OVERVIEW OF UNDERGROUND POWER CABLES AT HIGH/EXTRA HIGH VOLTAGE LEVELS

2006

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Introduction to Europacable

Europacable is

- The Association of European Cable Manufacturers including ABB, Brugg, Nexans, NKT, Prysmian, Silec

Europacable aims to:

- promote of the use of underground cables for electricity transmission;
- ensure the complete and correct understanding of the technical specifications of underground cables by relevant stakeholders.

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Considerations re. use of Underground Cables

- Each electricity transmission project:
  - is unique;
  - requires its own careful analysis;
  - and needs specific solutions.

Europacable believes that:

- Underground cables are rarely appropriate for an *entire* new AC power transmission project
- For long projects, a combination of overhead lines & partial undergrounding may be appropriate to balance the needs of:
  - Regulators,
  - Economic stakeholders,
  - Local communities, and
  - Natural environment.

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Underground Cables

- For the last 30 years, the European cable industry has invested in innovative technology for underground cabling.
- Today, underground cables are the optimum technical and economical solution for the transmission and distribution of electrical energy in cities and in densely populated areas in most economically advanced countries.
- Underground cables are also a good solution for those cases where
  - the construction of new overhead lines creates difficulties in gaining planning consent,
  - crossing waterways,
  - areas of prestigious infrastructure development,
  - future urban expansion, and
  - outstanding cultural,environmental and natural heritage.

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Underground Cables Reliability

- Extra High Voltage (EHV) underground cables form part of the backbone of the electricity transmission system, reliability considerations are therefore a key priority.
- IEC (International Electrotechnical Commission) standards provide all the functional requirements necessary to guarantee suitable quality of the underground cable system.
- CIGRE (International Council on Large Electric Systems) studies the technical, economic, environmental, regulatory and organisational aspects of technological developments.
- EUROPACABLE offers its support to present clearly the potential use of EHV cables to all stakeholders, particularly the most complex transmission projects.

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Examples of major 400kV projects in Europe

Location	Project	Cable circuits x Length (km)	Time period
Copenhagen	Elimination of OHLs in urban area	1x12, 1x22	1996/9
Berlin	Connect West/East systems	2x12	1996-00
Vale of York (UK)	Area of outstanding beauty	4x6	2000/1
Madrid	Barajas Airport expansion	2x13	2002/3
Jutland	Area of outstanding beauty, waterway & semi urban areas	2x14	2002/3
London	London Ring	1x20	2002/5
Rotterdam	Randstad “ring” waterway crossings	2x2.1	2004/5
Vienna	Provide power to centre of city	2x5.5	2004/5
Milan	Section of Turbigo-Rho line	2x8.5	2005/6

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Future Transmission Projects Under Discussion

Cabling of EHV projects in “sensitive” non urban areas is currently under in several areas of Europe, including:

- 400kV – 220 km connection from Beauly to Denny, Scotland
- 380 kV – 98 km connection from Rothenturn (Burgenland) to Kainacthal (Steiermark), Austria
- 380 kV – 100 km connection from Elixhausen to Kaprun, near Salzburg, Austria
- 400 kV – 150 km connection from Contentin to Maine in Normandy, France
- 400 kV – 150 km connection from Sils, Switzerland to Verderio, Italy

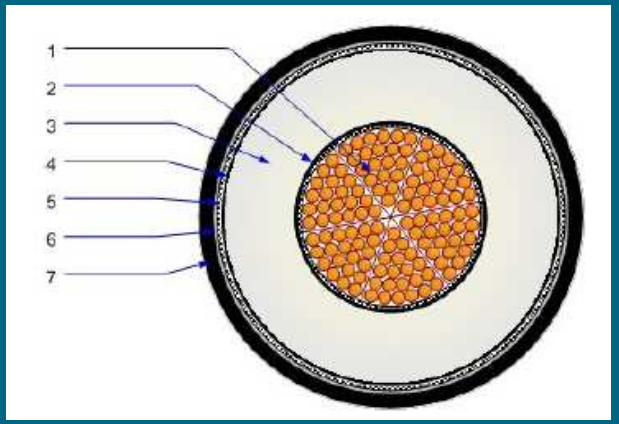
The 400 kV XLPE Cable

Extruded XLPE underground cables for voltages up to 400 kV are taking the place of traditional oil filled cables because of significant advantages that include:

- ❑ Easier installation and jointing
- ❑ Better environmental compatibility
- ❑ Reduced installation cost
- ❑ Reduced or practically zero maintenance

400 kV XLPE cable design

1 Copper conductor
2 Semiconductor
3 XLPE insulation
4 Semiconductor
5 Waterblocking
6 Welded aluminium sheath
7 PE outer sheath



