What technology steps are needed for intercontinental energy exchange?

Dr. Marc Jeroense

MJ MarCable Consulting AB

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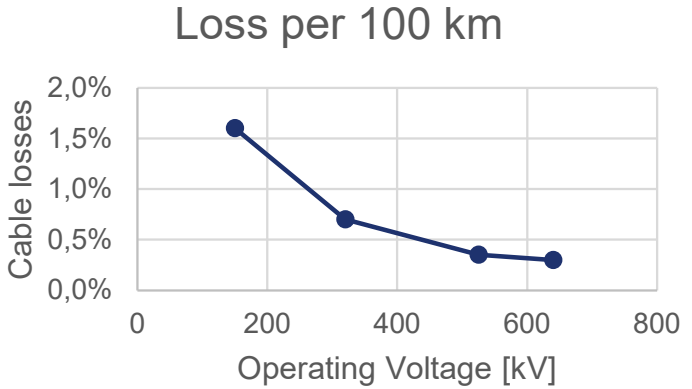
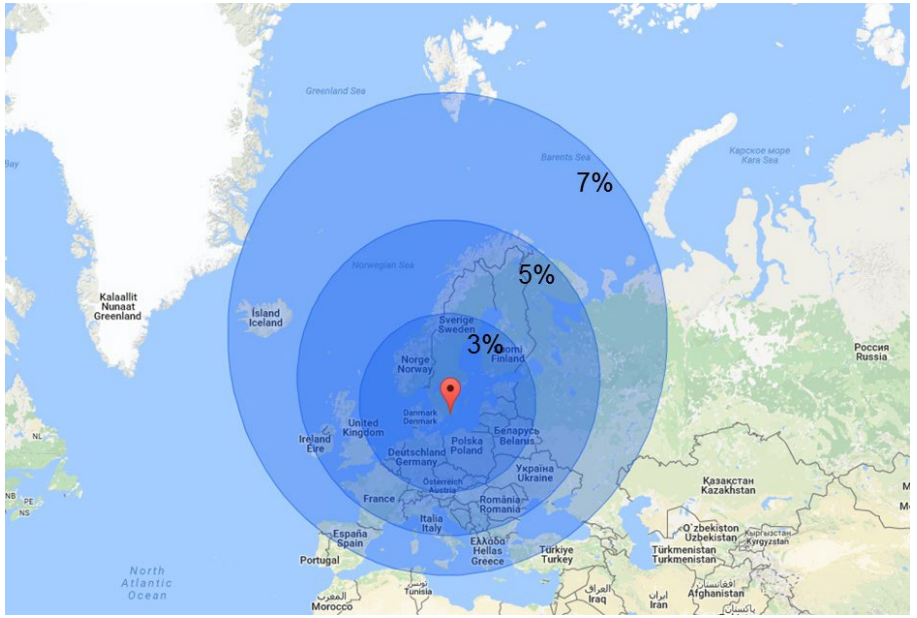
What technology steps are needed for intercontinental energy exchange?

- Distance and power
- UG and submarine
- More complex system layouts
- Availability

