

Cost/Benefit Analysis of HTSC Cable Systems

Make it or Break it

Gert Aanhaanen

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Cost/Benefit Analysis of HTSC Cable Systems



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Cost of a cable connection

What is the price of an HTSC Cable?



Price XLPE versus HTSC Cable			
Voltage [kV]	Rating [MVA]	Type	Price [M€/km]
132	1370	HTSC	1.65
400	1370	XLPE	0.85

Conclusion

HTSC cables are not made of gold!

Cost of a Cable Connection



ROI

NPV

LCC

TCO

WLC

- Financing
- Depreciation period
- Interest rate
- Utilization
- Future cost of energy

Cost of a Cable Connection



Social Cost / Benefits Analysis

and

Risk Analysis

Cost of a Cable Connection



Cost factors

- | | |
|-----------------|------------------------------|
| 1. Cable System | Dominant for decision proces |
| 2. Civil Works | |
| 3. Interest | |
| 4. Joule Losses | |
| 5. Maintenance | |
| 6. Right of Way | |
| 7. Removal | |

Cost of a Cable Connection

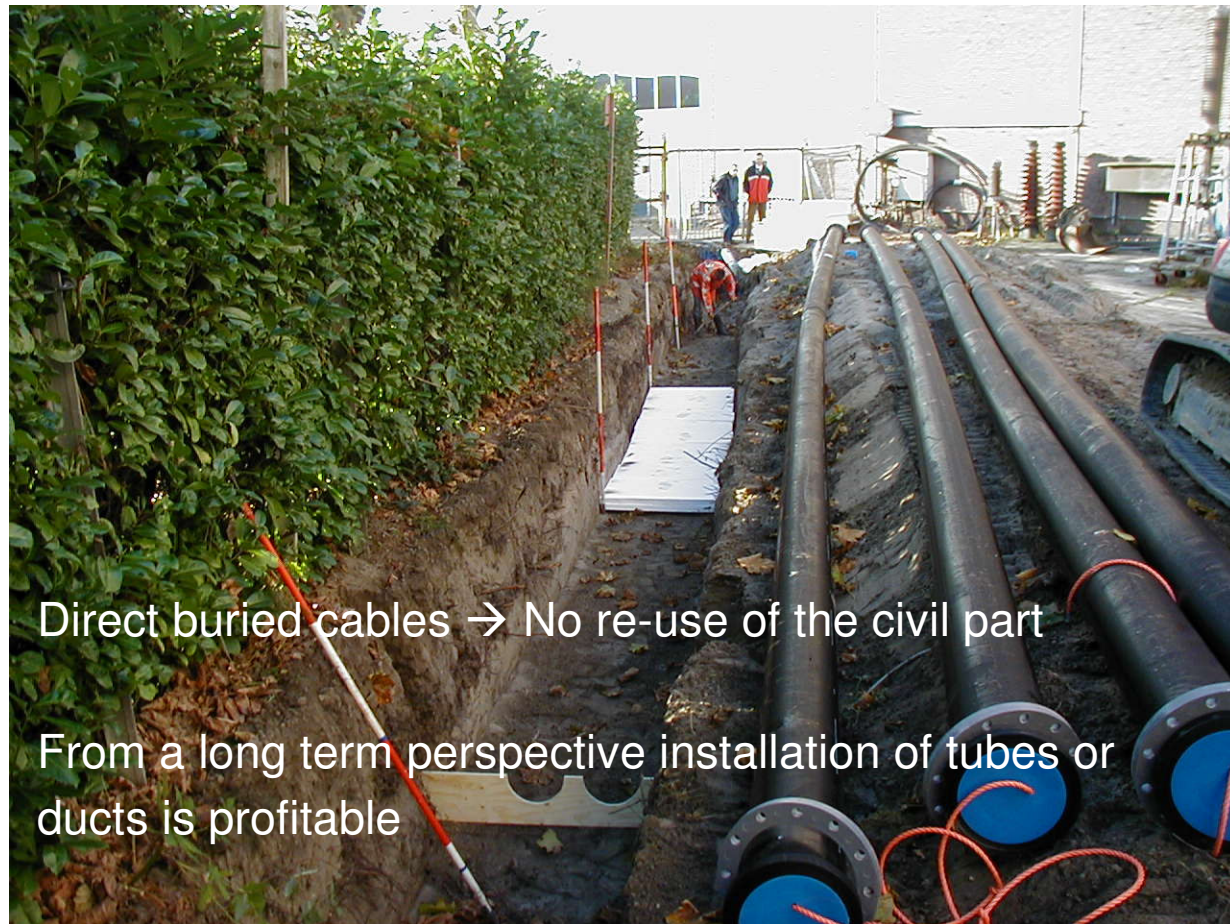
Cost of a Cable project (Switchgear excluded)

