Bipole III Transmission Project

Clean Environment Commission
Public Hearings

Fall 2012

System Planning

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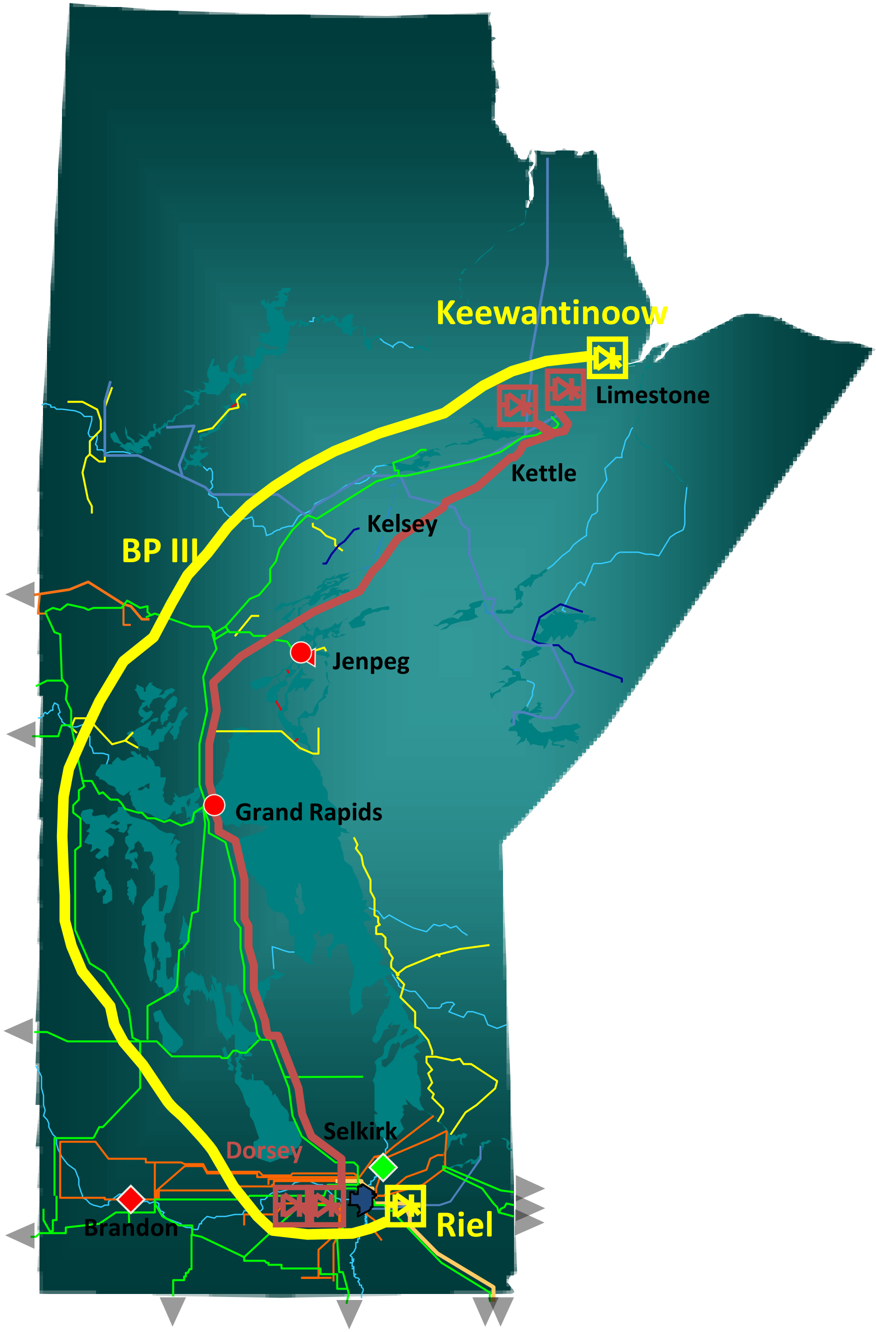
Manitoba Hydro



OVERVIEW

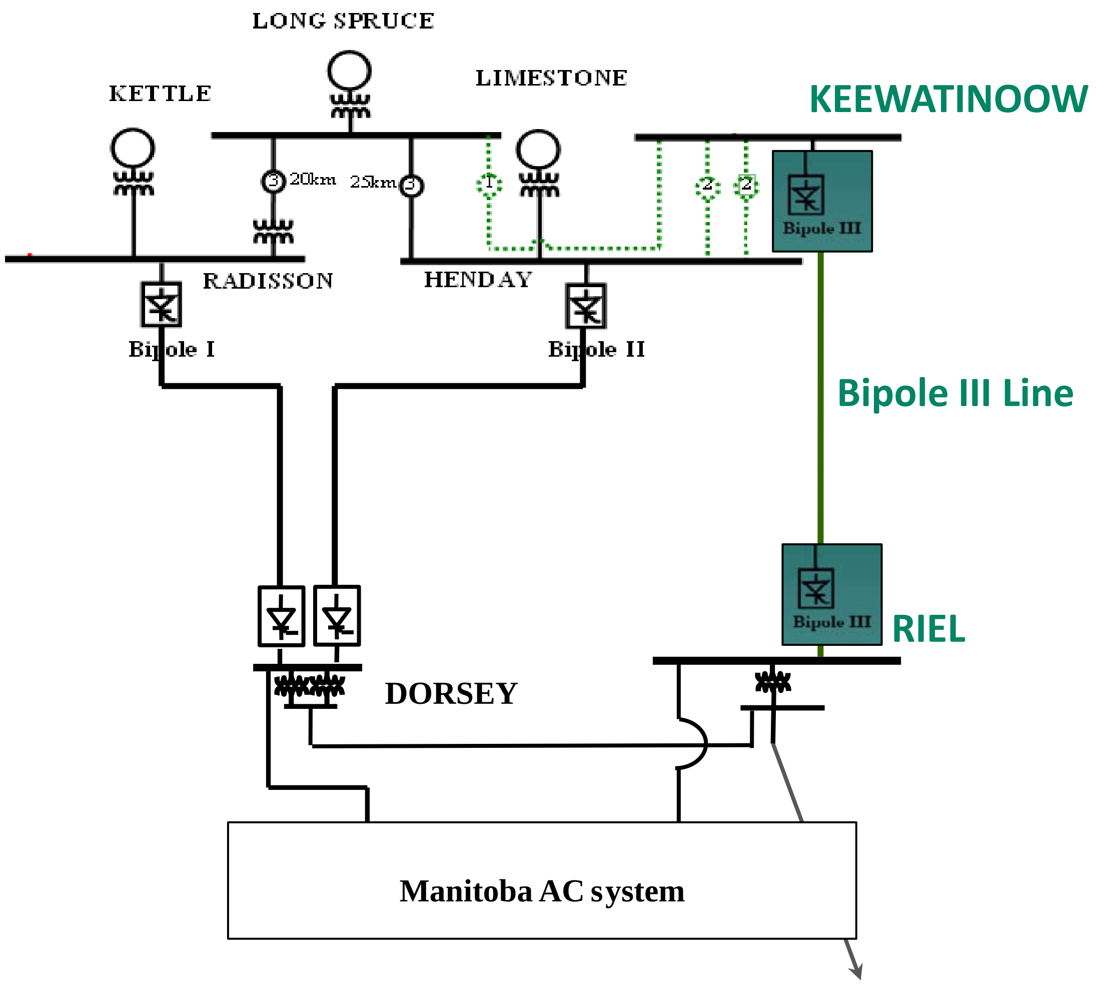
- Transmission Options
- 500 kV HVDC ~ 1384 km transmission line
- Keewatinoow converter station
  - Rated 2000 MW
  - Northern Collector System transmission
- Riel 2000 MW converter station
  - Rated 2000 MW
  - Riel 230 kV AC transmission
- Converter Technology Options
  - LCC vs. VSC
- Conclusion

