



Second Euro-mediterranean **Rendez-vous on Energy**

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Why HVDC for the Mediterranean interconnections

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ALSTOM GRID

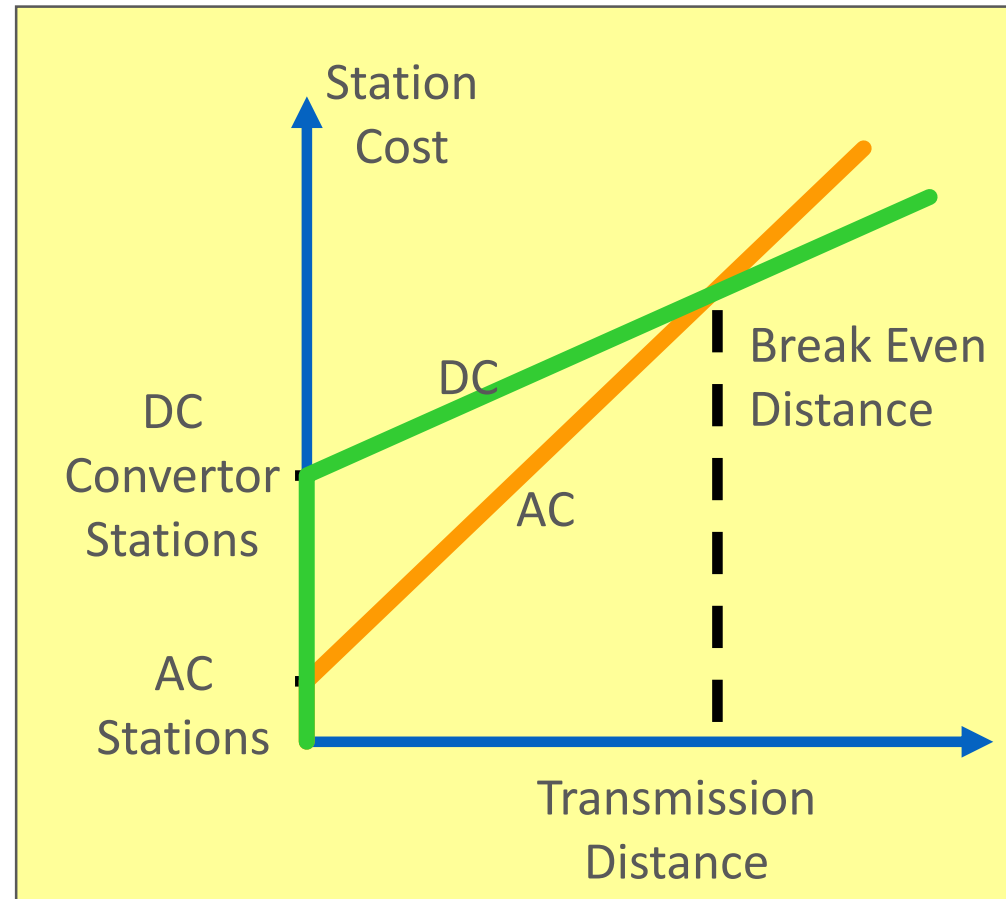


AGENDA

- WHY HVDC
- TWO TECHNOLOGIES
- CONFIGURATIONS
- HIDDEN BENEFITS
- CONCLUSION

WHY USE HVDC?

