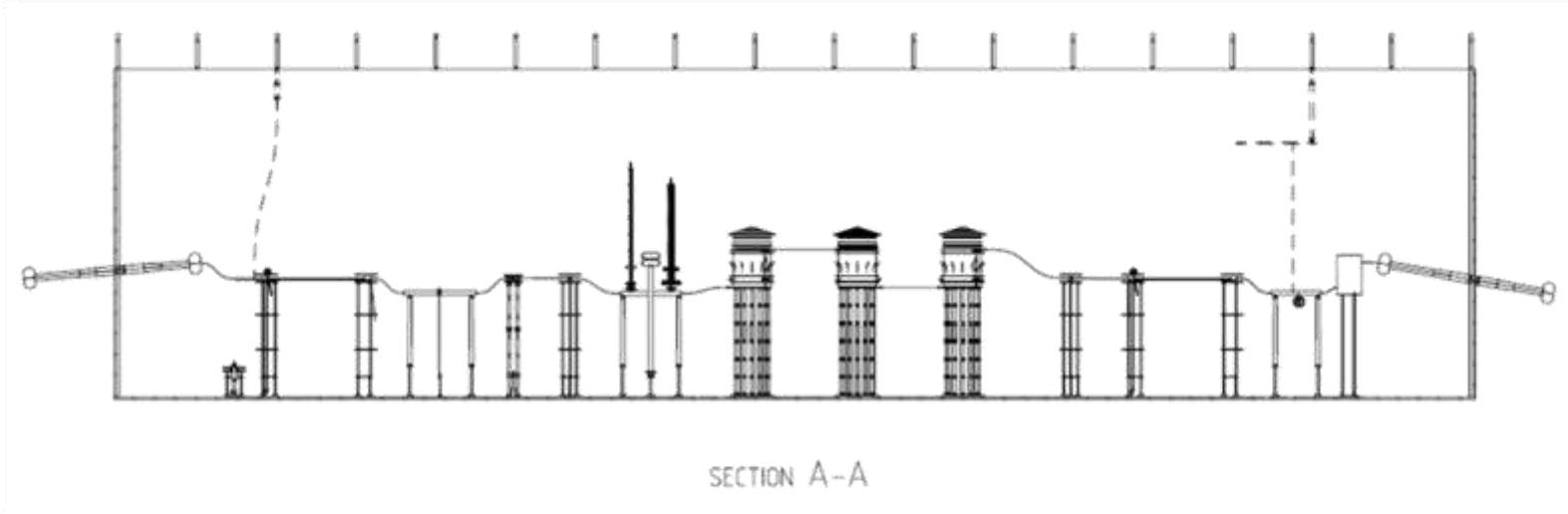
Image: SGCC Xiangjiaba project China

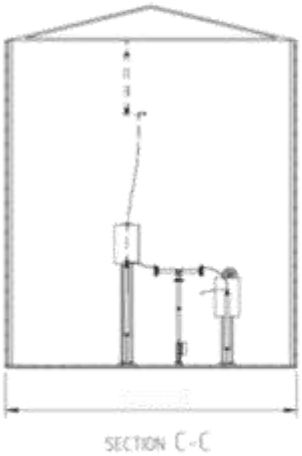
- **Valve Design**
  - Optimized Electrodes
  - More efficient shielding
- **Indoor DC Yard**
  - To avoid Wind loads
  - To avoid pollutions

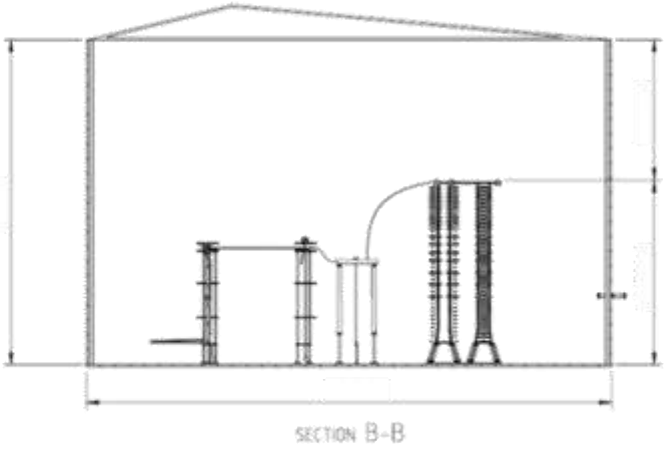
System design
Station layout – external view