Transmission Options

- High Voltage DC
- High Voltage AC

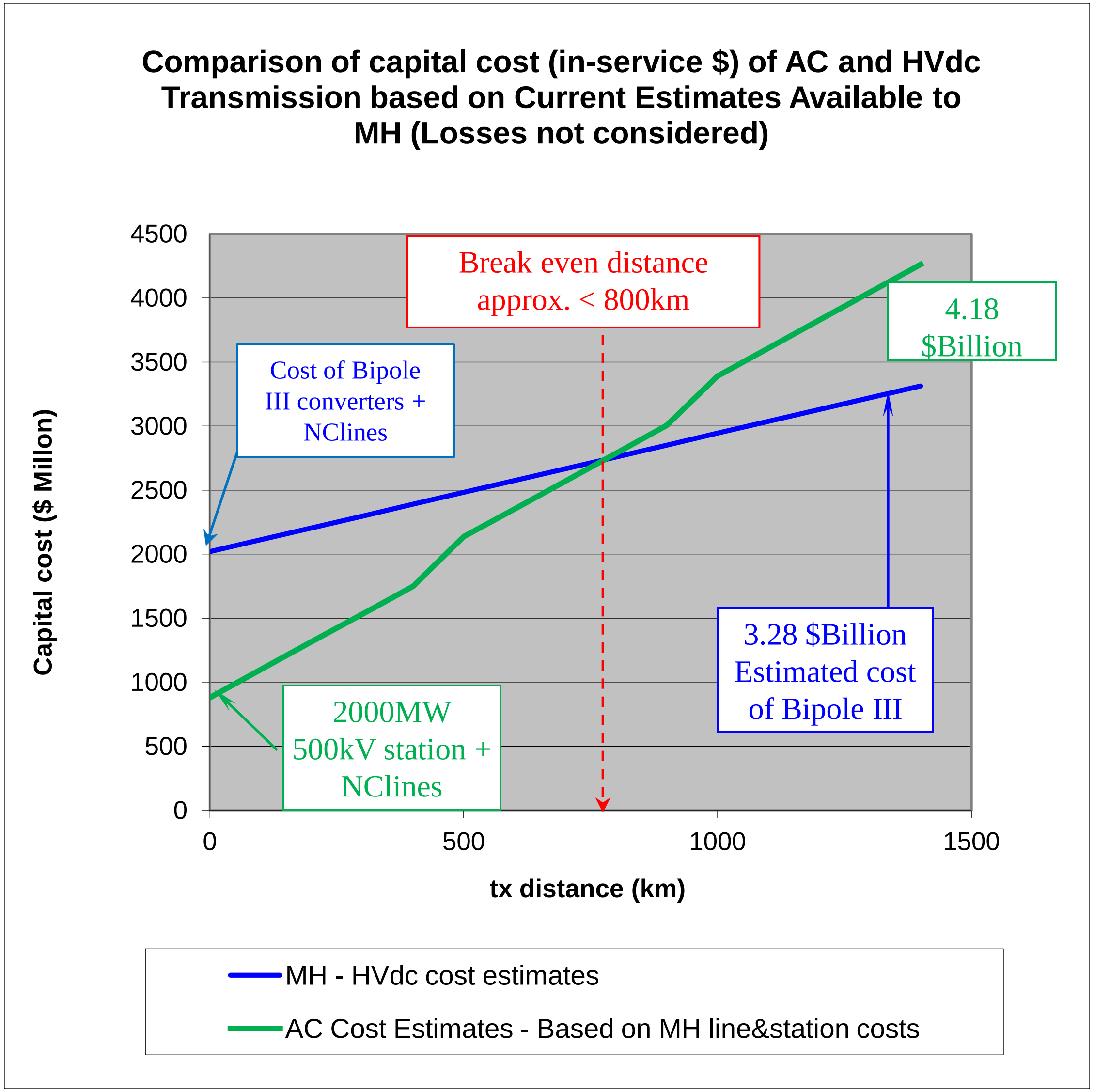
Why HVdc ?

- Technical Merits
  - Facilitates Connection to isolated Northern Collector System
  - Lower Losses



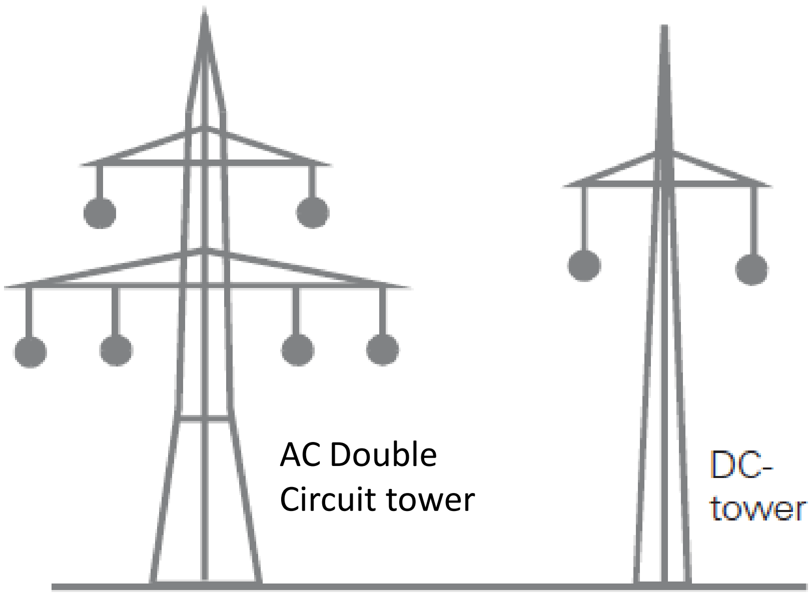
Why HVdc ?

- Economic considerations
  - HVdc converters are costly
  - HVdc line is less costly
  - AC stations are less costly
  - AC line is more expensive
  - <u>HVdc more economical than AC for long distance</u>



Why HVdc ?

- Environmental advantages compared to AC
  - Smaller transmission tower
  - Narrower right-of-way



*Source : HVdc – **Proven Technology for Power Exchange** by Siemens*

Bipole III Transmission – Sending End

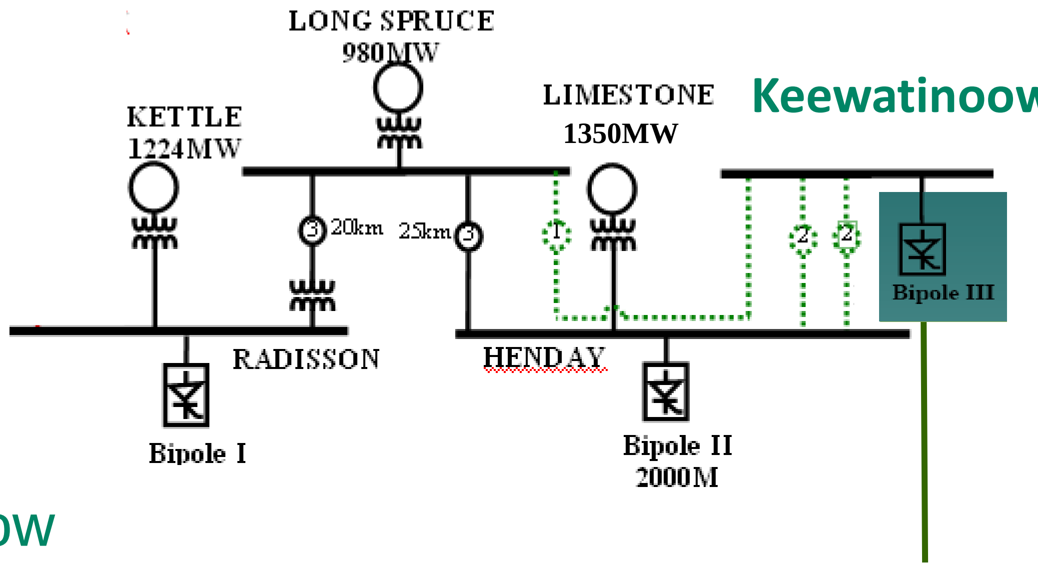
- Northern Converter - Keewatinoow CS
- Northern Collector System Lines
  - Long Spruce – Keewatinoow