- Submarine links
 - >50km
- Frequency conversion
 - 50-60Hz
- When synchronism of AC connections is impossible
- Lower Losses
- Embedded within existing AC Networks
- City Infeed



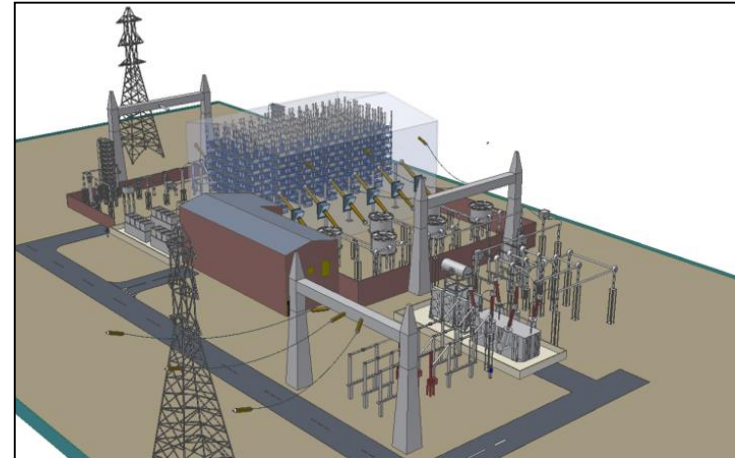
TWO HVDC TECHNOLOGIES

Line Commutated Converters LCC – HVDC/UHVDC



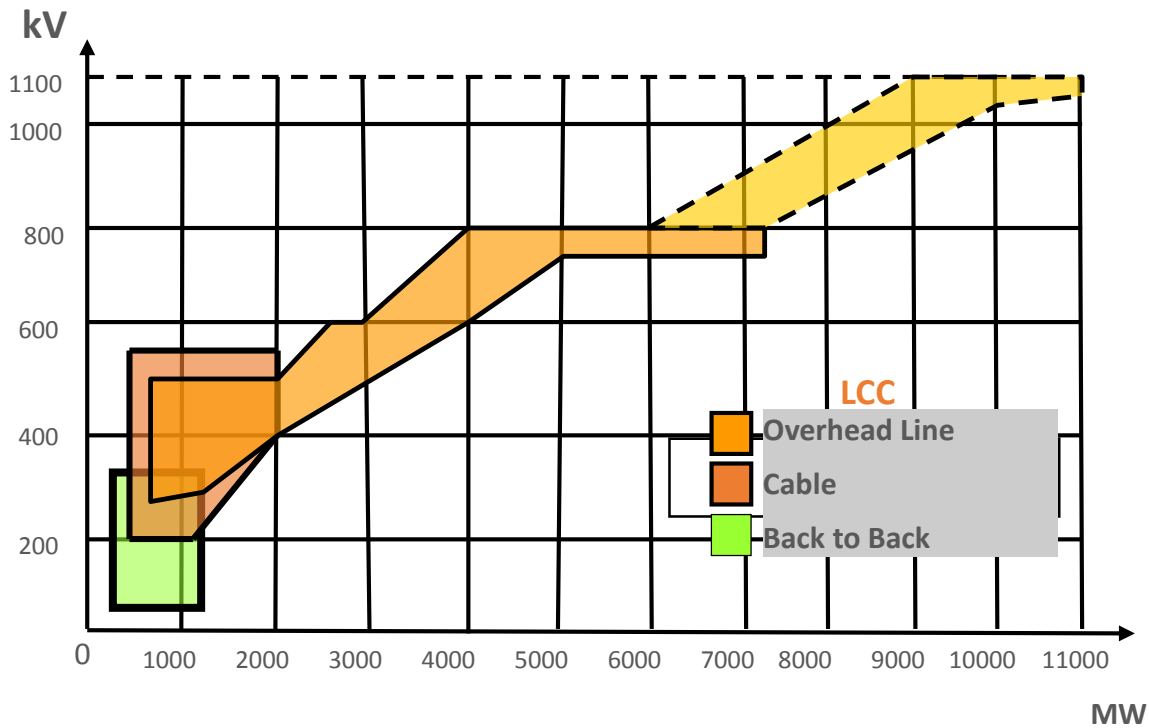
- More power transported (up to 10GW)
- Best for onshore transmission through Overhead Lines
- Bigger footprint (~3 times VSC)
- Lower losses < 0.8%