- Cable System
- Civil Cost
- Technical and legal preparation



Cost ratio recent 150 kV projects		
Area	Cable System	The rest
Urban	30%	70%
Rural	40%	60%

Cost of a Cable Connection



Direct buried cables → No re-use of the civil part

From a long term perspective installation of tubes or ducts is profitable

Cost of a Cable Connection



- Third Party Damage → Hard protection
- EMF → Normally EMF reduction has a negative influence on the ampacity
- No inconvenience for communities → No long open trench

Cost of a Cable Connection



Fear of every Board and Assetmanager is a low availability and early termination of an innovative technique

This risk can be mitigated by

- The use of tubes and ducts
- Start with small scale projects
- Create a low dependence on this cable
(This technique is very attractive for the connection of power stations, the financial risk is quite high)

Cost of a Cable Connection



Joule Losses → Related to annual costs and CO₂ reduction

Reasonable requirement for an HTSC Cable

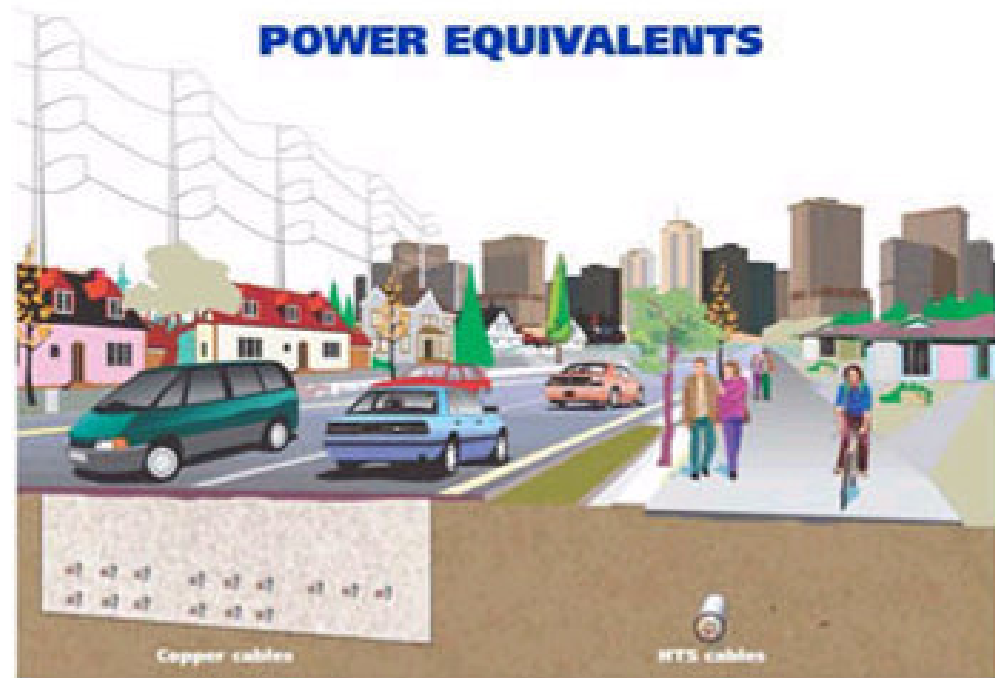
Saved cable losses > Pump losses



- Generator connection
- Connection in a (n-1) safe grid

Take the OH line as starting point

Benefits of HTSC Cables



- Extreme compact
 - No external magnetic field
 - Large transmission capacity, 132 kV HTSC can compete with 400 kV OHL
 - Transmission capacity independent from environment
- 12 • Limiting short circuit level