Distance and Power

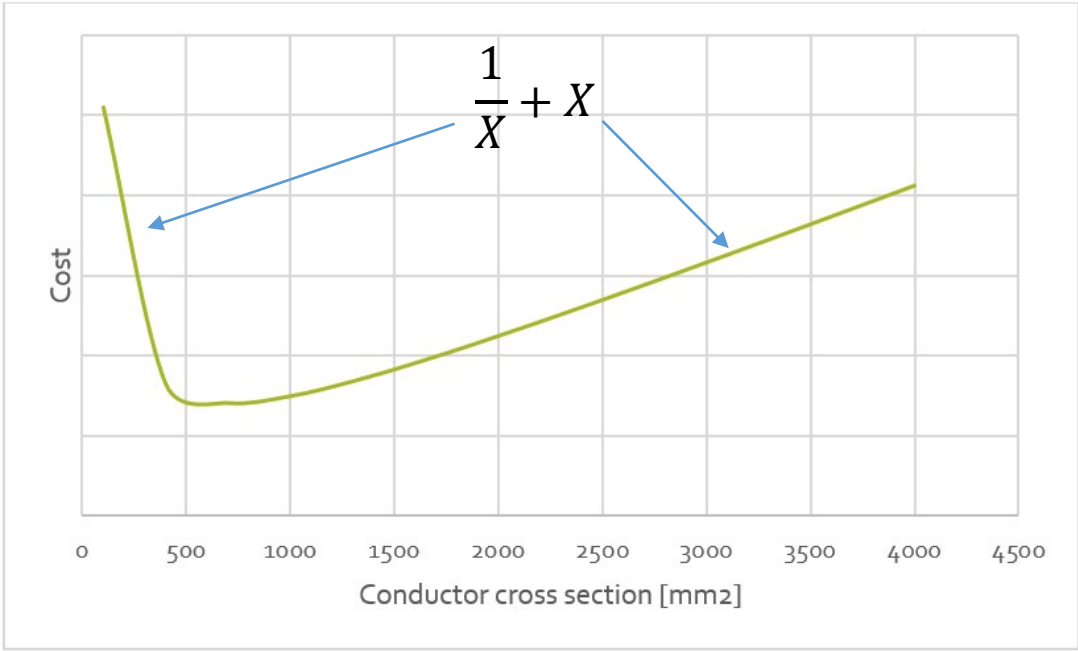
- Double the power
  - Double voltage (keep losses)
  - Double current
    - 4-fold increase losses with same cable
    - lower with ”larger” cable
- Reliability, redundancy
- Is there another way?





Loss evaluation leads to larger conductors

- Increased CAPEX lagre conductors
- Increased OPEX smaller conductors
- Optimum at larger cross sections
  - Cable operates at less than maximum temperature