Voltage Source Converters VSC – HVDC

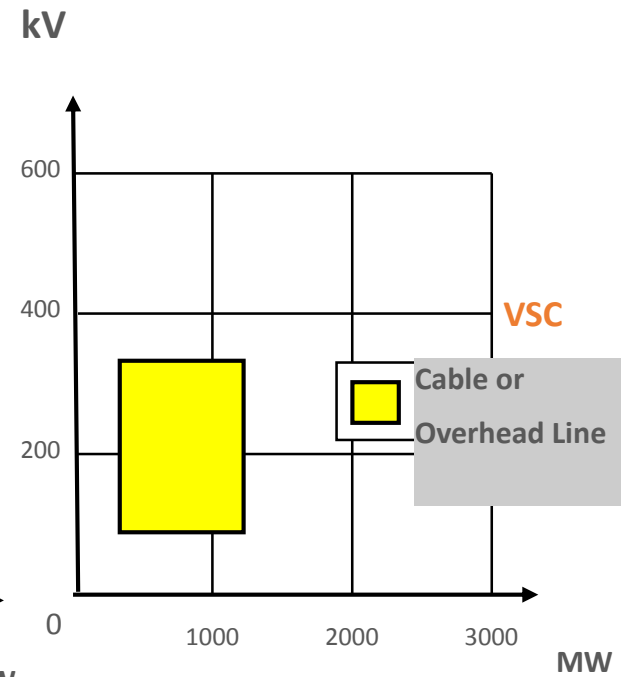


- Optimised for 1 GW today
- Multipoint for a “DC grid”
- Able to manage black-starts
- Good for weak AC systems
- Works with Cost effective cable systems