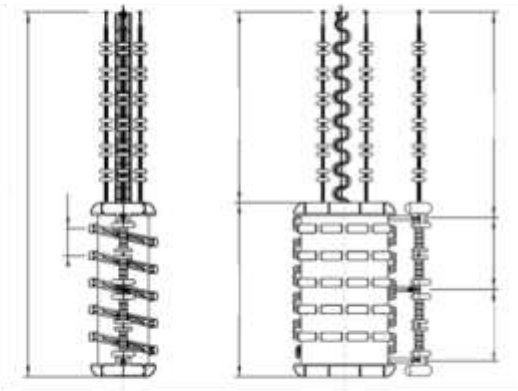


System design
Station layout – internal view

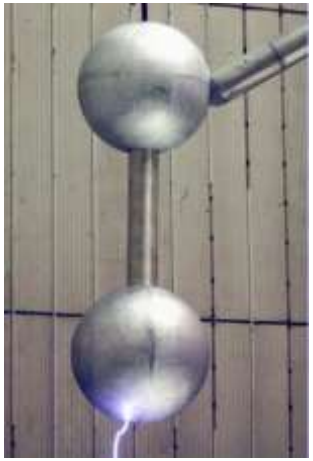


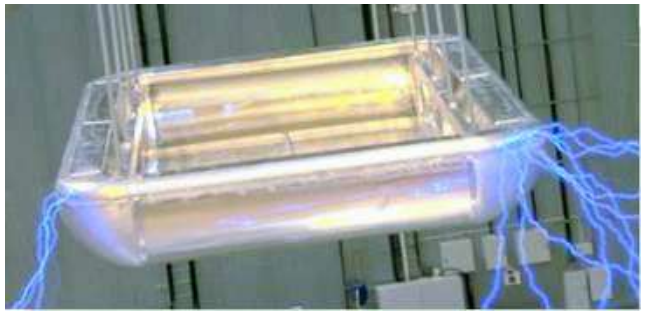






System design
Performed studies





Fundamental system studies

- Main circuit parameters
- Insulation coordination
- Transient studies
- Technical specification

Insulation design & testing

- Large air clearance
- Optimized shield design

Station layout

System design
Cooperation between ABB and SGCC

**SGCC = State Grid Corporation of China.*

System studies

- System optimization
- Insulation coordination

Station layout

- Valve hall design
- Indoor/Outdoor DC yard

Equipment qualification

- Review of design and test results

Transformer site assembly

Discussion and assessment on insulation test

Type tested apparatus
Successful performance

- Wall bushing
- Transformer bushing
- Transformer mockup
- By-pass switch
- Surge arrester
- DC coupling capacitor (RI filter)

ABB finished the R&D of critical equipment within the time frame given by SGCC.