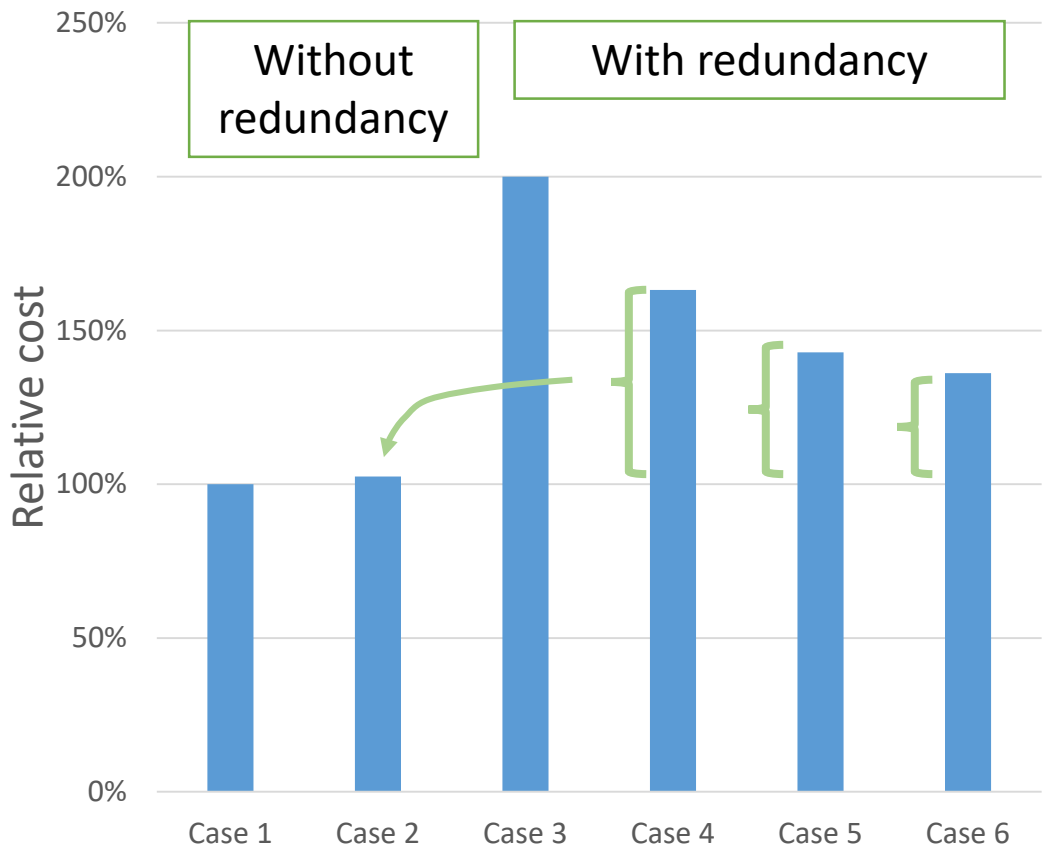


What is the price of redundancy?

- Case 1 – 1 system, 320 kV, 800 MW
  - 1240 mm² Alu
- Case 2 – 1 system, 640 kV, 1600 MW
  - 1290 mm² Alu
- Case 3 – 2 systems, 320 kV, 2x800 MW
  - 2x1240 mm² Alu
- Case 4 – 2 systems, 320 kV, 2x800 MW (loss optimized, capable of 2x1400 MW)
  - 2x3300 mm² Alu
- Case 5 – 2 systems, 450 kV, 2x800 MW (loss optimized, capable of 2x1500 MW)
  - 2x2000 mm² Alu
- Case 6 – 2 systems, 525 kV, 2x800 MW (loss optimized, capable of 2x1550 MW)
  - 2x1700 mm² Alu

Cost estimate includes cable + installation + loss

OBS: example with certain assumptions (environment, route length, transit distance, ….)



“Distance and Power – What is needed?”

Before we jump to the next voltage level – we need experience of todays developed levels

System redundancy is an option; this will put pressure on manufacuring capacity

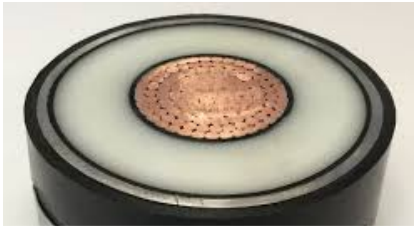
Only then to higher voltages with material characterics: Homogeneity and Low Loss

UG and submarine

Manufacturing capability

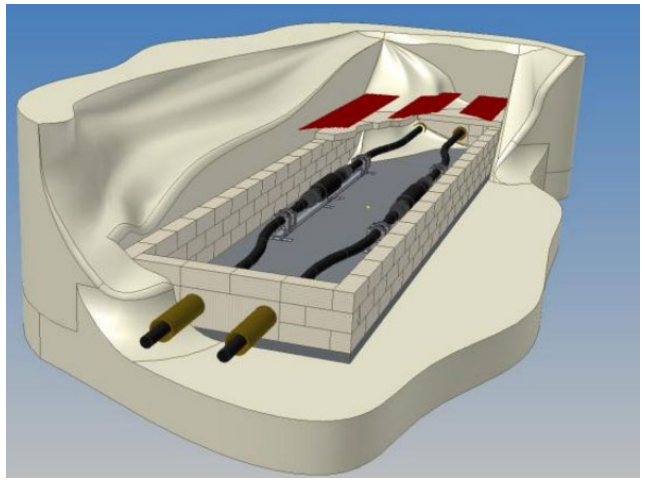
- Different technologies – main categories: lapped and extruded
- World-wide capacity of lapped is less than world-wide capacity of extruded

- On the long run – Will the ***main*** future of DC cables be written ”extruded”?



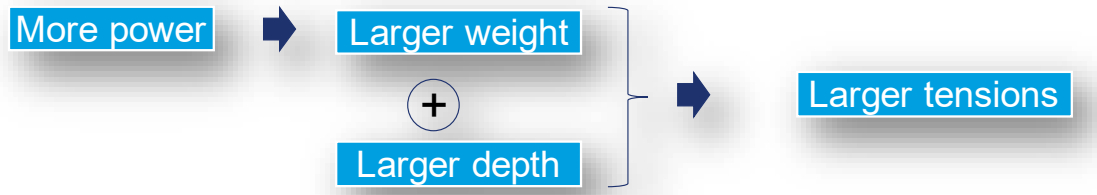
Joint

- Jointing time at land and sea is a cost factor
- Number of joints in large UG projects gets high



Deep sea

- Weight
- Water pressure
- Installation forces/pressures
- Joint design
- Aluminium / Copper / Lead / …
- Steel and/or polymer strength elements



“UG and submarine – What is needed?”