WHICH TECHNOLOGY: LCC OR VSC



Thyristor LCC HVDC

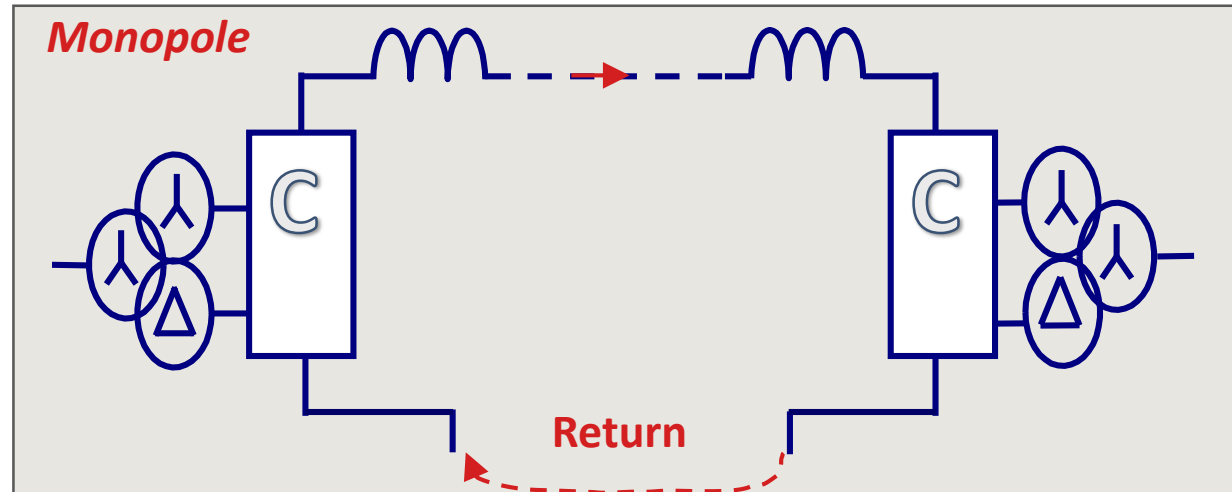


IGBT VSC HVDC

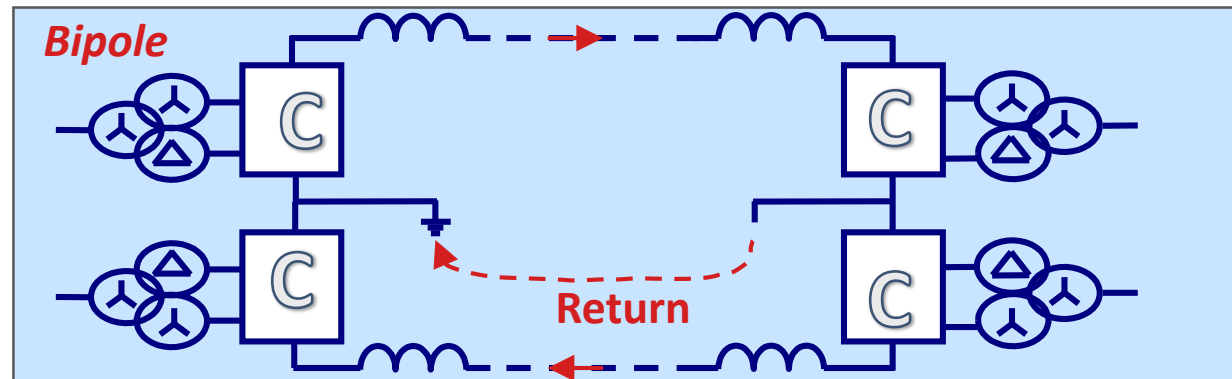
MONOPOLAR/BIPOLAR HVDC SYSTEMS

→ Equivalent to AC Single Circuit Line

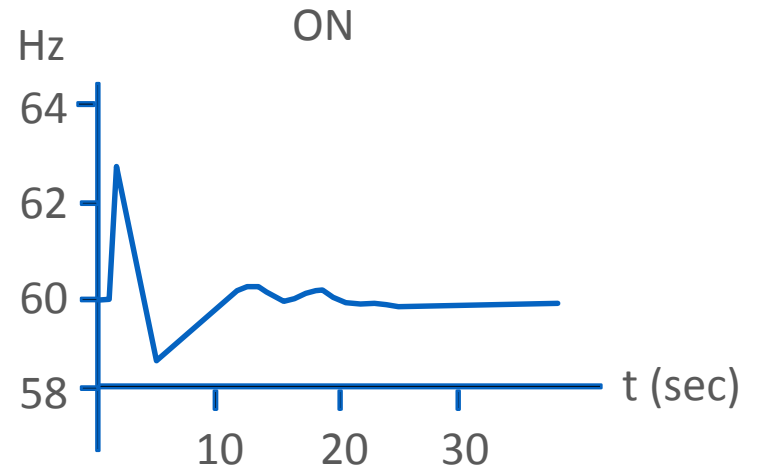
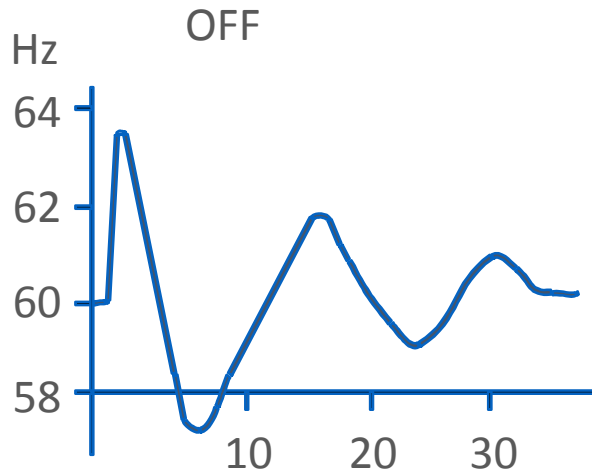
- Return can be :
- Metallic (Cable)
 - OR
 - Via Sea (Sea Electrode)



