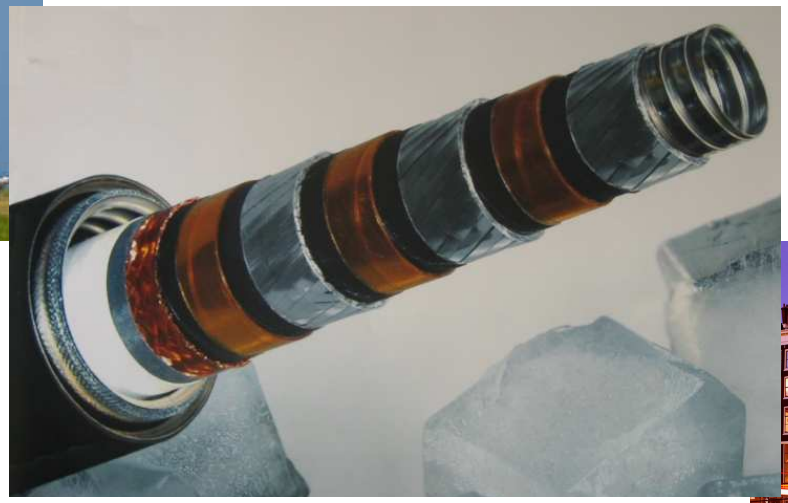
Frankfurt (Germany), 6-9 June 2011

Efficient connection of large-scale DER with intelligent superconducting cables



Irina Melnik – the Netherlands – Session S4 – 1152

Efficient integration of large-scale DER is a challenge for electrical power systems

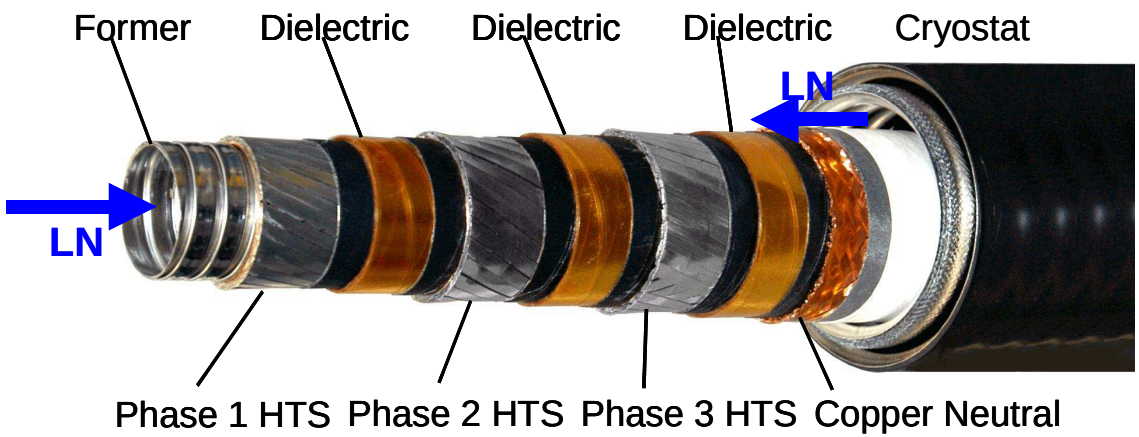
Technical bottlenecks:

- High level of fault currents
- Increasing of produced reactive power
- Unstable voltage levels
- Overloading

