WETS'07 Workshop

7th International Conference on Insulated Power Cables

Paris – La Défense

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Long Distance Cable Systems, Learnings from WETS'07

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Scope of WETS'07 Workshop

Specific workshop for invited experts

- 48 participants
- 17 nations

"Long distance cable systems" (>10 km, AC insulated cables)

- Overview and Statistics
- Experience in service
- Main achievements
- Compensation of reactive power
- Cost

Organized by Jicable & Prospective 2100

Supported by Cigré

Background of the Workshop

Wets'07

Previous international survey

- Based on a 2005 questionnaire
  - 54 links from 22 countries,
  - Up to 500 kV and 39.8 km
- Updated in 2007
  - Characteristics of cable and compensation
  - Operating results
  - Economical aspects

Conclusions

- About 50 HV to EHV insulated cable line longer than 10 km are operated throughout the world
  - Longest in Japan (500 kV, 39.8 km, 2000)
- Fixed or adjustable compensations of the reactive power
  - Performed by trusted technologies
- Wide range of space occupation and costs of compensation
  - 1 to 6 m^2 / MVAr
  - 3 to 30 US k$ / MVAr for 345 or 400 kV
- Satisfactory operating conditions and results
  - In steady state as well as in exceptional operating conditions
  - Some of them are in service for more than 20 years!

Danish experience

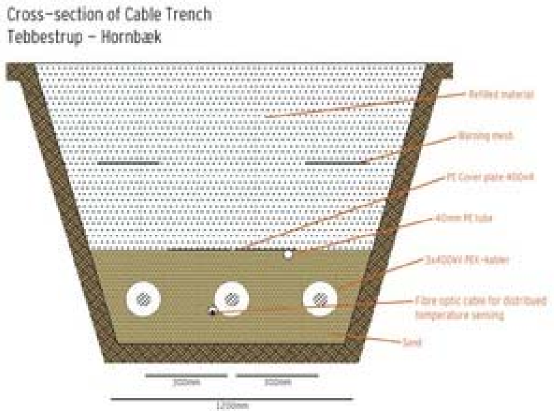
400 kV XLPE cable in Copenhagen area

- With direct burial laying
- Compensators directly connected to the line

150 kV cable for offshore wind farm

Depending on the environment

- absence of regulation about EMC and laying protections against external effects in case of breakdown



Spanish experience

Land cables

- 400 kV in Barajas (Madrid airport)
  - tunnel – 2x13 km – 2500 mm² XLPE

Submarine cables

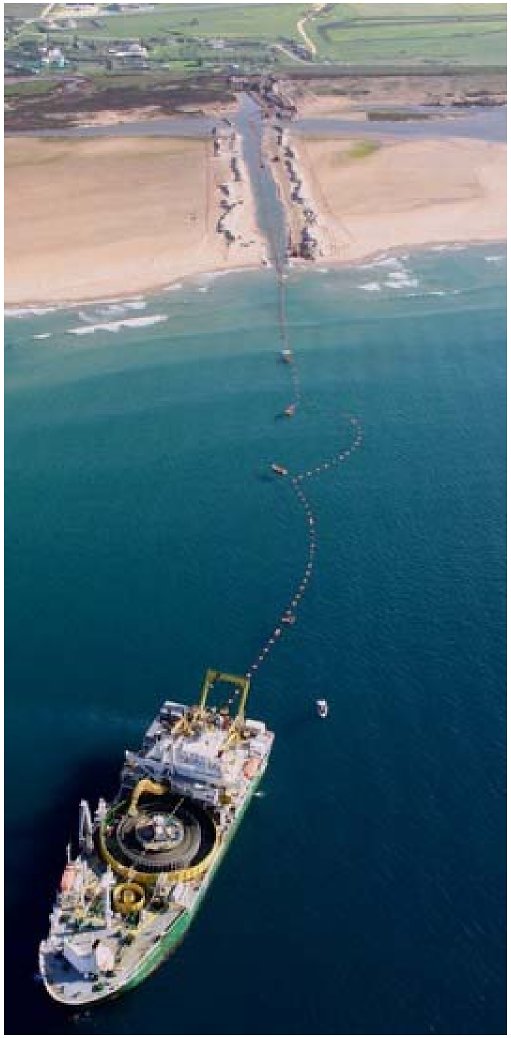
- Spain-Morocco 400 kV AC interconnection
  - submarine and land cable in OF design, commissioned in 1997 and 2006