    1 x 230 kV line

    - 52 km
  - Henday – Keewatinoow

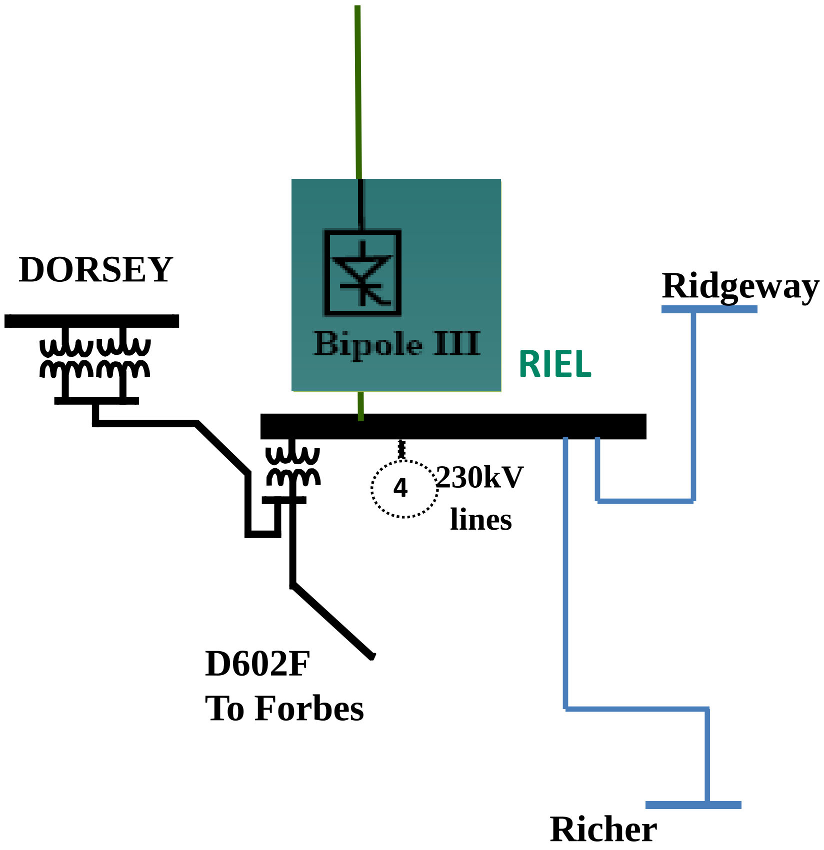
    4 x 230 kV lines

    – 27 km each

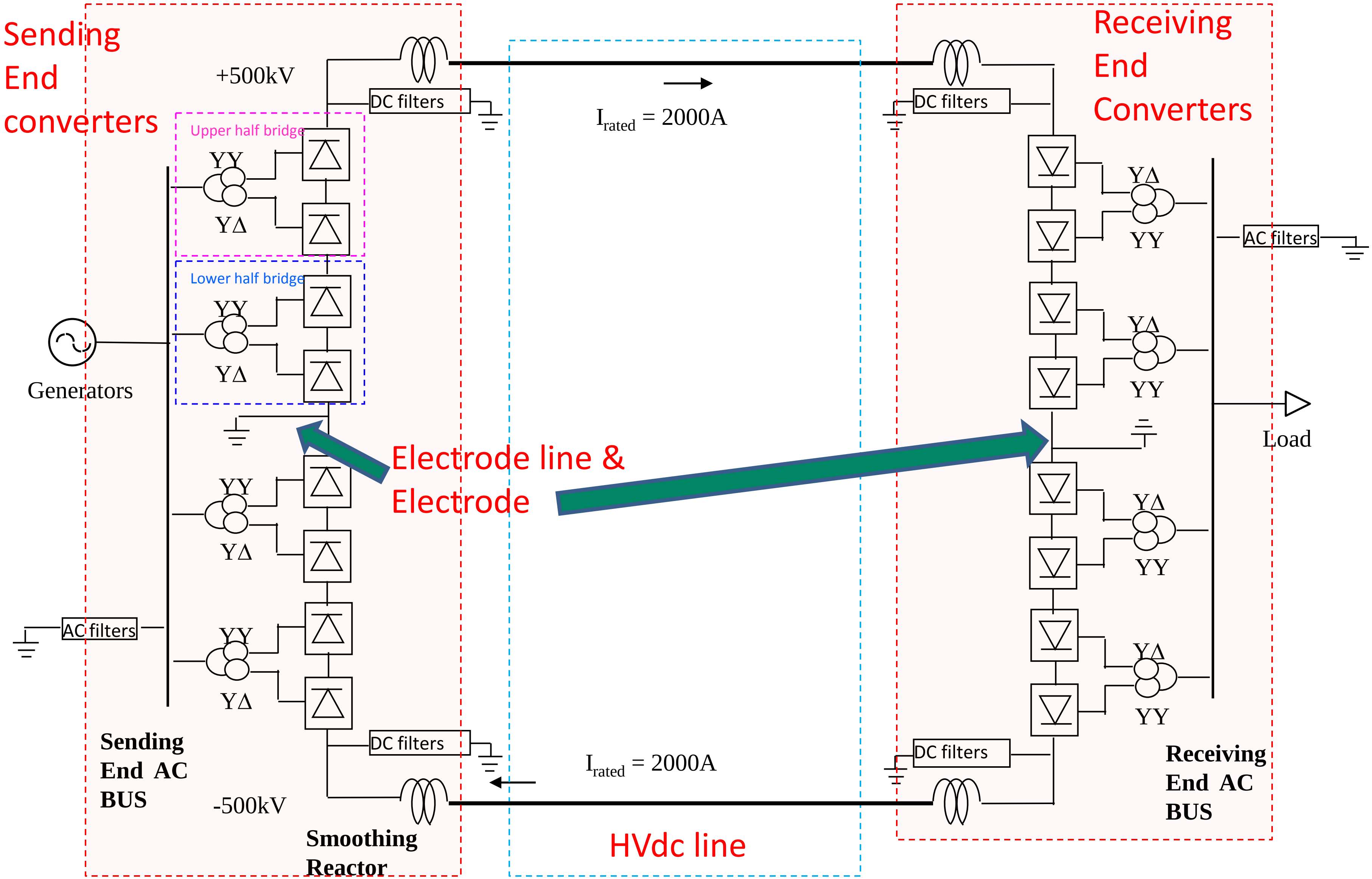


Bipole III Transmission – Receiving End

- Southern Converter - Riel CS
  - Sectionalize Richer 230 kV lines R49R

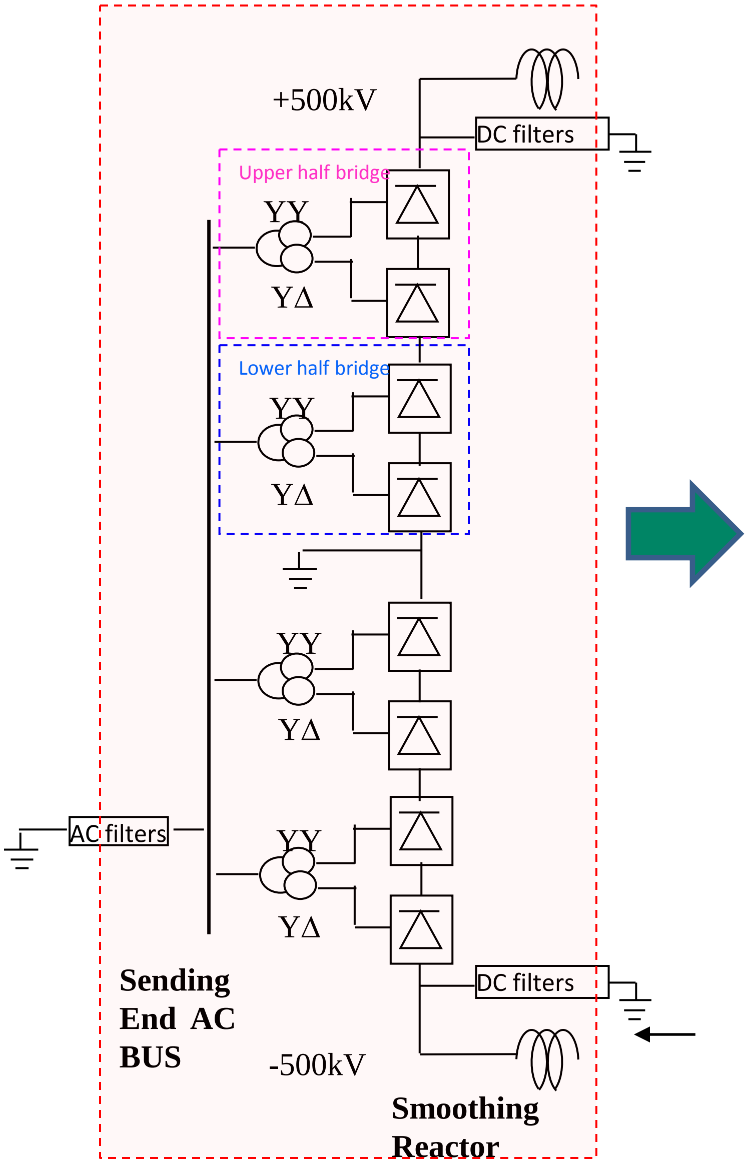


What is HVdc ?



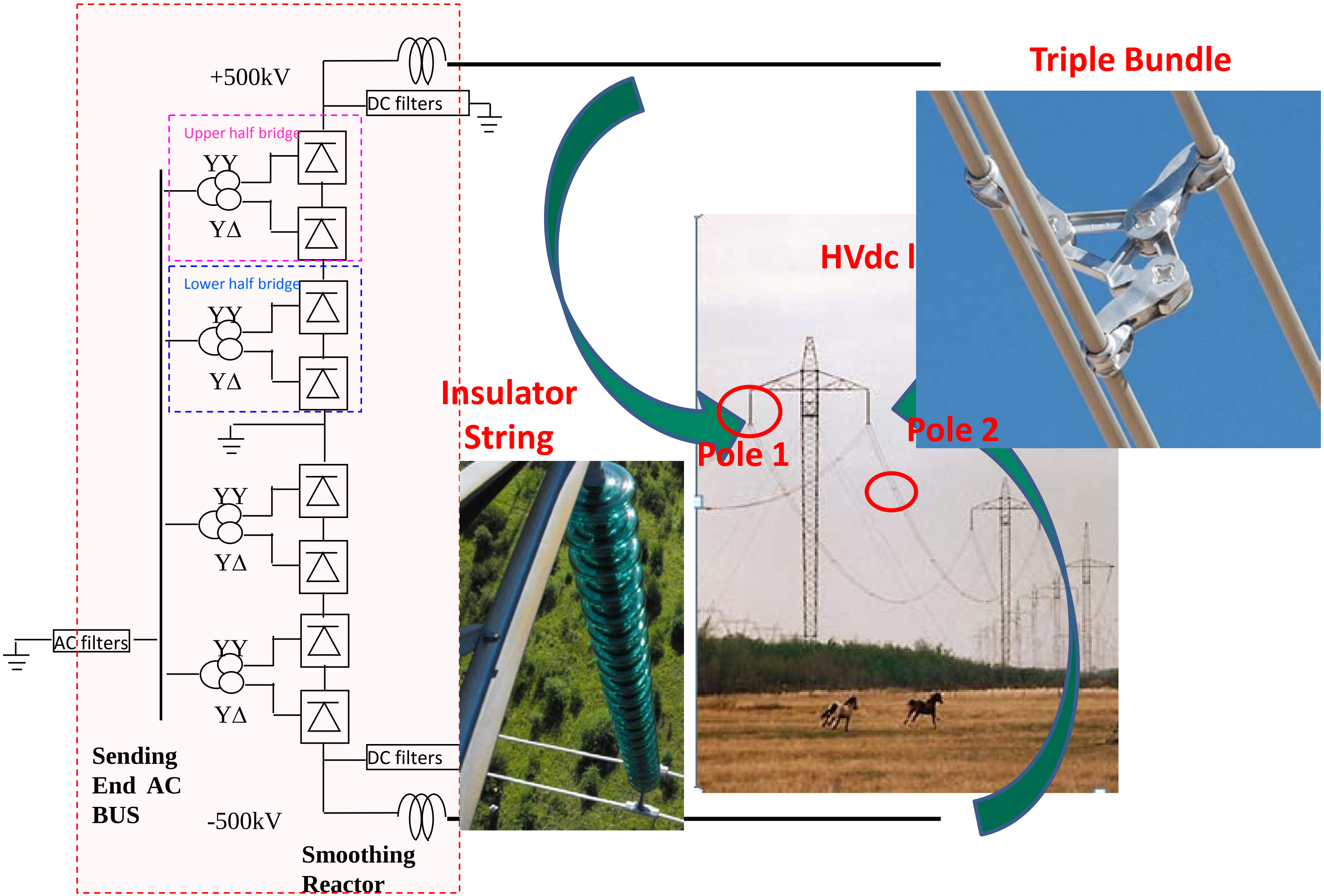
Sending
End
converters
+500kV
DC filters
Upper half bridge
YY
YΔ
Lower half bridge
YY
YΔ
Generators
YY
YΔ
YY
YΔ
AC filters
Sending
End AC
BUS
-500kV
DC filters
Smoothing
Reactor
I rated = 2000A
Electrode line &
Electrode
I rated = 2000A
HVdc line
Receiving
End
Converters
DC filters
YΔ
YY
AC filters
YΔ
YY
Load
YΔ
YY
YΔ
YY
DC filters
Receiving
End AC
BUS