6 km FCL HTS cable system in the Netherlands

- Cooperation Alliander, Ultera and TU Delft

HTS Triax® cable



Benefits of the FCL HTS cables technology

- High transport capacity

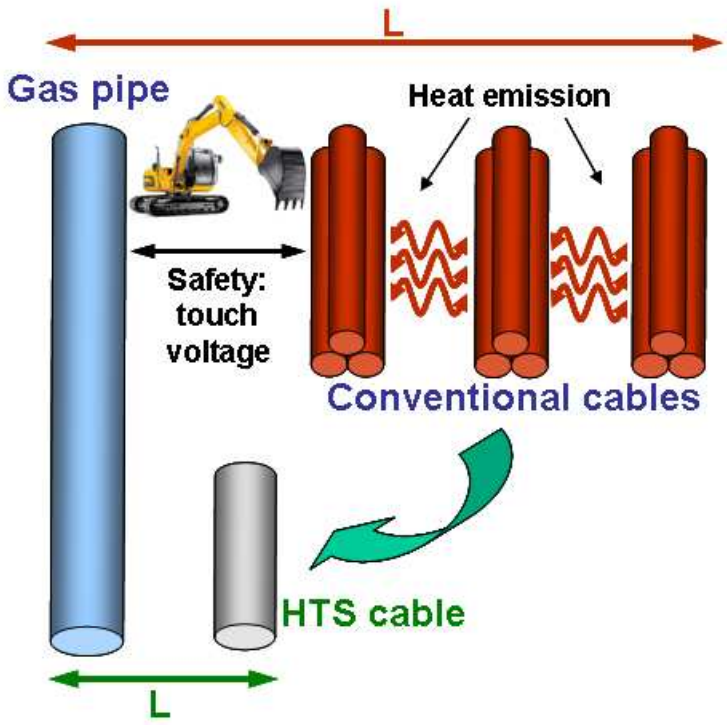
10 times more power transport than
by conventional cables of comparable
radial dimension

HTS tape conductor can carry
300 A/mm2 at 77 Kelvin

- Reducing of transformer steps

Benefits of the FCL HTS cables technology

- Small footprint

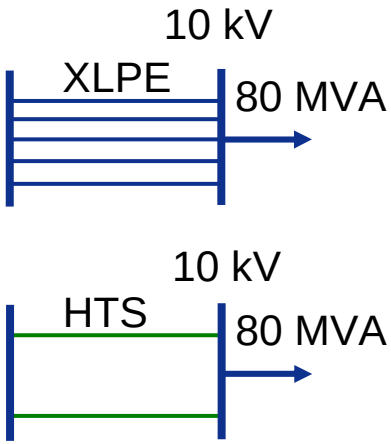


- Very low heat emission
- Very low electromagnetic emission

Benefits of the FCL HTS cables technology

- Reduced voltage fluctuations
- Low energy losses

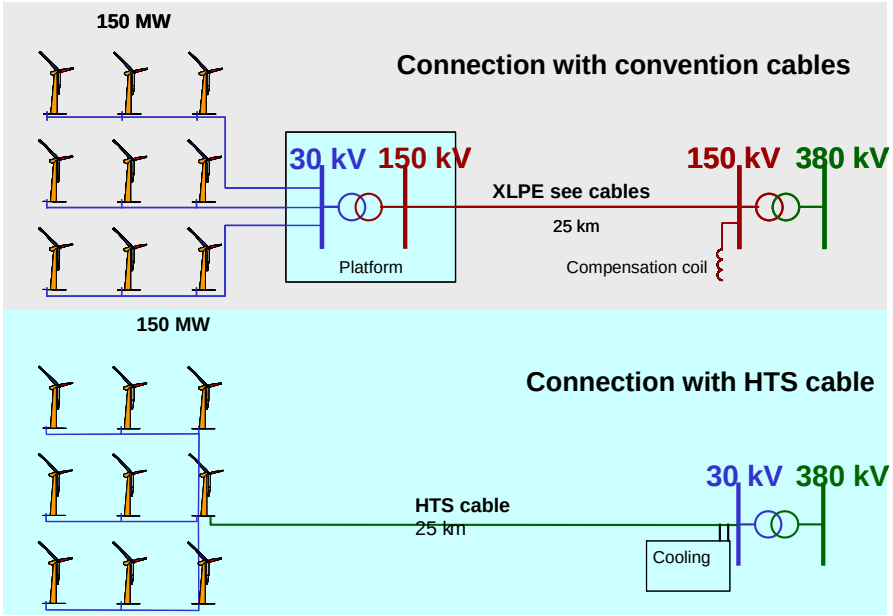
Transport of 80 MVA with redundancy at 10 kV



Cable system		I nom A	ΔU kV	Loss kW	Loss MWh
Conventional cables	5 x 630 AL	5 x 575	0,37	745	2234
HTS cables	2 x HTS Cable	2 x 2900	0,04	147	1218