Compensation

- Mainly installed for economical reasons or for contingency situation

Cables in tunnel

- A fire protection paint is laid on the cable jacket (flame retardant)



Japanese experience

Long distance UG Lines for many years in very big cities

- First OF cables, now with XLPE design
- 275 and 500 kV
- EHV cables mostly in tunnels
  - Flame retardant PVC jacket

Connections between islands

- 500 kV cable installed in the frame of the bridges

Significant efforts to decrease the number of joints

- Cost of jointing, traffic disturbances during installation, potential higher risk of reliability
- Development of innovative solutions to increase the length of cable on drum
  - optimized cable design
  - special drums, transporting solutions
- Two examples of 2500 mm² XLPE cables
  - 500 kV, max length between joint = 1800 m
  - 275 kV, max length between joint = 2500m




Compensation - Basics

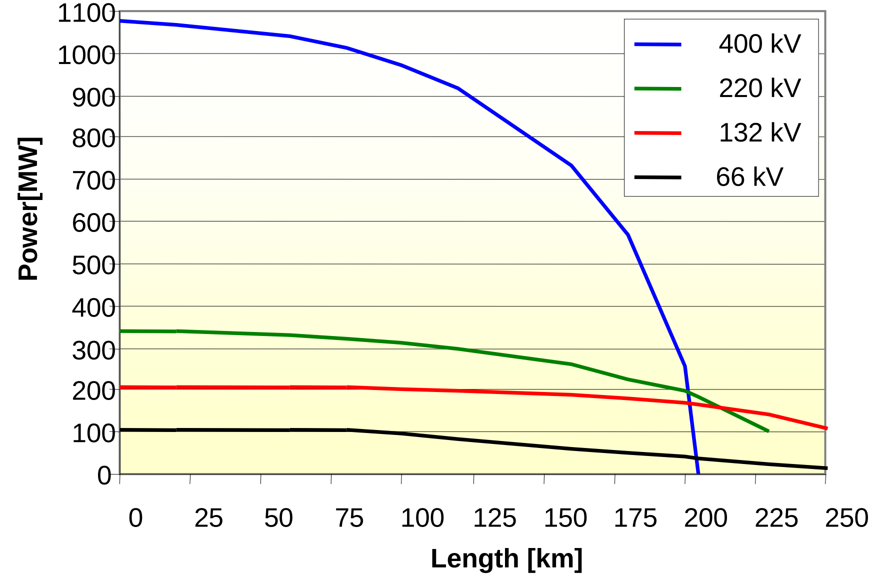
Analysis of influencing parameters and benefits of reactive power compensation

- Some economical given for the case of 220 kV / 400 MW

Application for a pre-study, presented at Cigré 2002 session

- 132 kV XLPE cable of 200 km crossing Iceland
- 18 reactors banks every 20 km

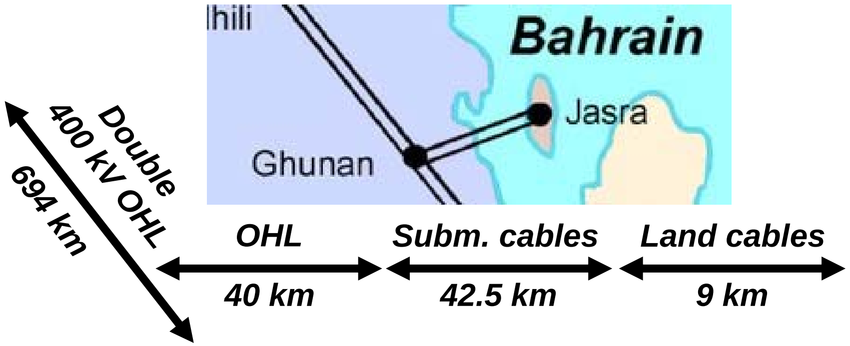
Discussion about the necessity to take into account losses in shunt reactors