We will probably see an increase in **extruded** DC technology (capacity constraints)

Quick and reliable jointing technique will be needed

An increase in high-tech HVDC joint manufacturing capacity

Deep sea solutions – design and installation

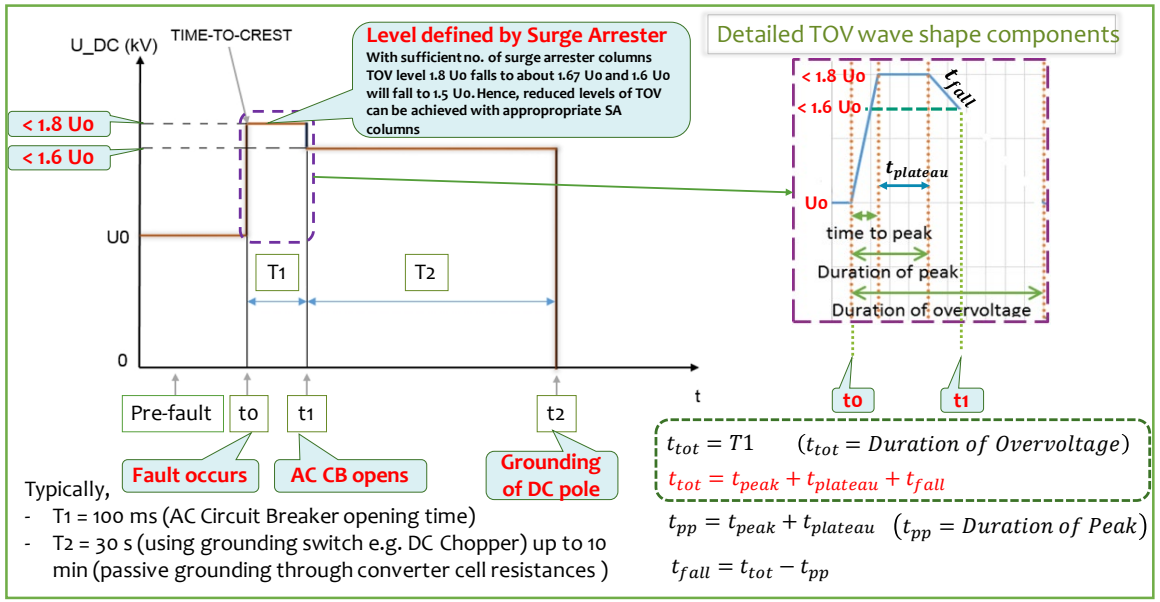
More complex systems layouts

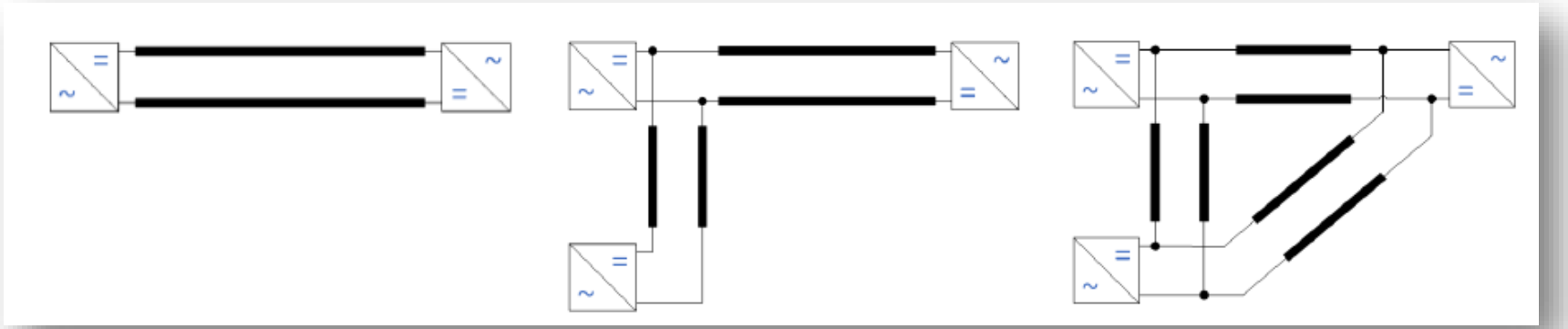
Beyond SI and LI