Converter Station



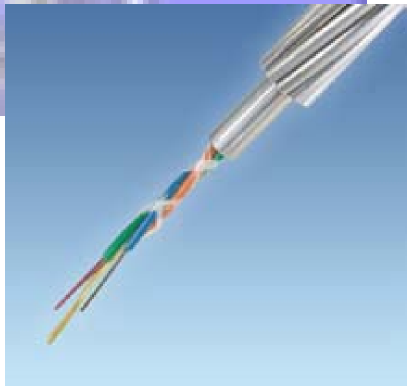
Converter Station (Henday)

HVdc Line – Two Conductors

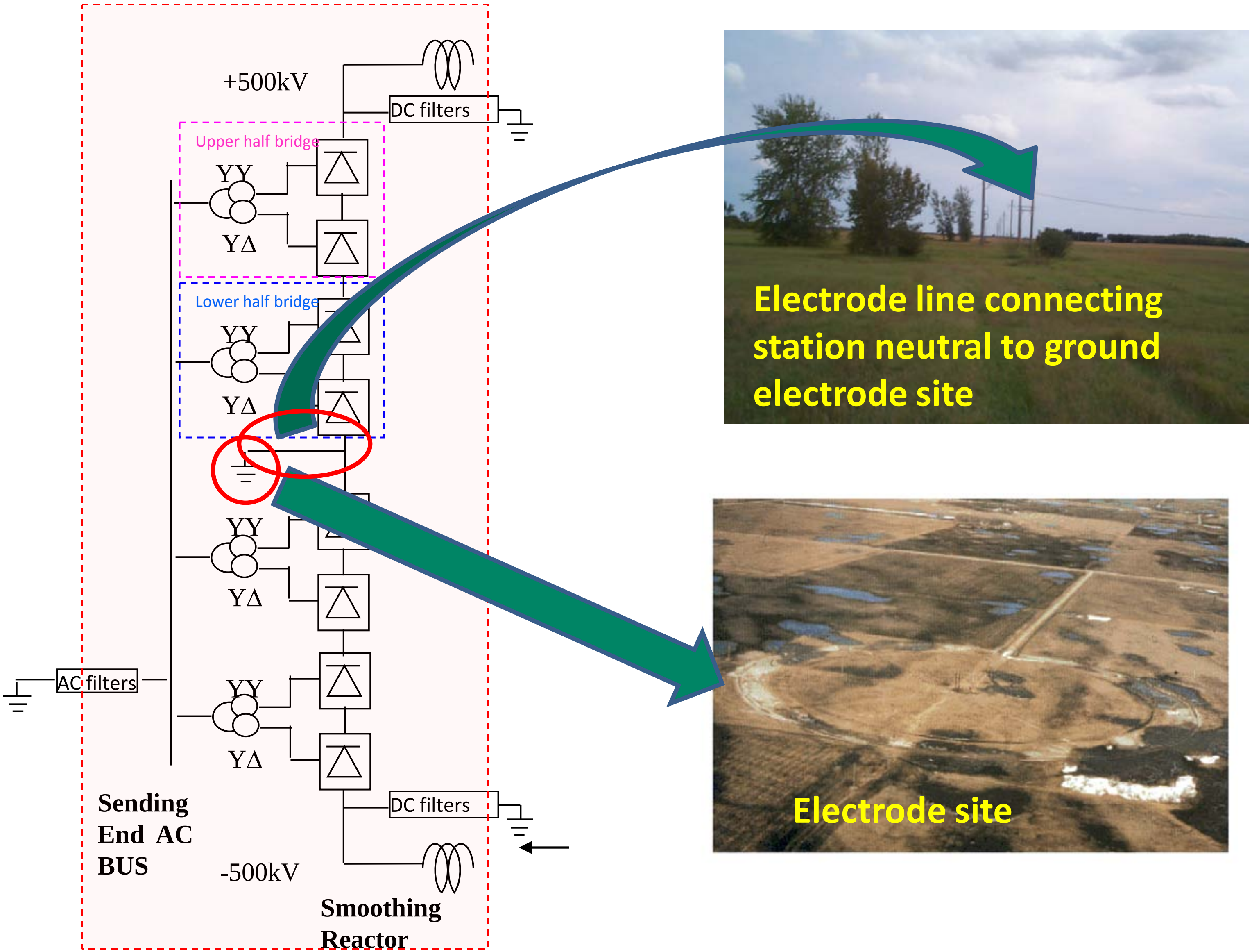


Shield Wire & Communication

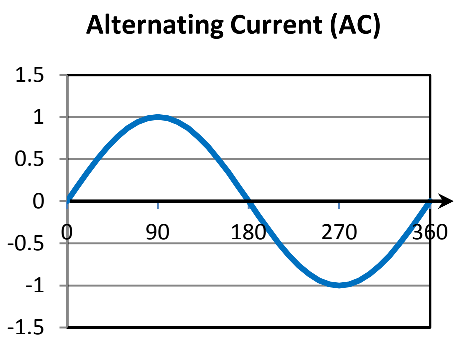
- Optical Ground Wire
  - Lightning protection
  - Communication