CO_2- emission reduction

Connection of an off-shore wind park



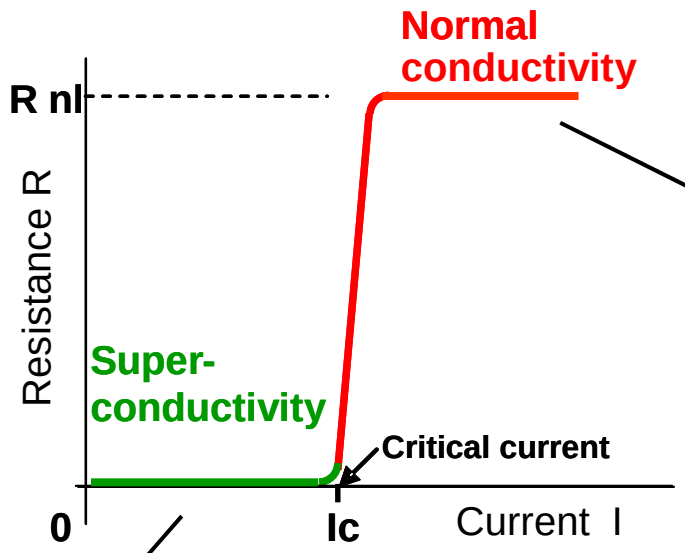
CO2-emission equivalent: 140.314 kTon

CO2-emission equivalent: 43.332 kTon

CO2- reduction HTS: 96.982 kTon (69%)

in the life time of 20 years

Fault current limiting (FCL)

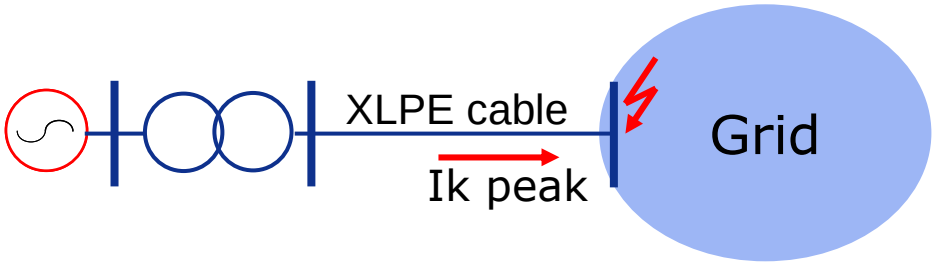


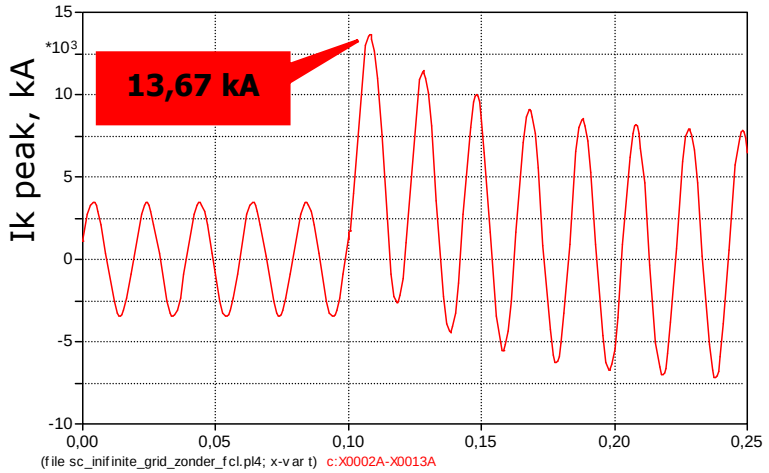
- High impedance
- Short circuit currents limiting during faults