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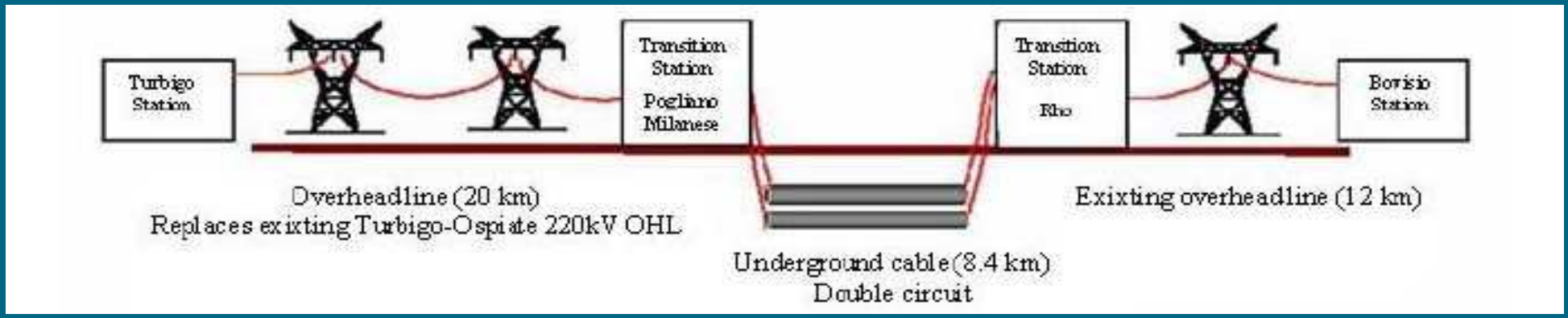
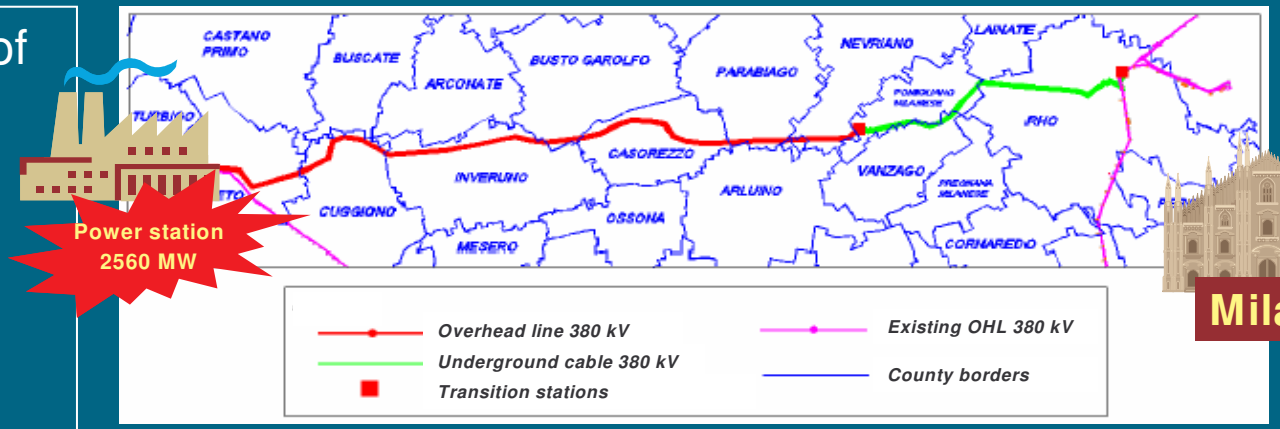
The Turbigo-Rho Italian 400 kV Project



The undergrounding of part of 40 km long line led to the speeding up of authorization procedures. The line was necessary for the reinforcement of the transmission grid in a very congested area avoiding the risk of future blackouts.

The max. power rating of the circuit is 2.2 GVA



Benefits of the project:

- To overcome the generation limits of the Turbigo power station and reduce congestion
- To improve voltage control in the Milan area
- To reduce transmission losses