Benefits of HTSC Cables



- Hard shell protection
- Joints in line with the cable → No extra space needed
- Upgrading opportunity
→ start with a 3 phase Cable and substitute with HTSC Cable

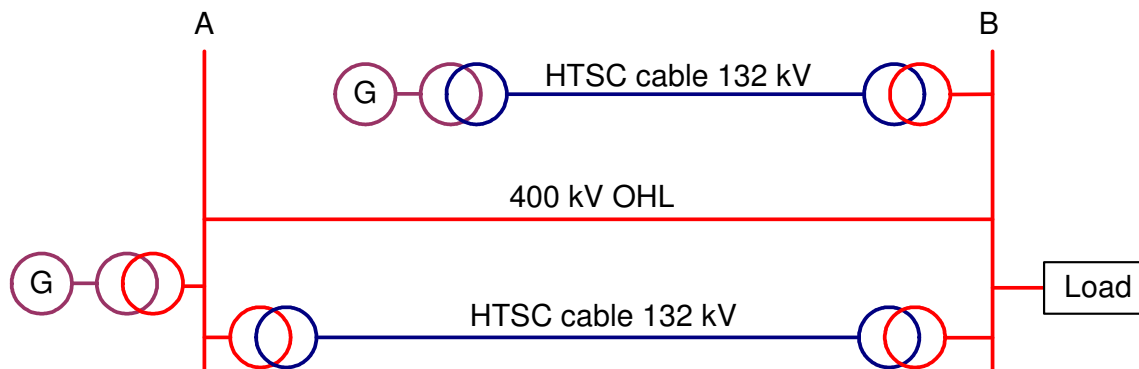
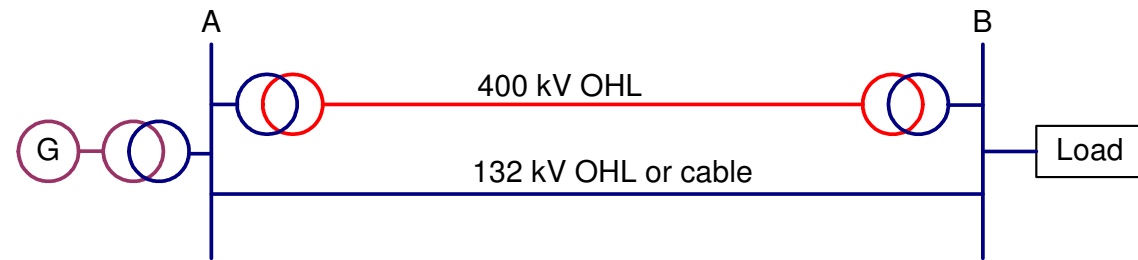