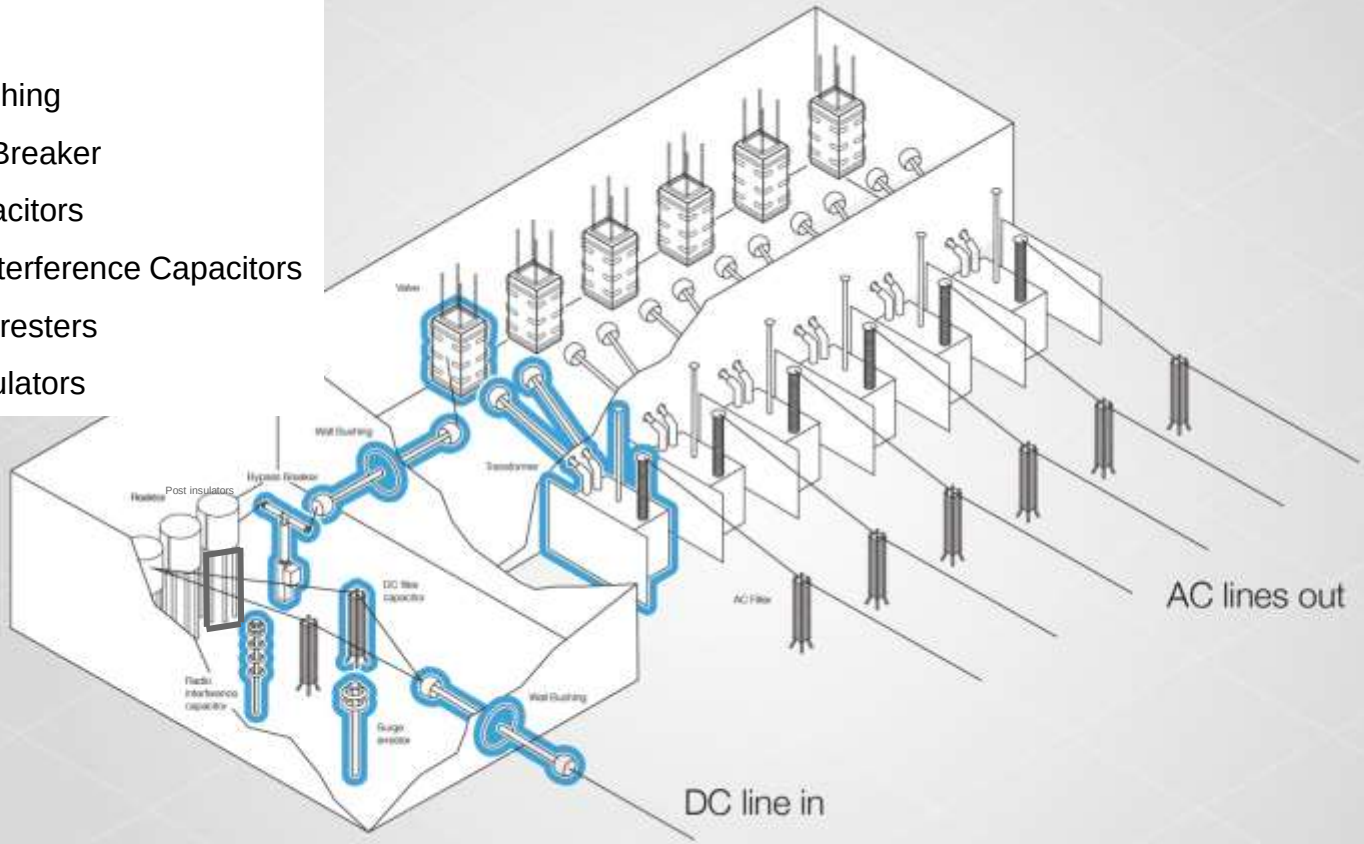
DC yard apparatus
DC filter capacitor

800 kV UHVDC
DC filter capacitor.

- Original design did not withstand specified wind loads.
- New design to fulfill mechanical requirements

1100 kV UHVDC
The full set of equipment developed by ABB

- Converter Transformers
- Valves
- Wall Bushing
- Bypass Breaker
- DC Capacitors
- Radio Interference Capacitors
- Surge Arresters
- Post insulators



1100 kV HVDC Infographic link

Production and test facilities

A new test hall was built in order to increase the capacity to meet the needs of the new voltage level.

The production and test facilities were built or upgraded for the new UHVDC technology – 1,100 kVDC

- New Composite Insulator production line
- Increased Lab capacity
- New winding machines for the bushing condenser core

Summary

ABB can provide

- Complete system solutions between 800-1,100 kV
- A solution including all critical equipment
- An optimized technical – economical solution
- A solution that minimizes risk

ABB is fully committed to the delivery of UHVDC systems between 800 and 1,100 kV

Power and productivity
for a better world™