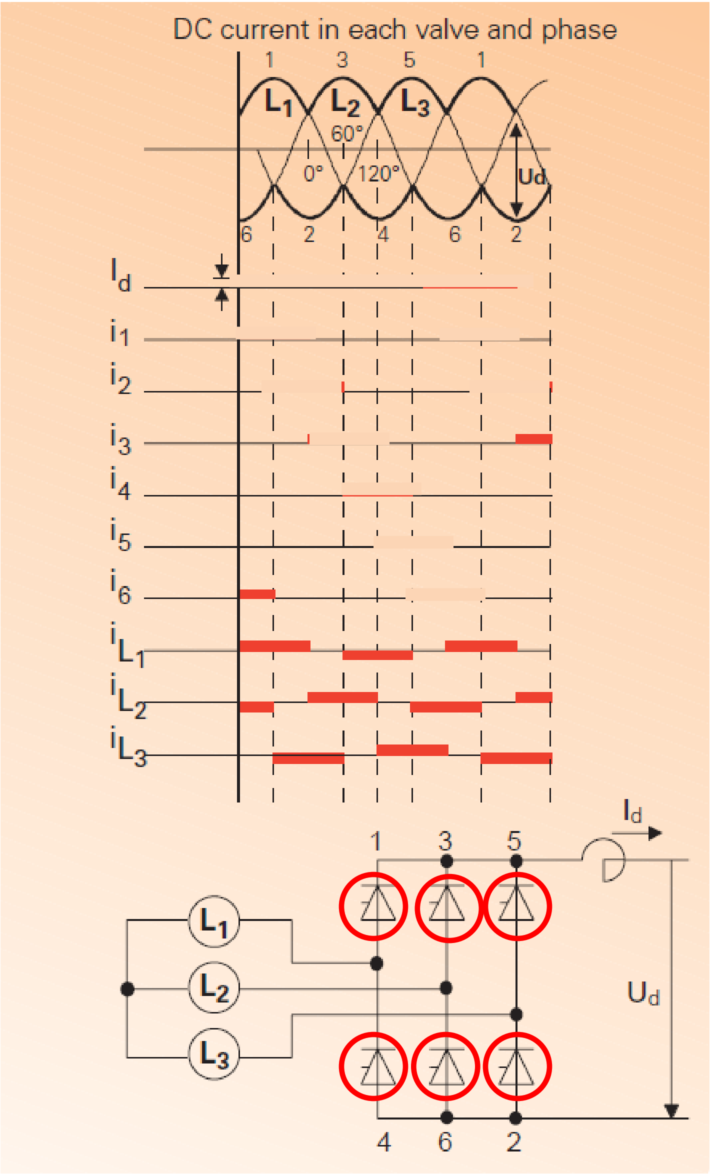


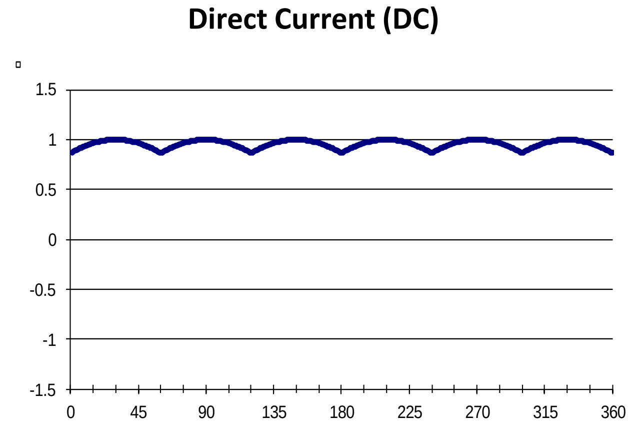
Electrode Line & Electrode



Converter - Converts ac ⟷ dc







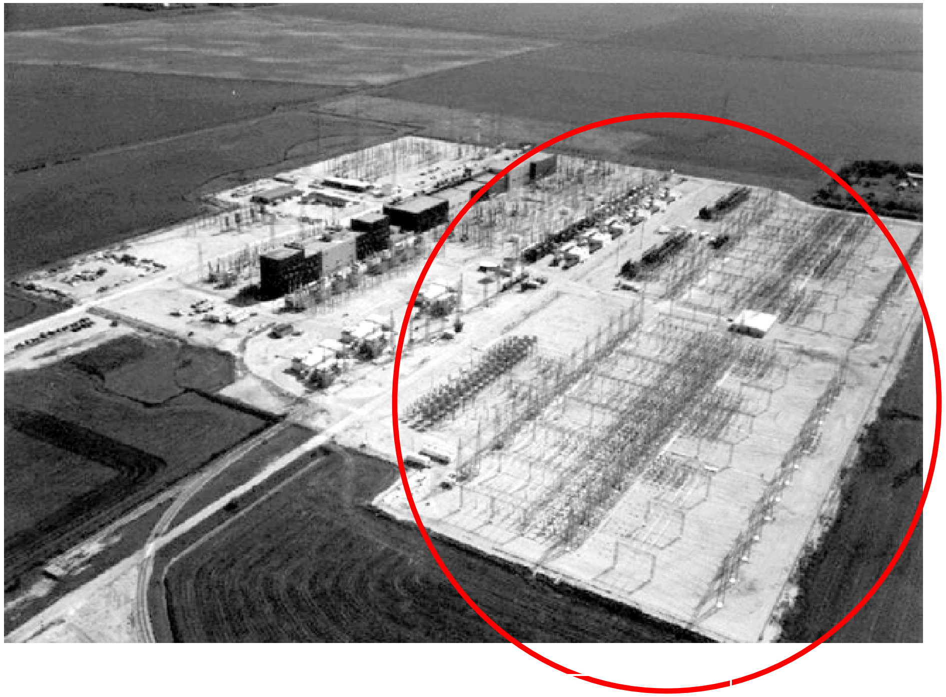
- Filters clean up the ripple further

*Source : HVdc – **Proven Technology for Power Exchange** by Siemens*

HVdc Converter Components

AC Switchyard

Station bus and circuit breakers that are used to terminate transmission lines from the ac transmission system/generating stations, the ac harmonic and high frequency filters, converter transformers etc.



Dorsey Converter Station

HVdc Converter Components

AC Harmonic and High Frequency Filters

- Removes the harmonic (multiples of 60 hertz) currents created by converter operation
- Supplies the reactor power consumed by the converter.

Radisson AC Filters

HVdc Converter Components

Converter Transformer

- Interface between the ac system and the thyristor valves.
- Specialized transformer that must be designed to withstand dc voltage stresses & ac harmonics
- Contains Oil for insulating and cooling

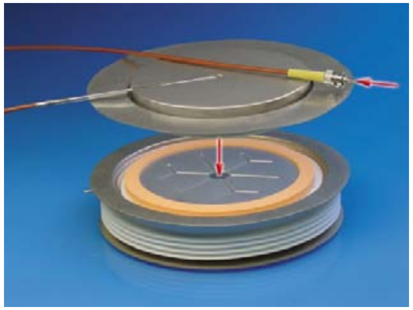
BPII Converter Transformers

HVdc Converter Components

Converter Valves

- Provides transformation from ac to dc (or dc to ac)
- Most LCC converters are 12 pulse bridges – 12 valves each containing many series connected thyristors to achieve the dc rating of the scheme.
- <u>Designed for each project</u>
- Valves are normally contained in a special purpose building called a valve hall.

BP I Valves



BP II Valves

HVdc Converter Technology

Converters LCC or VSC

- Line Commutated Converter (LCC) –
  - like BPI & II
  - known technology - lot of experience
- Voltage Source Converter (VSC)
  - New technology with many appealing benefits
  - Suitable for weak AC systems like MH's
  - Control of active and reactive power
  - Black-Start Capability
  - Synchronous Condensers not Required at Riel
  - However new technology – new challenges
    - eg. DC line fault clearing
- Decision after tenders received

HVdc Converter Components cont ..

DC Smoothing Reactor

- Reduces the dc current ripple caused by the conversion process on the dc line.
- Limits the line fault currents
- Protects the thyristor valve from lightning hits on the dc line.

BPII Smoothing Reactors

HVdc Converter Components cont ..

DC filters

- Eliminates ac harmonic currents on the dc line, which can cause interference with adjacent telecommunication systems

Dorsey DC Filters

HVdc Converter Components cont ..

Synchronous Condensers

- Provides reactive power to the HVdc converters
- Provides inertia (flywheel) to maintain acceptable system frequency
- Provides voltage control at the ac/dc interface.

Dorsey Synchronous Condensers

HVdc Line Design

Design Loads

- Three types of loads considered:
  - Reliability loads based on weather data
  - Security loads – Anti cascading towers at about 5km intervals
  - Safety loads – for construction and maintenance work
- Reliability level of 150 yr Return Period for weather loads selected

- Two main weather load zones established based on analysis of the weather data:

Loading	Southern Zone	Northern Zone
Design Wind Speed	107 km/h	93 km/h
Design Ice Thickness	33 mm	25 mm

- Different combinations of wind and ice loads considered

HVdc Line Design

Conductor

- To carry the required current (2000A), minimize losses minimize flashovers and minimize EMF effects
  - Minimum conductor diameter: 37 mm
  - 3-Bundle Configuration
  - Thermal ampacity of 4500A

- Optimization based on
  - sag and clearance
  - conductor cost
  - tower cost
  - tower design

HVdc Line Design

Towers – Two Types

- South zone - Self supporting 4-legged towers
  - Reduce impact on farming practices
  - More expensive
- Northern zone Guyed towers
  - Better suited for difficult soil conditions
  - Less Expensive

Family of Towers

- Tangent tower for straight line sections
- Angle towers for where the route takes turns
  - based on analysis of the preferred route

HVdc Line Design

Reliability Level

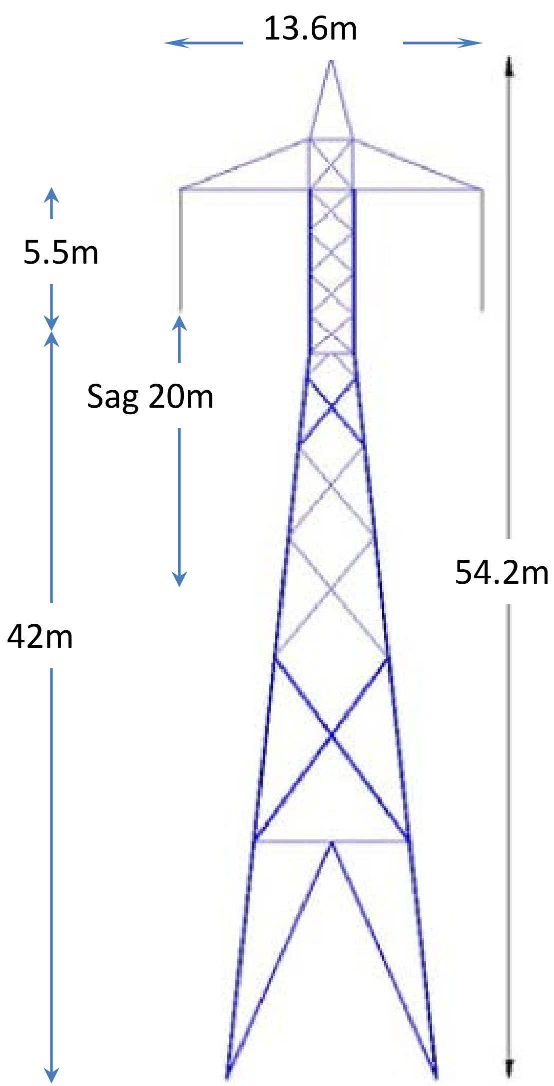
- Reliability level of 150-yr Return Period for climatic weather