When evaluating future systems, point-to-point, radial and meshed:

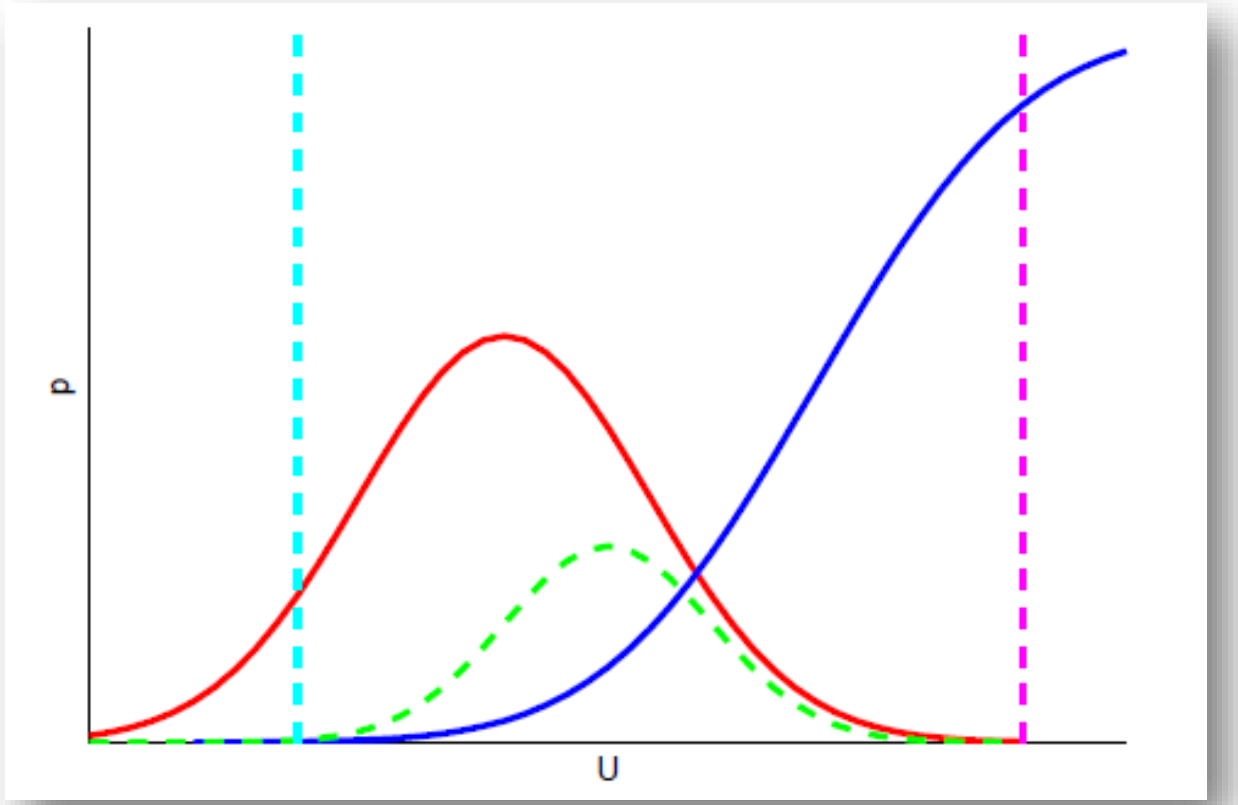
The standard SI and LI wave shapes and levels might not cover reality anymore

Symmetric monopole example





Deterministic vs probabilistic approach



Probability density of overvoltage

Breakdown probability of insulation

Risk of failure

“More complex system layouts – What is needed?”

