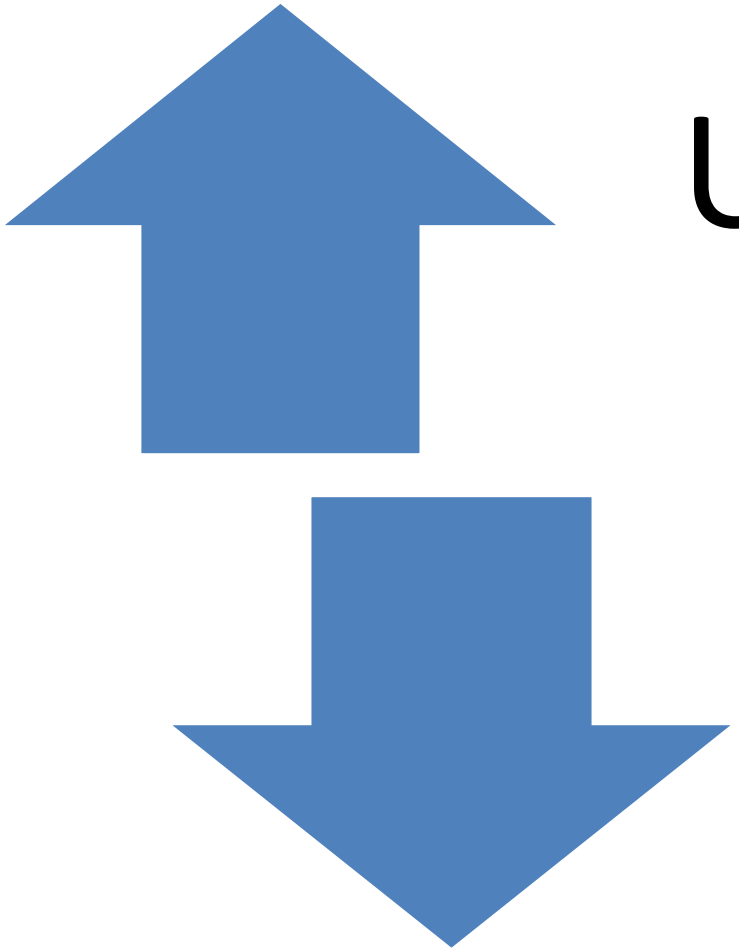
Investigations into the Upgrading of Existing Transmission Lines from

HVAC to HVDC

A Smart Grid Solution

$$SIL = U^2 / Zc$$



U x U

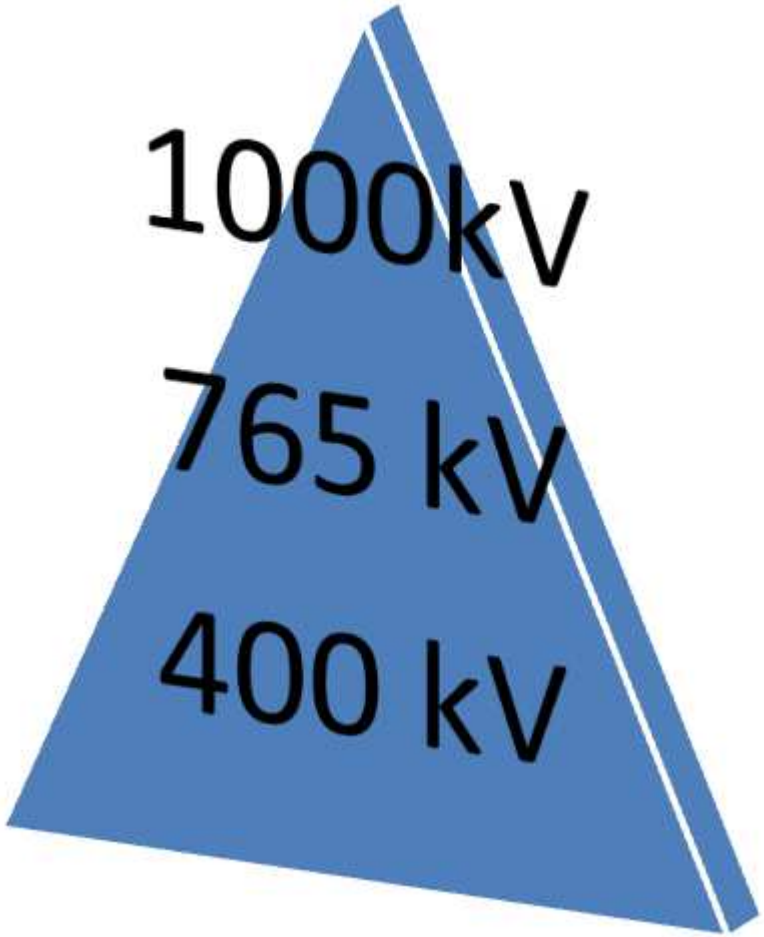
Zc

Engineering Choice

Zc
- FACTS
- Hingorani

Zc
- Understood
- Theory

Zc
- Understood
- Application



Innocent Action = Expensive Result

Unused Power Transfer Gap Increases

Unused Gap = CCCC - SIL

Survey of Lines In Service

400 kV

SIL = 670 MVA **CCCC = 1796 MVA**

Unused Gap = 1,1 GVA

765 kV

SIL = 2364 **CCCC = 5152 MVA**

Unused Gap = 2,5 GVA

DC to AC to DC

- 1882 Thomas Edison Pearl Street Substation
  - DC Technology

- 1884 Power Transformer - Transmit at a different voltage than generated
  - AC Technology

- 21 st Century Smart Grids
- Energy Efficiency/Energy Conservation/Energy Savings
  - DC Technology for Bulk Power Transfers

Another Smart Grid Application

UPGRADE EXISTING TRANSMISSION

HVAC TO HVDC

Case Study 1 : 400 kV AC to 300 – 500 kV DC 600 MW up to 3 GW

AC Audible Noise

L50 wet 53,1 dBA

L50 Fair 20,2 dBA

Radio Noise @ 500 kHz

L50 wet 72 dBA

L50 fair 42,5 dBA

Electric Field = 1,5 kV/m edge of servitude

DC Audible Noise

L50 wet 32,1 dBA

L50 Fair 38,1 dBA

Radio Noise @ 500 kHz

L50 wet 28,5 dBA

L50 fair 41,5 dBA

Electric Field = 3,5 kV/m edge of servitude

Case Study 1 : 765 kV AC to 800 kV DC 2,5 GW to 5 GW

AC Audible Noise	
L50 wet	54,7 dBA
L50 Fair	29,7 dBA

DC Audible Noise	
L50 wet	36,4 dBA
L50 Fair	42,4 dBA

Radio Noise @ 500 kHz	
L50 wet	61,8 dBA
L50 fair	44,8 dBA

Radio Noise @ 500 kHz	
L50 wet	29,1 dBA
L50 fair	42,1 dBA

Electric Field = 2,0 kV/m
edge of servitude

Electric Field = 4,7 kV/m
edge of servitude

DC TECHNOLOGY

- ✓ Higher Power Transfers
- ✓ Lower Power Losses
- ✓ Enhanced Power System Control and Operations
- ✓ Electrical Barrier to Cascade Tripping in Complex AC networks
- ✓ Existing assets recycled for smart grid and super grid development