- This reliability level is recommended for all overhead lines above 230 kV voltage level

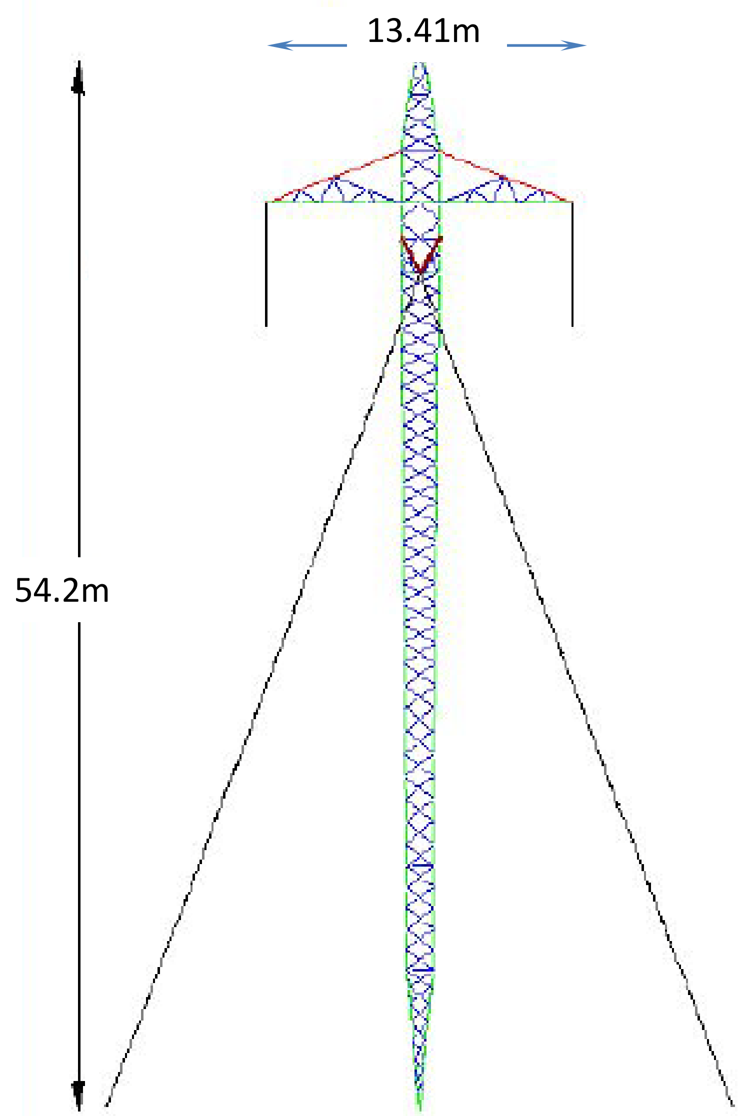
- Reliability level of 500-yr return period:
  - Sections of the Bipole III within 50 km from the Bipole I & II

  - Amounts to a total of approx. 340 km.

Typical HVdc Tower

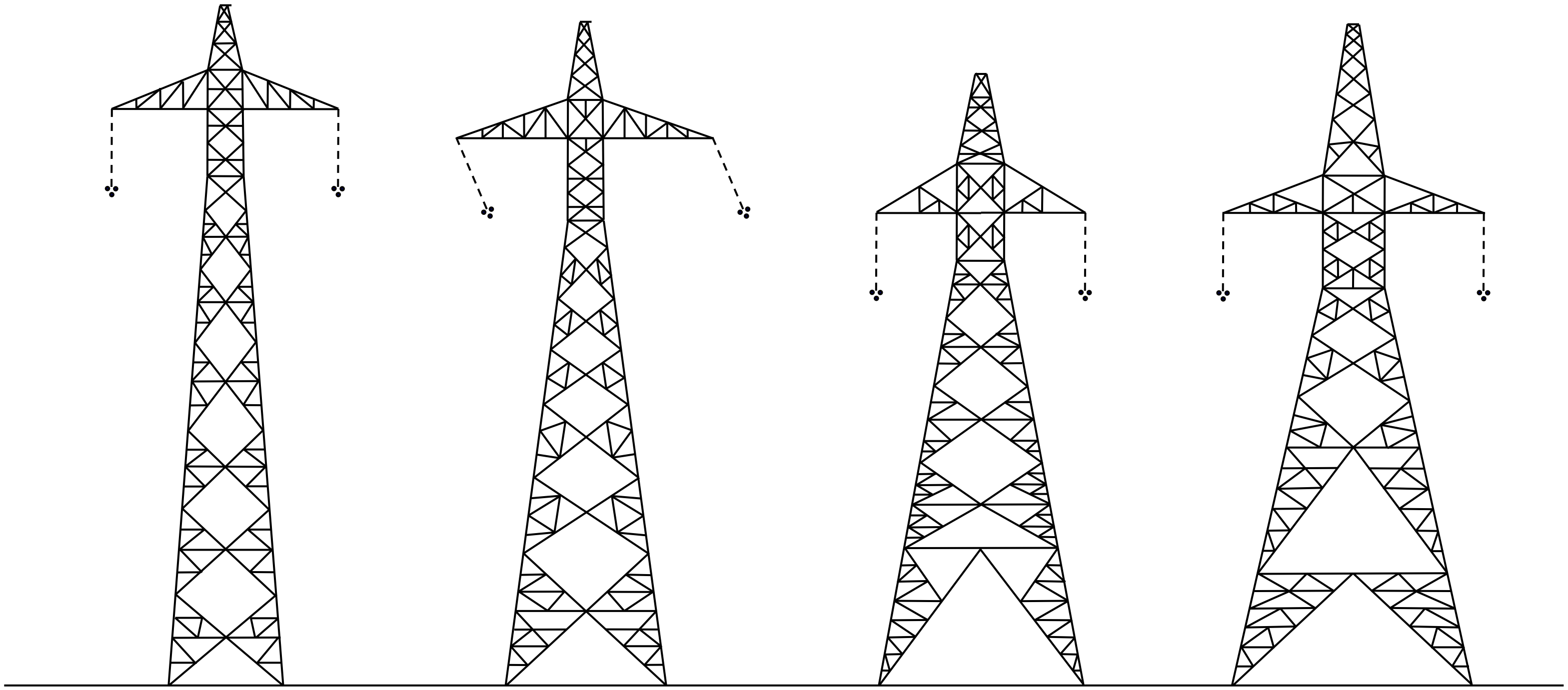


Typical Self
Supporting
Tower Footing
7.85m x 7.85m
approx 64m^2



Towers:

- Family of Self Supporting Towers



0°-2° TANGENT
SUSPENSION TOWER
A-540
Height: 41 – 56 m

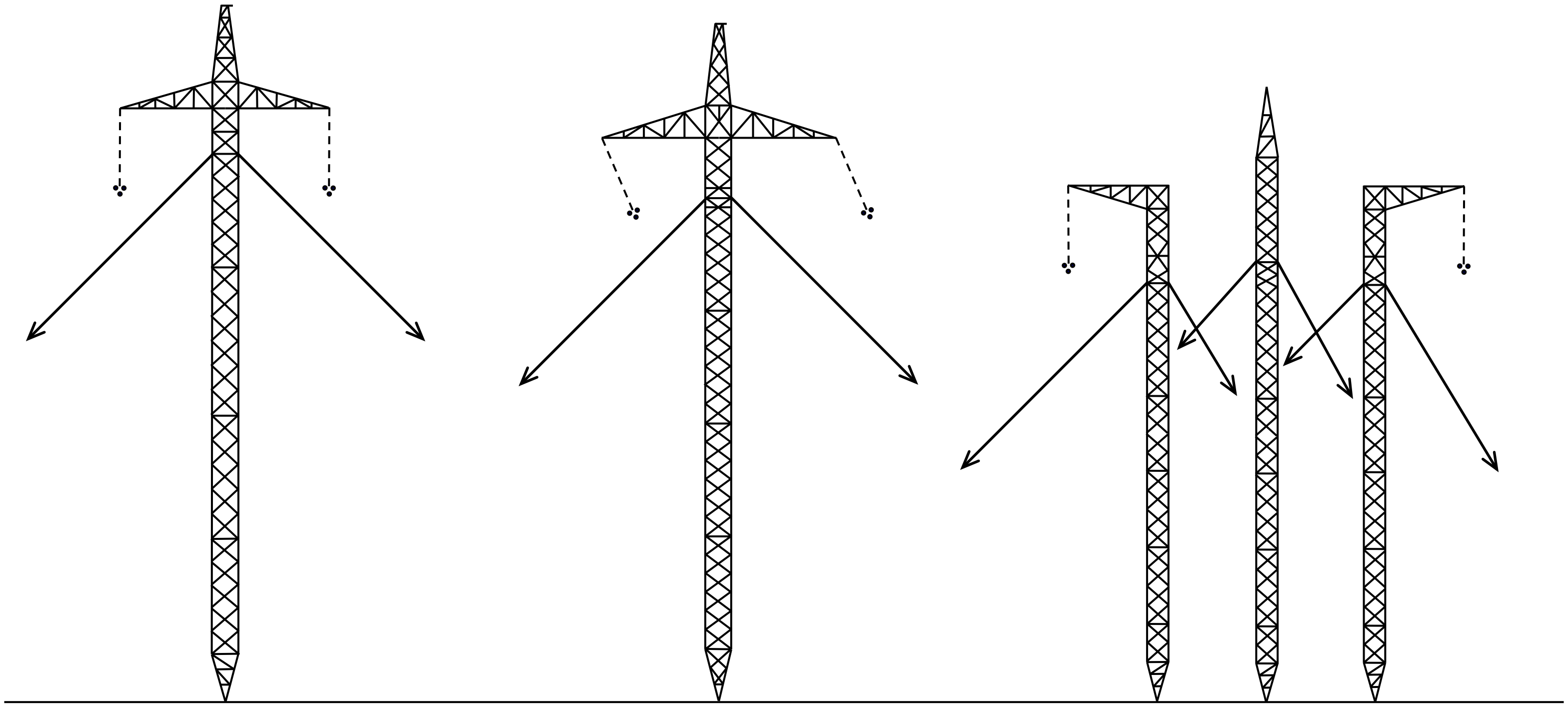
2°-7° LIGHT ANGLE
SUSPENSION TOWER
B-540
Height: 43 – 55 m