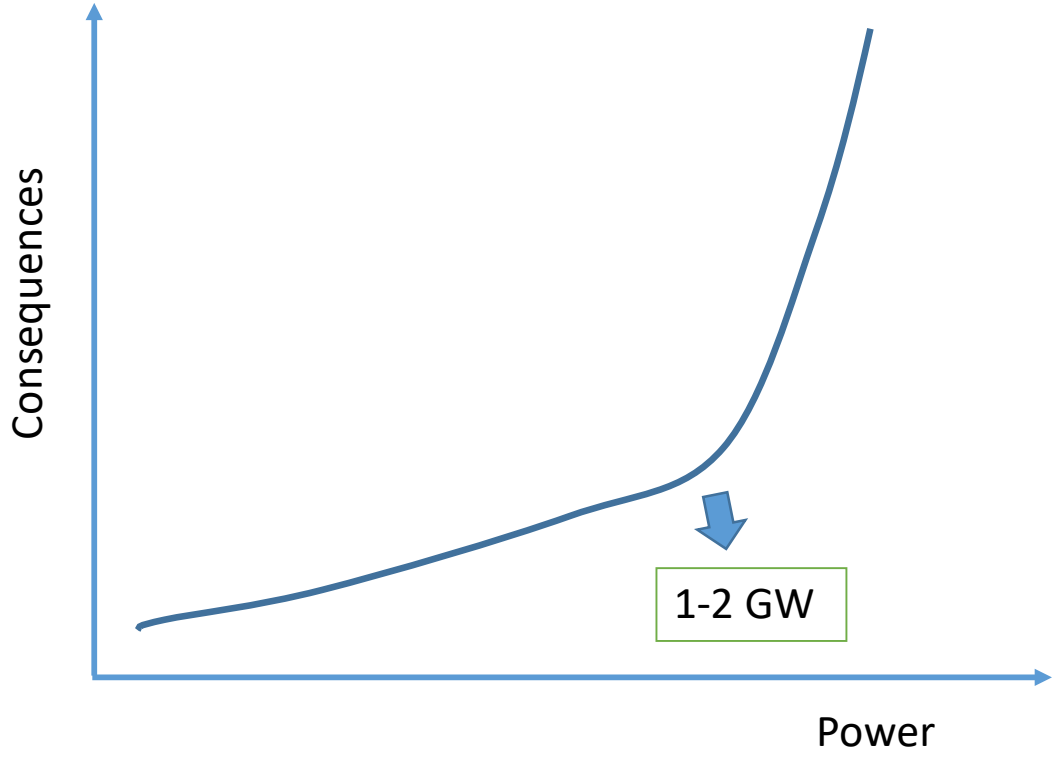
System studies showing the standardized wave shapes and levels the cable system will ”see”

For point-to-point systems, radial and meshed systems

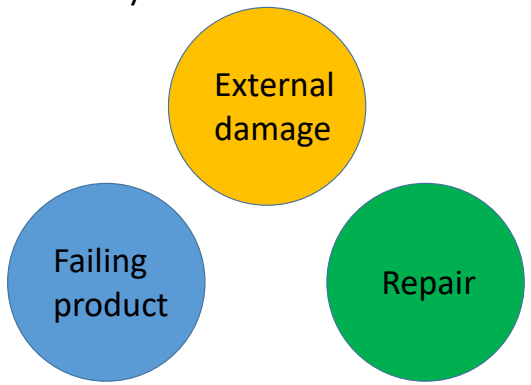
Study the probabilistic approach to determine design values for protection and withstand capability

Availability

Availability needs responsible actions



"The end customer is interested in availability, not in reliability"



“Availability – What is needed?”

Higher level of QA and QC, early implemented at the launch of new technologies and products

Early involvement of CIGRE

Transparency

Repair preparedness

Fault localization for long lengths