Compensation – Major projects

GCC Project (interconnection of Gulf States)

- Total power = 650 MVA per circuit
- Shunt reactors at both ends of the 400 kV cables
  - 4x125 MVAR for one end
  - 2x125 MVAR + 2x300 MVAR for the other end
  - Level of reactive compensation ≈ 96 %



500 kV Shin-Toyosu Line (Tokyo)

- 500 kV XLPE cable – 39.5 km
- 2 circuits – 900 MW/circuit
- Total compensation by shunt reactor banks
  - Best solution is to install shunt reactor at both ends, in order to limit the overvoltage at the termination when cable line is opened
  - To reduce cost installation and components, shunt reactors banks must be installed at the lower voltage part

Vancouver Island

- 3 locations of the reactive banks
  - both ends and intermediate point on the Texada island

Example of Elstree to St John's Wood Tunnel (UK)

Major EHV cable tunnel in London

- Single circuit of 2500 mm² Cu 400 kV XLPE cable
- DTS monitoring
- PD couplers on accessories
- Forced air cooling

Installation in a tunnel because of highly urbanized area

- Issues linked to the construction of shafts and substations
  - Site access
  - Traffic
  - Consultations and authorizations
  - Relationship with local communities

Example of limiting environmental impact

Environmental study carried out for a 20 km long HV cable line in France

- Located in a 100% rural area
- Laying in PEHD ducts
- Cable lengths of about 3 km made possible by pushing/floating laying method)
- Project defining guidelines for conducting such projects with environmental perspective
  - Land use after works
  - Issues related to soil replacement (topsoil, seeds and foreign species…)
  - Thermal criteria
  - Choice of UGC versus OHL
- Very satisfying healing process of the natural grassland

Long length superconducting cables

Current situation on June 2007

- Three major HTS AC cable projects in the USA

Cable design	Cable maker	Location	Utility	Cable characteristics	Cable in operation
	Southwire (Ultera)	Columbus (OH)	AEP	200 m / 13.2 kV / 3 kA / 69 MVA	August 2006
	Sumitomo	Albany (NY)	Niagara Mohawk	350 m / 34.5 kV / 0.8 kA / 48 MVA	July 2006
	Nexans	Long Island (NY)	LIPA	600 m / 138 kV / 2.4 kA / 574 MVA	*2007*

Studies on progress

- One case presented at Jicable'07 [1]
- Possible mid-term project
- Very long HTS DC cables can be foreseen

- [1] MV AC project in Amsterdam

Cable parameter	Value
Voltage	50 kV
3-phase current	2900 A rms
Transmitted power	250 MVA
Total length	6 km
Cable core unit length	2 km
Cable design	Cold dielectric, triaxial (concentric phases)
Cooling fluid	Liquid nitrogen
Number of cooling stations	2 (one at both ends)

- [2] Expectations

Cable parameter	Value
Voltage	138 kV
3-phase current	2400 A rms
Transmitted power	574 MVA
Total length	10 km
Phase unit length	≥ 500 m
Cable design	Cold dielectric, one cryostat per phase
Quantity of HTS tape	2400 km
Cooling fluid	Liquid nitrogen
Number of cooling stations	3 (one at both ends and one intermediate)

Conclusions

Fruitful workshop

- 30 presentations, with high expertise and interesting service experience
- Lively discussion with spontaneous contributions

Many innovations

- Increasing both cost competitiveness and the ongoing ability to provide viable and reliable solutions to present and future challenges

Overhead and underground solutions are complementary rather than mutually exclusive

A good “prophecy” for the further optimization of HV and EHV systems…