7°-25° MEDIUM ANGLE
DEAD-END TOWER
C-540
Height: 40 – 49 m

25°-92° HEAVY ANGLE
DEAD-END TOWER
D-540
Height: 44 – 53 m

Towers:

- Family of Guyed Towers



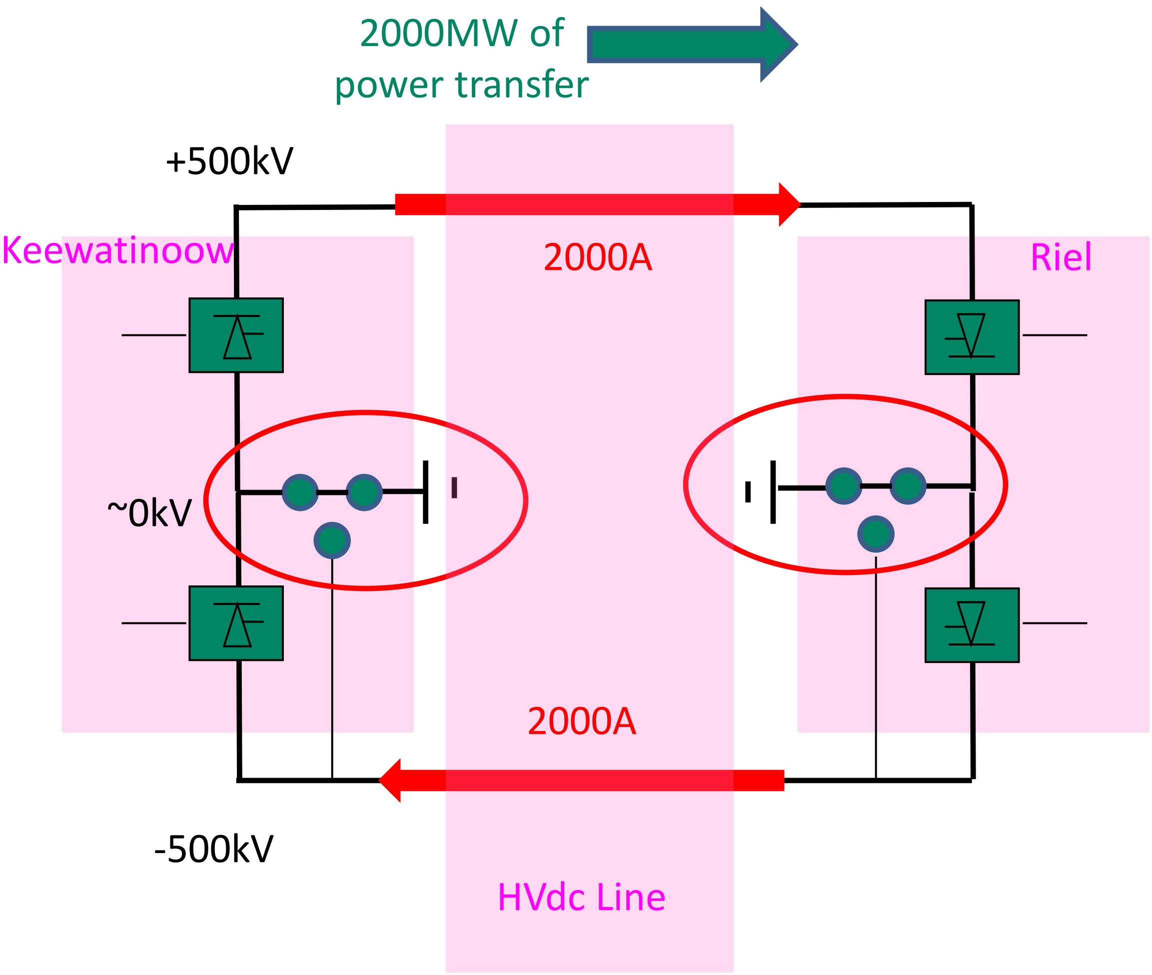
0°-2° TANGENT
SUSPENSION TOWER
A-530
Height: 41 – 56 m

2°-7° LIGHT ANGLE
SUSPENSION TOWER
B-530
Height: 45 – 54 m

7°-60° HEAVY ANGLE
DEAD-END TOWER
C-530
Height: 40 – 49 m

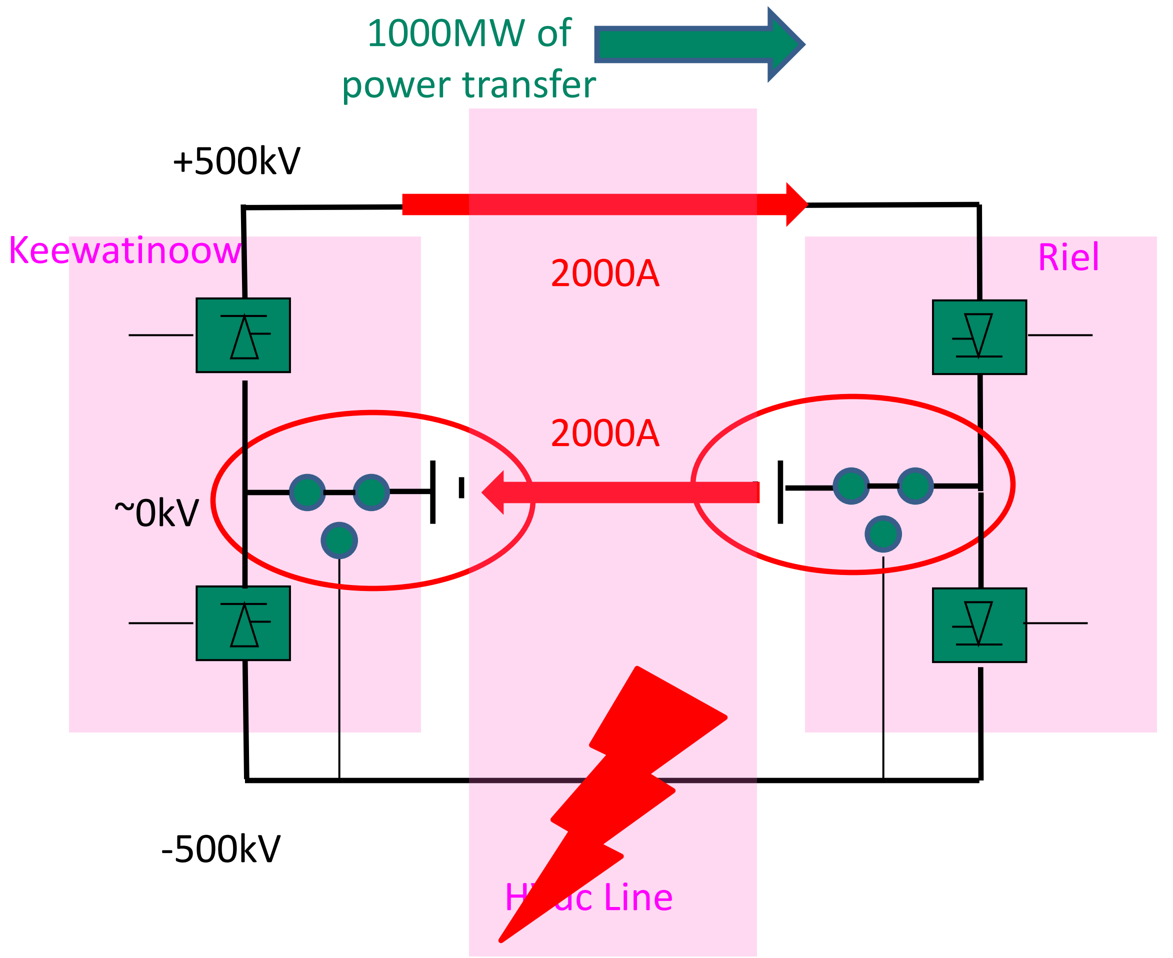
Ground Electrode

- Under normal operation
  - For defining the system voltage by providing a reference to earth
  - Insulation coordination
  - Over voltage protection
  - Carries very small unbalance current