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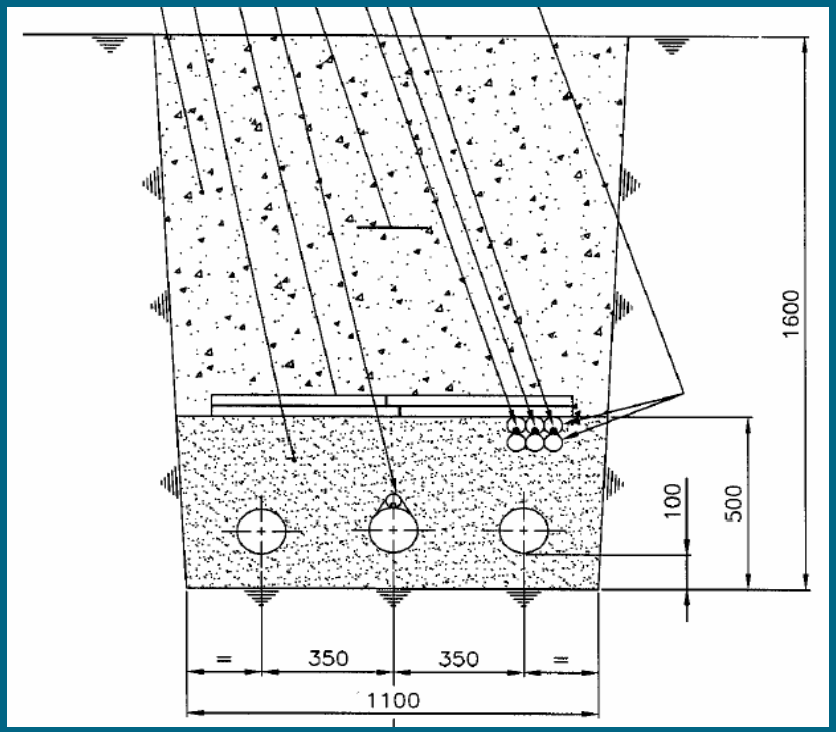
Construction Issues

- At least a couple of meters totally cleared right-of-way required
- Access for heavy equipment along the entire length
- Number of cables will depend on the power rating



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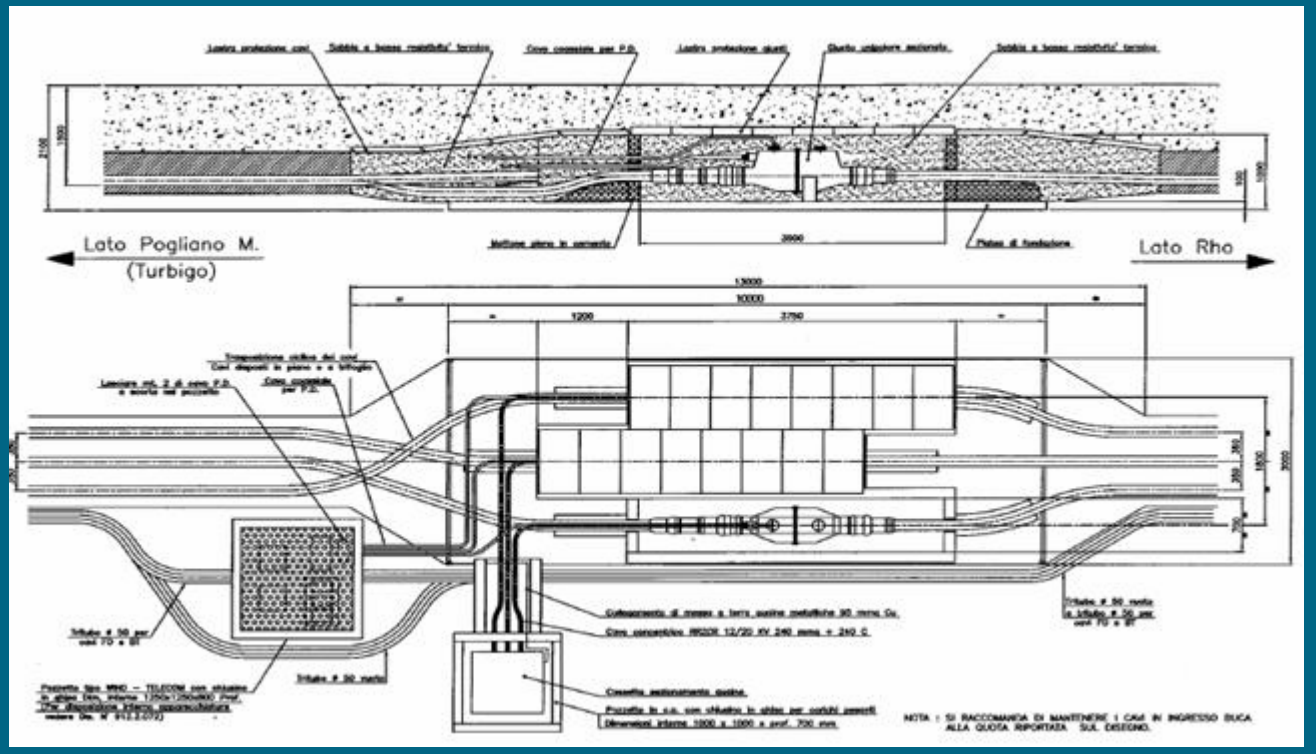
400 kV XLPE Cable Joint Bay

The 400 kV cables may be delivered in lengths of 800 to 900 meters, lower voltage cables may be longer.