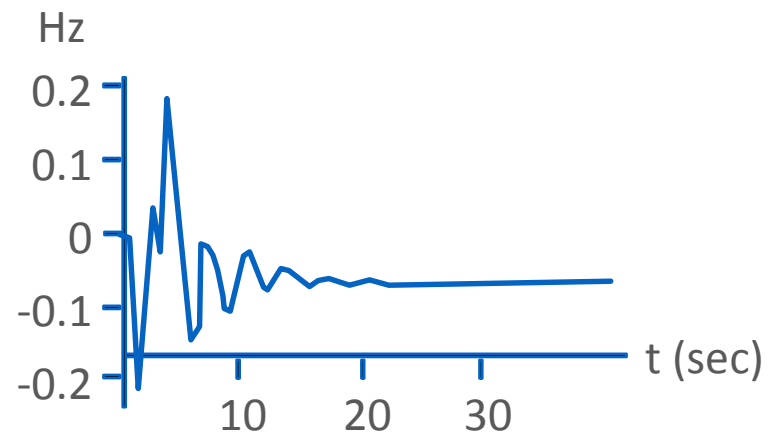
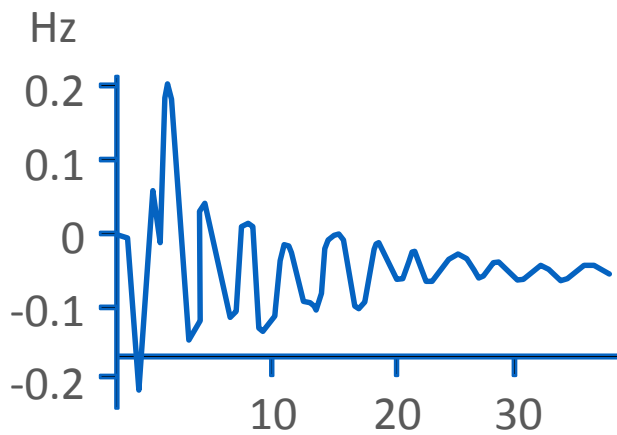
→ Equivalent to AC Double Circuit Line