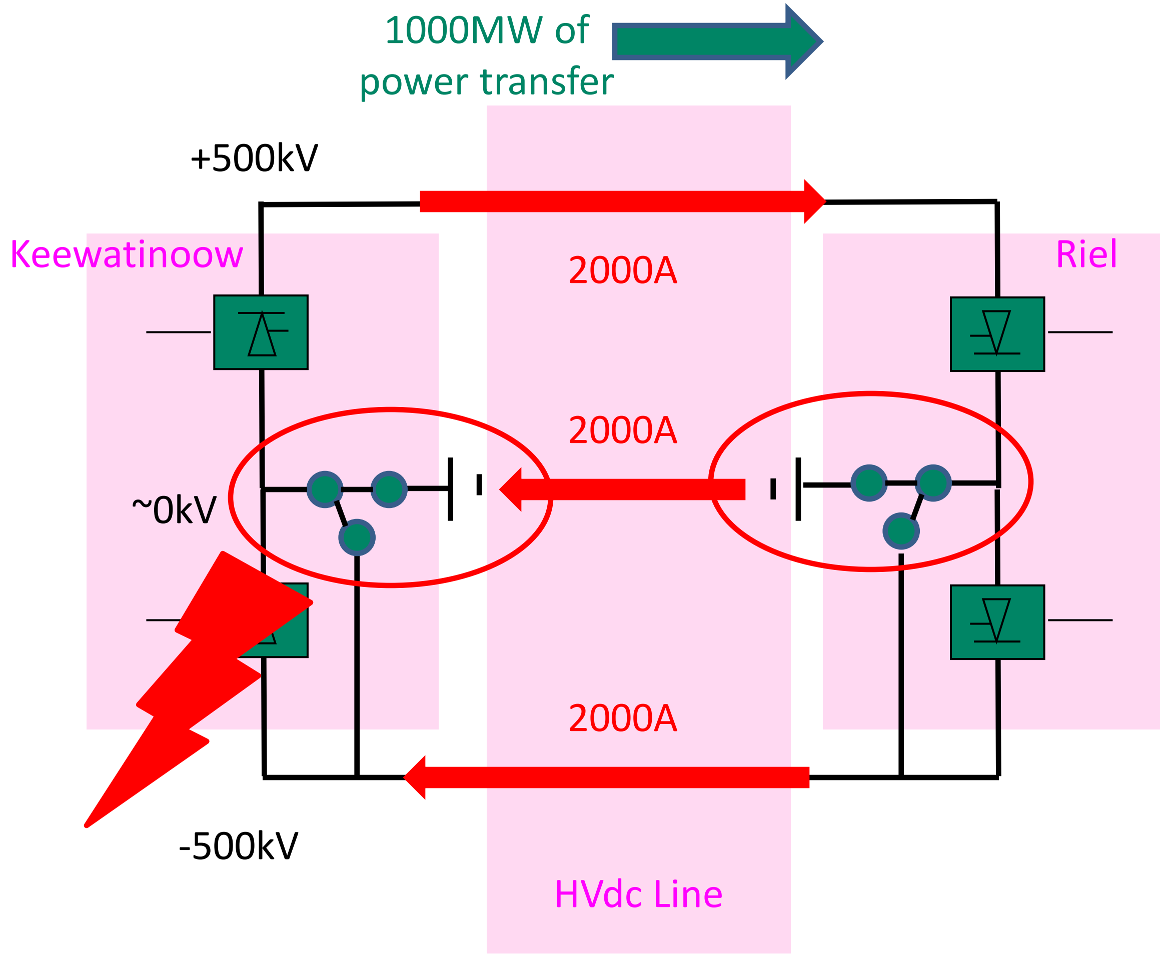
Ground Electrode

- During loss of a Pole Conductor
  - provides a temporary current return path for through the earth
  - monopolar operation



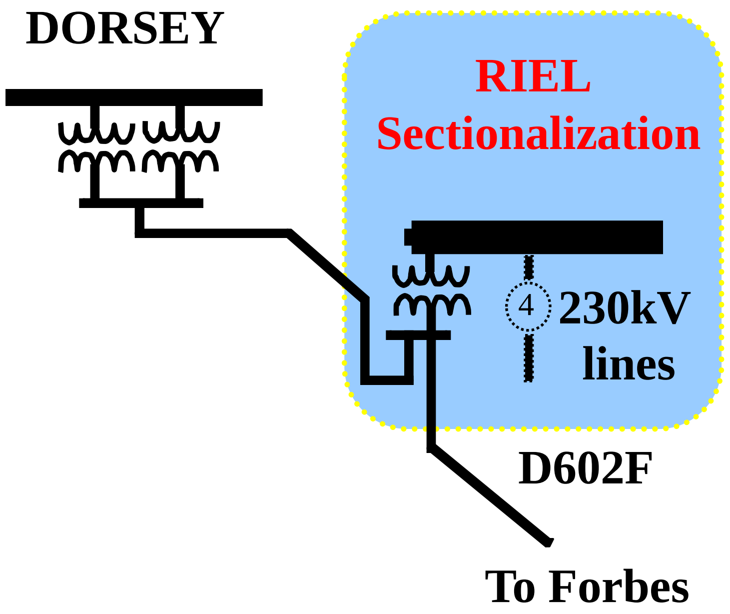
Ground Electrode

- During loss of a Converter Pole
  - provides a temporary current return path till metallic return is established.



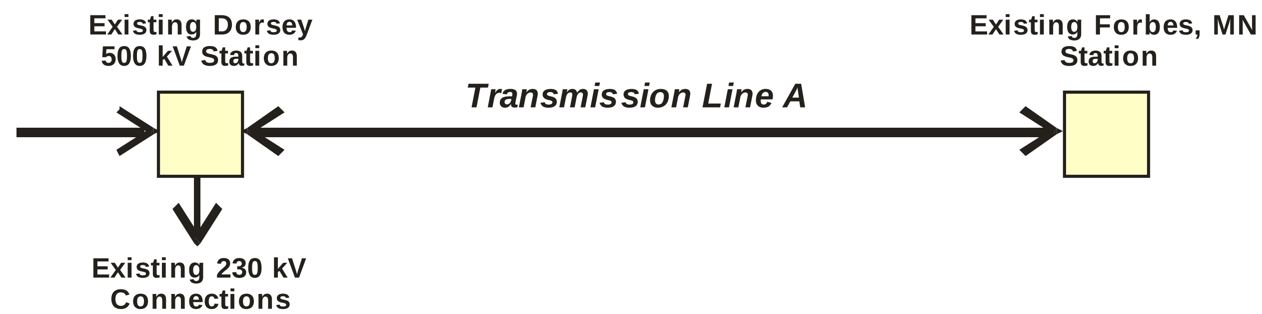
Riel Reliability Improvement Project

- A separate project
- Enhances reliability by securing the import capability
- Sectionalized 500kV
  - D602F
- Sectionalized 230kV
  - R32V, R33V



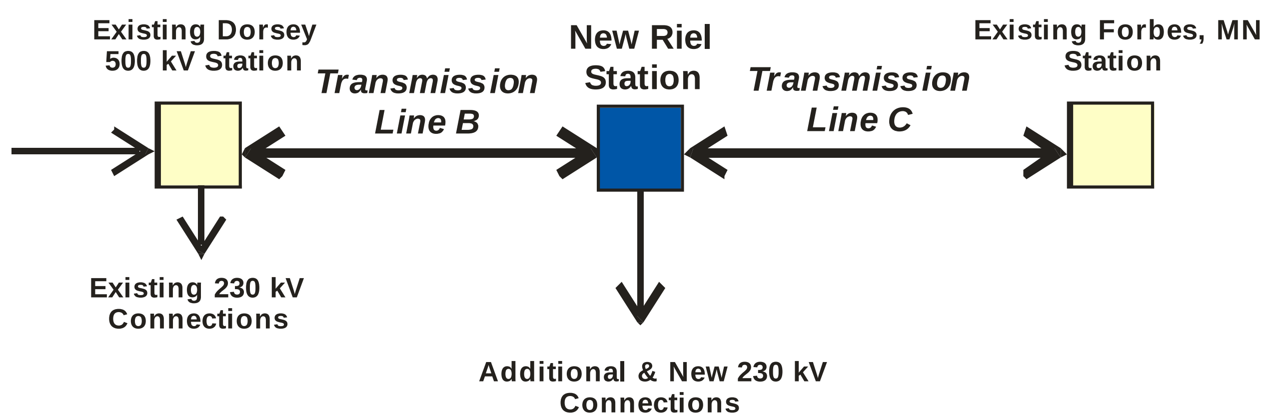
What is "Sectionalization"?

Before



One line (Transmission Line A) before the new station is constructed becomes two lines (Transmission Lines B & C) after the station is constructed.

After



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Conclusion

- Provided an overview of the Bipole III Project
- Defined the details of the HVdc transmission system
- Demonstrated the complexity of the HVdc converter stations
- Provided insight into why we need long lead times to restore the HVdc Bipoles I and II in the event of a catastrophic outage!!!!
- **Highlights the need for Bipole III**