Benefits of HTSC Cables

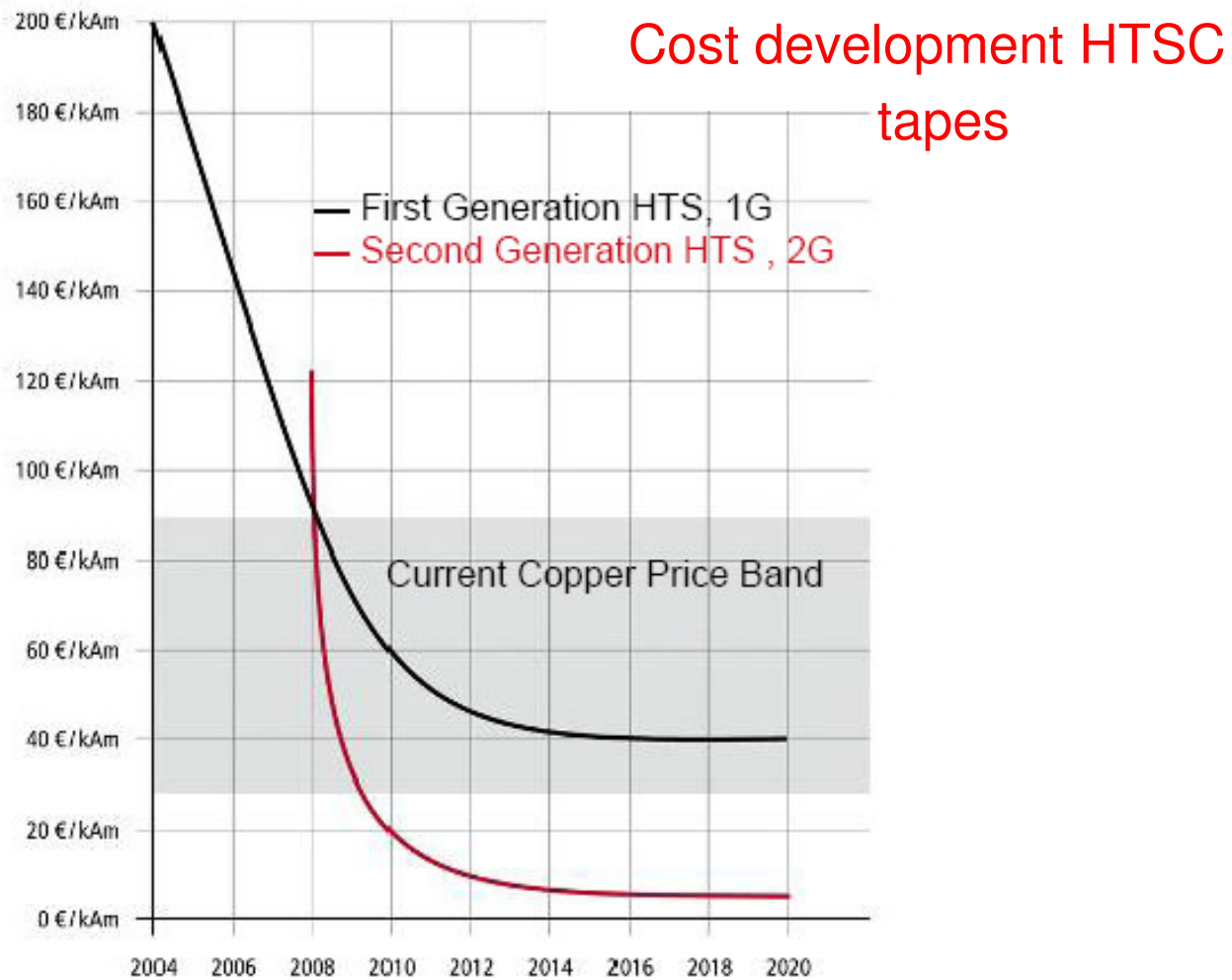


Electrical properties Cables and OH lines				
Property	132 kV HTSC Coax	132kV HTSC Triax	400 kV OHL	400 kV UGC
Inductance [$\mu\text{H}/\text{km}$]	83	48	5700	390
Capacitance [nF/km]	402	725	6	190
Reactive power [Mvar]	2.2	4.0	0.3	9.6

Benefits of HTSC Cables



Benefits of HTSC Cables



Concerns Needs Answers



Confidence

- Life expectancy of an HTSC cable
- Short circuit behavior
- Reliability → Active elements → Maintenance costs
- Availability of the system
- Need of a track record

Concerns Needs Answers



Feasibility

- Current distribution over parallel lines → Use of transformers in parallel
- Leakage of liquid nitrogen → No greenhouse gas
- Safety to the public → Additional rules accepted by authorities

Concerns Needs Answers



Feasibility

- Overcome height differences → HDD up to -25m
- Connecting offshore windfarms → Maximum length of a cooling section
- Switchgear → > 4 kA

In Conclusion



- HTSC cable is coming into practice and concerns seem to be solvable
- Benefits are an amazing small foot print and no EMF
- Price development of HTSC cables can make it competitive
- HTSC cables will find its first application as parallel line

Only a real life project can show the reliability and availability

A photograph of an offshore wind farm at sunset. Three large wind turbines are visible in the foreground, with several smaller service vessels in the distance. The sky is a deep orange, and the water reflects the light. The text "The End" is overlaid in the center.

The End

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