HIDDEN BENEFITS

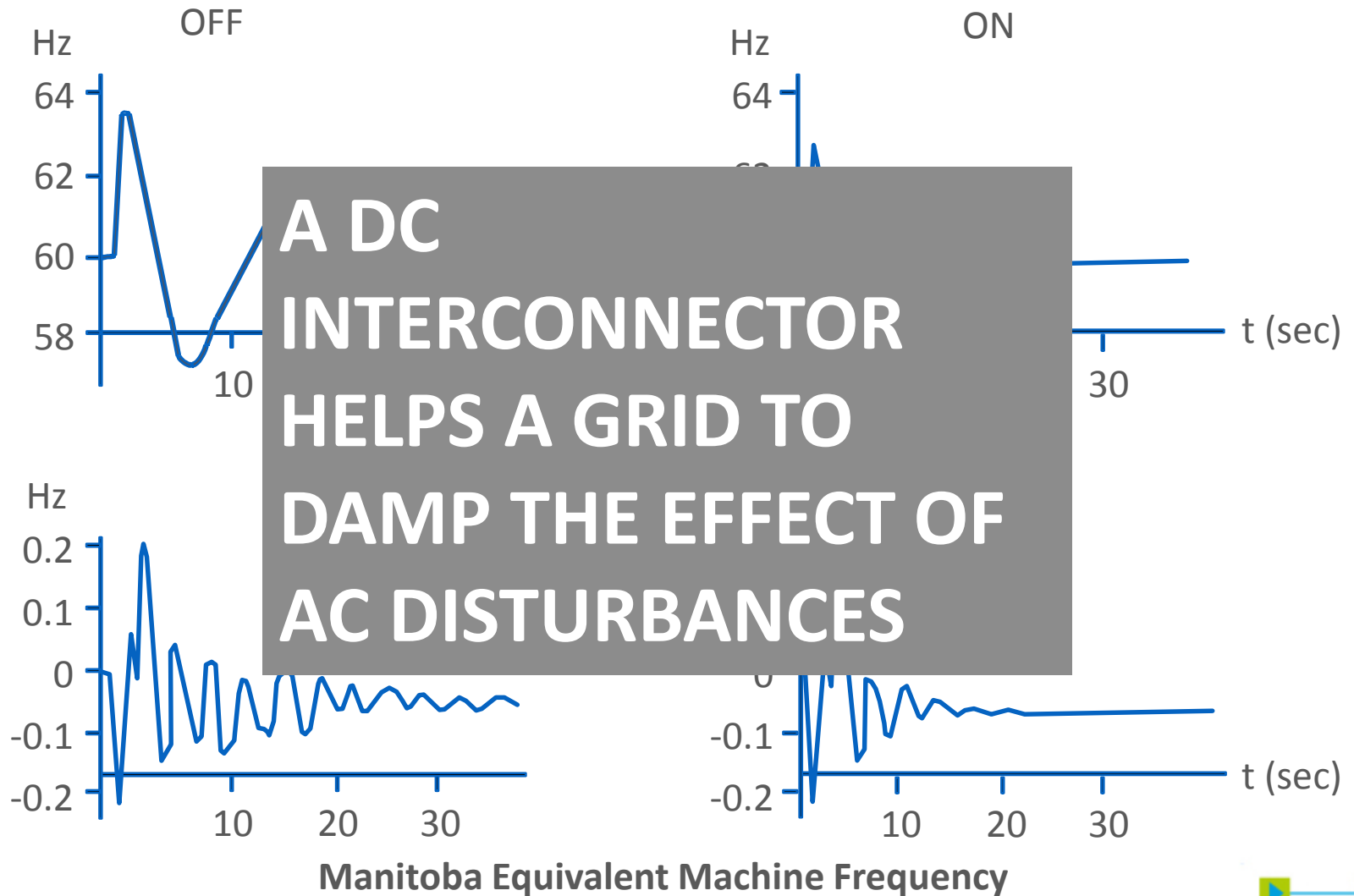


Kettle Generator Speed

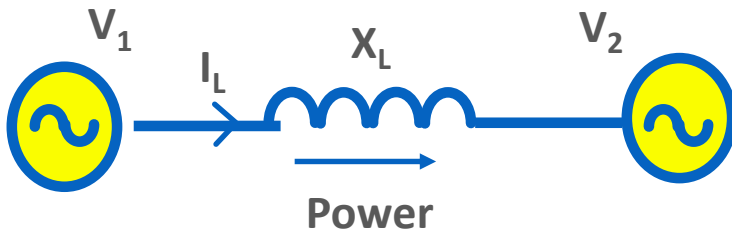


Manitoba Equivalent Machine Frequency

HIDDEN BENEFITS



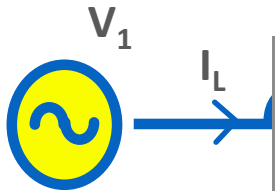
HIDDEN BENEFITS



$$\text{Power} = \frac{V_1 V_2}{X_L} \sin \delta$$

- V_1 Sending end voltage
- V_2 Receiving end voltage
- X_L Reactance of transmission network
- δ Angle between sending and receiving end voltages