For extruded XLPE cables, joints can be directly buried in a trench approx 13m long and 3m wide. In some cases a concrete vault may be necessary for special requirements, i.e. inspection of joints, impact on traffic etc.

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Countryside Trenching

- Needs negotiation with the land owner to obtain the right of way
- The soil is still propriety of the owner and is still available for agricultural activities
- Landscape can be completely reinstated within 18-24 months

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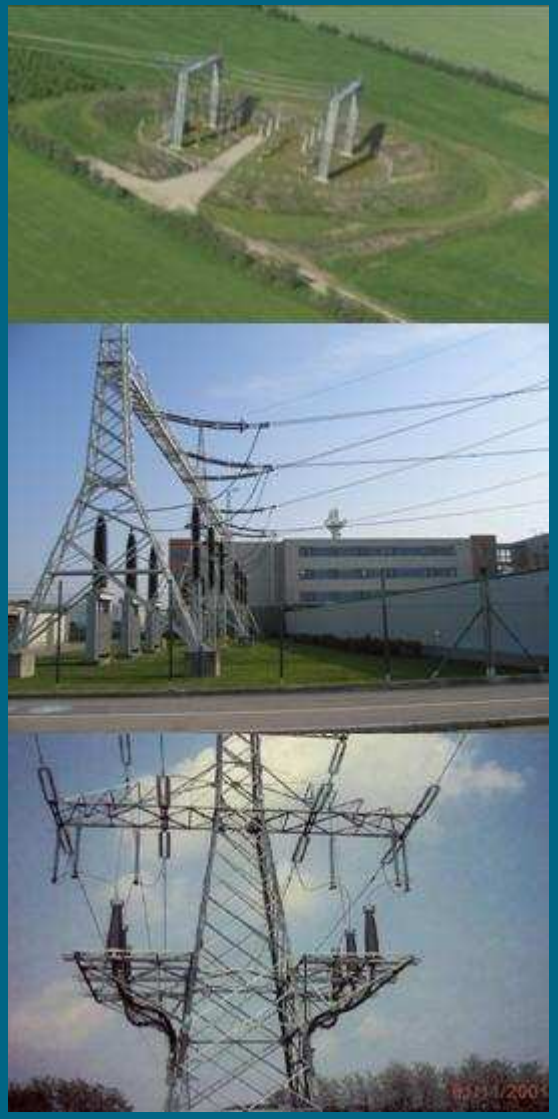
Overhead-Underground Transition Stations

Termination compound for voltages of 400 kV can be a tennis court size (e.g. Denmark & Vienna)

Termination compound for voltages of 275 kV or lower can be very simple (i.e. attached to pylon)



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Impact on the network

- The insertion of a new interconnection in an existing network requires a detailed investigation at the planning stage.
- Studies that have been conducted on some 400 kV transmission grids show that the characteristics of cables may in many cases be beneficial to the general behaviour of the network.
- For very long cable connections, i.e. more than 20 km, a study of the grid is necessary in order to evaluate if the installation of compensation equipment is required.
- If needed, the compensation equipment (shunt reactors) can be applied at the existing substations, and no extra compound area is necessary for their installation.

Other Transmission Possibilities

- Underground point-to-point DC cables over longer distances on land are technically feasible but require converter stations at both ends.
  Depending on power rating these can cost up to €75m each.
- Sub sea AC cables connections are currently feasible for long distances but maximum length of cable depends on the voltage.
- Sub sea DC cables with a capacity of 2,000MW are technically feasible although the highest underwater capacity cable planned at present is 1,200MW. No practical limits of distance, the longest distance is currently 580km.

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Summary – Benefits of Cables

- Greater security of supply, particularly in bad weather
- Lower transmission losses
- Virtually no maintenance
- No noise or air pollution (due to “corona discharge”)
- No electric field and lower magnetic field outside the right of way
- XLPE cables have successful track record
- Recent European Commission study shows cables have similar asset life to OHL conductors
- Landscape can be reinstated
- Long planning delays can by avoided

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Conclusion

- Europacable's aim is to provide independent, factual information about its technology to all interested stakeholders.
- We do not take views on individual projects which are unique and require careful analysis and specific solutions.
- We recognise that UGC
  - Are rarely appropriate for entire new AC Power transmission projects;
  - Are at installation more expensive, but that costs can only be reviewed by full life cycle analysis.
- For controversial projects, partial undergrounding can provide a compromise to allow a project to move forward which might otherwise be blocked for many years.

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