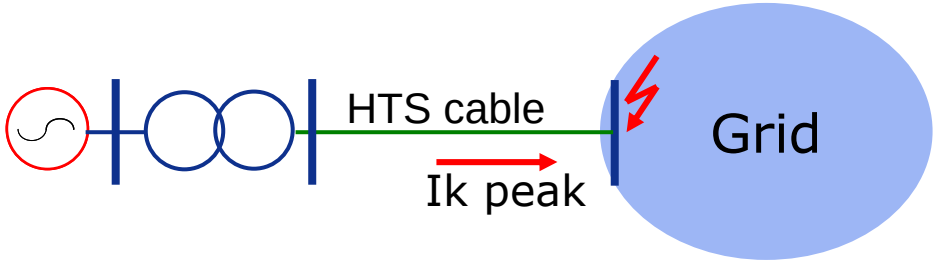
- Low impedance

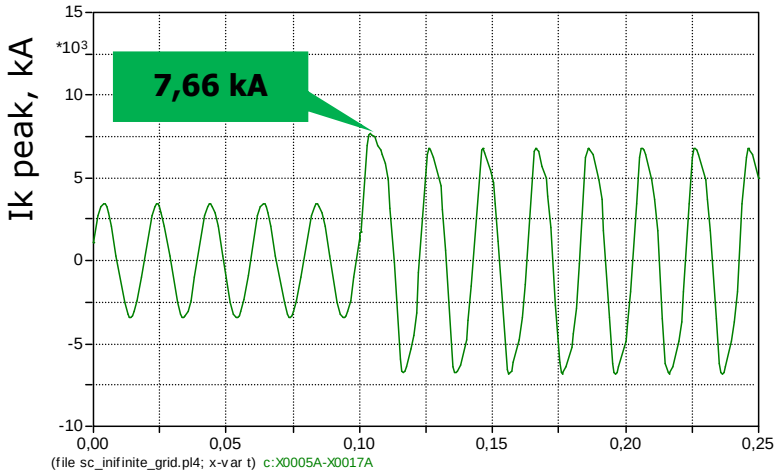
- Low energy losses
- Stable voltage profile

FCL simulations









Huge potential market for HTS cables

Potential market by 2020 in the Netherlands

	Wind on-shore	Wind off-shore	CHP
Total DER expectation	4.000 MW	6.000 MW	14.000 MW
Only large-scale DER	1.000 MW	6.000 MW	2.000 MW
Power of one unit	20 MW	300 MW	200 MW
Number of required connection cables	50 cables	20 cables	10 cables
Expected connection length	10 km	30 km	10 km
Total cable length	500 km	600 km	100 km

New achievements in developing of a long length FCL HTS cable

Project targets:

- AC loss 0.2 W/m/phase at 2.9 kArms
- Cryostat heat leak below 0.5 W/m
- Flow friction of 0.04

Already achieved results:

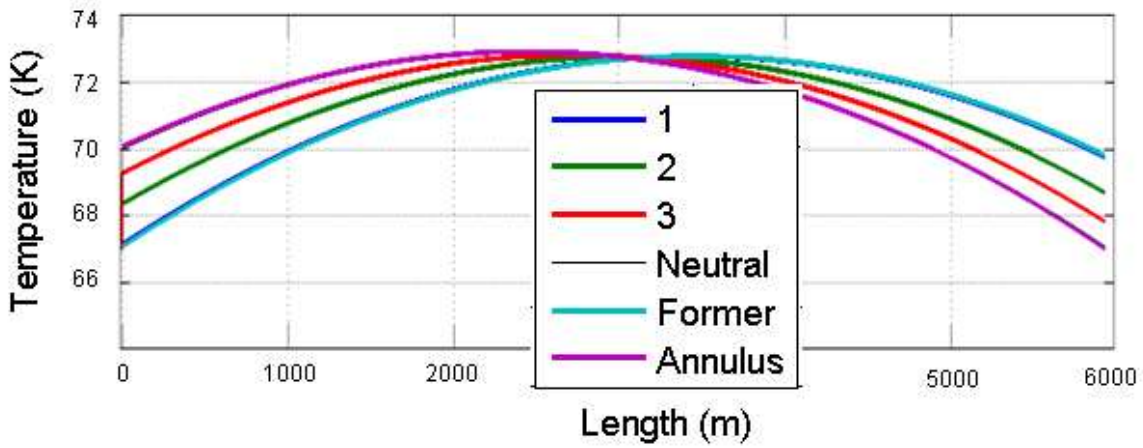
- AC losses 0.11 W/m at 3 kArms – measured at 60 Hz and 77 K
- Cryostat heat leak 0.5 W/m
- Test of a 45 m low friction cryostat.
  A mass flow of 0.3 kg/s resulted in a pressure drop of only 5 mbar

Temperature profile

Challenge:

Limit the difference between maximum and minimum temperature in long length cables

Achieved results:



A simulated temperature profile of a 6 km HTS Triax® FCL cable system, using the present-status performance values for AC loss and cryostat loss.

The modeled system has one cooling station at each end.

Conclusions

- The new HTS cable technology with intelligent built-in FCL solves many of the grid operators' most severe problems by connection of large-scale DER.
- The achievements, already made in the Dutch project, confirm that the stated ambitious targets to develop of a 6 km FCL Triax HTS cable will be reached.
- This is a large step to maturing the technology towards it's large-scale use.