HIDDEN BENEFITS



MORE POWER CAN BE TRANSMITTED IN AN AC INTERCONNECTOR WHEN THERE IS A DC INTERCONNECTION IN PARALLEL

Power =

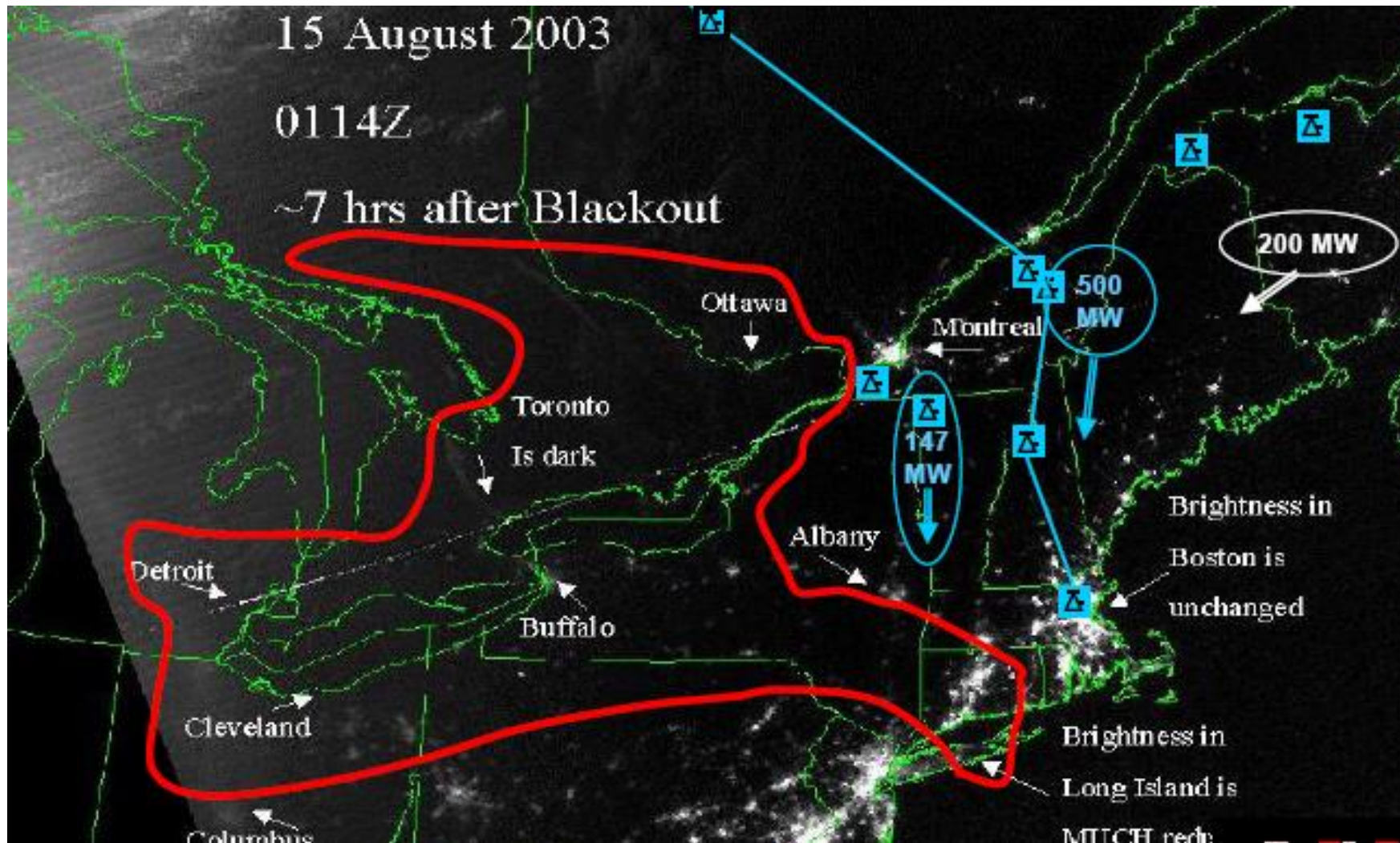
→ V_1 Sending end voltage

→ V_2 Receiving end voltage

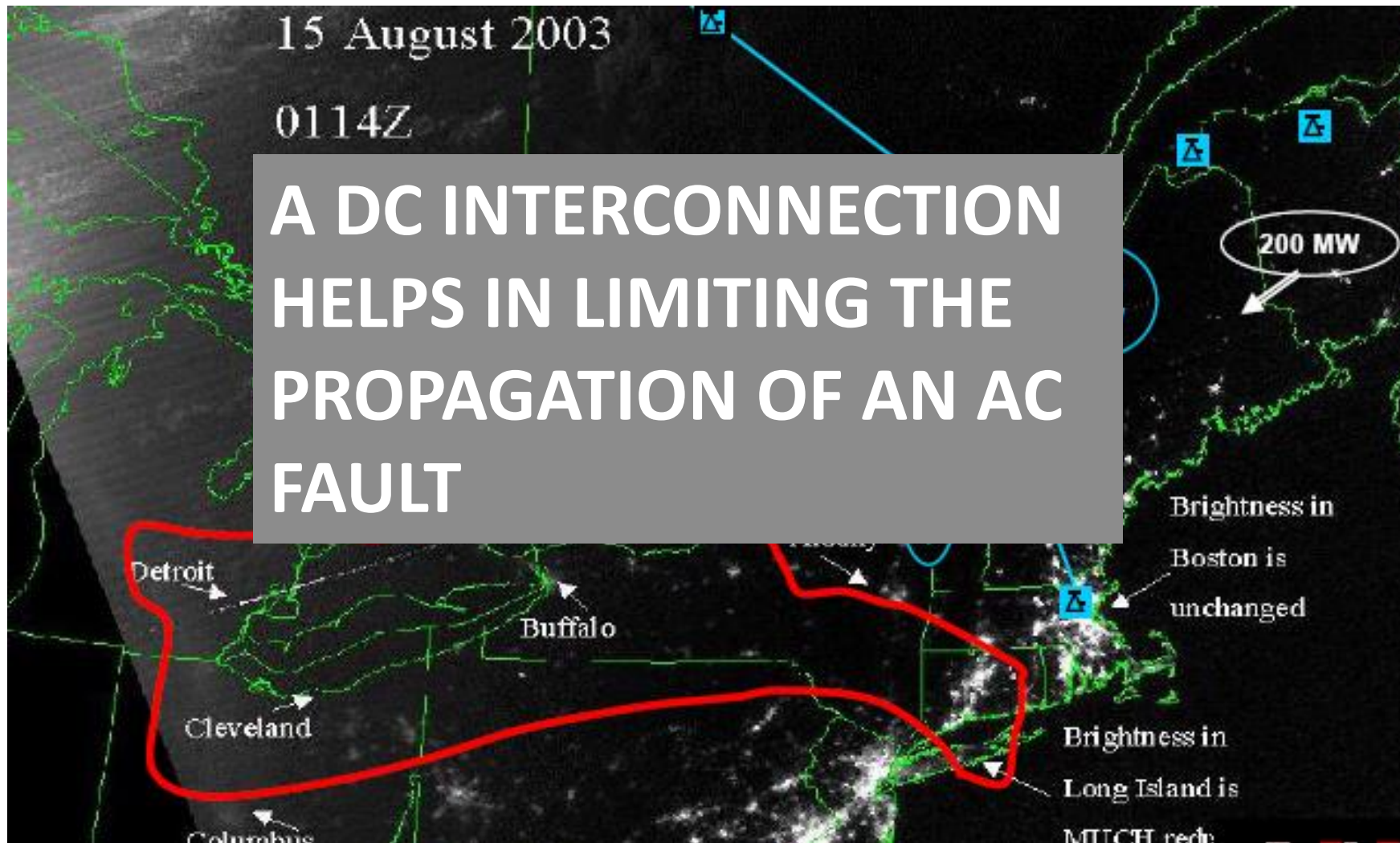
→ X_L Reactance of transmission network

→ δ Angle between sending and receiving end voltages

HIDDEN BENEFITS : SURVIVING A BLACK OUT



HIDDEN BENEFITS : SURVIVING A BLACK OUT



CONCLUSION

- HVDC is the right technology for MEDGRID Interconnectors
- The Technology is here, available & established
- Apart from helping with Security & other Economic Advantages, HVDC supports the existing AC Networks

WE ARE READY