
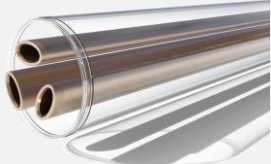


Technology comparison: Pressurized Air Cable vs. XLPE cable

Pressurized Air Cable or XLPE cable? Here is a comparison table for system parameters, economy, society, and technical parameters¹. All values provided are typical values for actual products or projects which may vary for every application.

Comparison: system parameters

Topic	XLPE cable 	Pressurized Air Cable 
Main layout	Underground, concrete encased cable duct block	Underground: Microtunnel, Pipes, walkable Tunnels.
Space requirement	Corridor 145 kV: ≈ 2.0 m Corridor 220 kV: ≈ 2.6 m Corridor 420 kV: ≈ 3.5 m	Pipe 110 kV: 0.7 m Pipe 220 kV: 1.0 m Pipe 420 kV: 1.2 m
Construction along the line	Wide trench for duct block. Jointing pit every ~1000 m	Pipe. Installation pit every ~300-500 m.
Line losses at I = 1000 A (Scales with I²)	145 kV: ~50 kW/km 245 kV: ~45 kW/km 420 kV: ~30 kW/km	145 kV: ~46 kW/km 245 kV: ~25 kW/km 420 kV: ~19 kW/km
Transmission power (typical values)	145 kV: ~400 MW 245 kV: ~900 MW 420 kV: ~2300 MW	145 kV: ~800 MW 245 kV: ~1600 MW 420 kV: ~3600 MW
Large scale use in the grid?	Limited: Resonances, reactive power requirement	Not yet. Can replace all overhead lines.
Operational experience	Extensive operational experience in all voltage levels	New technology. Experience similar to GIL or GIS.
Localization of a fault	Distance protection, impedance method.	Integrated in pressure monitoring: Indicates compartment
Repair in case of fault	Difficult repair. Jointing. No standard spare parts.	Repair per busduct. Standard spare parts.
Duration of a repair case	Several month	Several days
Parallel systems	Required for redundancy and high transmission power	Required for redundancy
Parallel systems	Required for >2000 A	Not required up to 4000 A
Monitoring in operation	Extra monitoring systems. E.g. PD, DTS, Sheath	Integrated pressure monitoring for all key parameters
Grounding	Cross-bonding with SVL to limit losses	Enclosure grounding at every available ground connection
Voltage upgrade 245kV → 420kV	Needed to reduce losses and increase transmission power	Optional to reduce losses and increase transmission power

¹ Focus on voltage levels ≥ 145 kV. However, PAC can similarly be used for MV as well.

Options for upgrade and grid enhancement	Can only replace sections of OHL	Continuous expansion of the grid possible
Exposition (as critical infrastructure)	Underground. Protected by duct block. Exposed interfaces.	Underground. Protected access. Rigid metallic enclosure.

Comparison: Economy

Topic	XLPE cable	Pressurized Air Cables
Investment cost: Line plus installation (without approval costs)	145 kV: ~1.2 MCHF/km 245 kV: ~2.7 MCHF/km 420 kV: ~5.0 MCHF/km	145 kV: ~1.5 MCHF/km ² 245 kV: ~2.9 MCHF/km ² 420 kV: ~4.3 MCHF/km ²
Cost for electricity losses during a 40-year operation at 1000 A	145 kV: ~2.1 MCHF/km 245 kV: ~1.6 MCHF/km 420 kV: ~1.0 MCHF/km	145 kV: ~1.0 MCHF/km 245 kV: ~0.6 MCHF/km 420 kV: ~0.4 MCHF/km
Costs dependency on rated current	Strong dependency: Higher current → higher cost	Low dependency on rated current
Economic limit to line length	Limited by reactive power and resonances	No limit in modern grids with battery storage
Costs for reactive power compensation	Significant for > 20 km length	None up to ~60 km length. Needed for >60 km length.
Delivery time: Wires, towers, pipes	Years	~month's
Cost for jointing pits, installation pits	~ 20 kCHF/pit	~ 20 kCHF/pit
Operation and maintenance	Little effort for maintenance.	Little effort. Integrated monitoring system.
Installation process	Digging trench. Concrete pouring. Cable pulling. Jointing	Dig pipe or microtunnel. Connect tubes. Roll them in.
Public tendering	Standardized. Many established suppliers.	No product-specific tenders yet. Only 1 supplier.
Expected lifetime	~40 years	> 40 years (like GIS)

Comparison: Environment and society

Topic	XLPE cable	Pressurized Air Cables
Approval process for line projects	Lengthy (cable duct block) Naturally project specific.	Faster due to zero emissions. Use of existings corridors.
Acceptability by societies	Bad during construction. Better than for OHL.	No reference yet. But better due to zero emissions.
Outside electric fields	None: Shielding.	None. Metallic enclosures.
Outside magnetic fields at 1000 A	< 100 µT in > 1.0 m distance < 1 µT in > 10 m distance	<100 µT in >0.3 m distance <1 µT in >3.0 m distance
Safety hazards	Fire. Internal arc fault. Grounding error.	Overpressure < 10bar in large pressure vessel

² Typical values for long, mostly straight installations.

Exposition for vandalism, sabotage, terrorism	Minimized. Arson attacks. Mechanical damage.	Minimized: Underground. Locked access. Rigid enclosure
Emissions to environment	Magnetic fields, heat, concrete ducts	Minor emissions.
Effects on neighborhood	Limited effect from EM fields.	Minor effects.
Recycling at end of life	Metals wires_ recyclable. Insulation material: Disposal	~ 99 % Aluminum. Fully recyclable.

Comparison: Technical parameters

Topic	XLPE cable	Pressurized Air Cables
Design and installation	Complex design & extrusion. On-site jointing needed.	Simple assembly. Installation in pits with special tools.
Insulation medium	Cross-linked PE (XLPE)	Pressurized air (~10 bar, dry)
Conductor material	Aluminum, Copper	Aluminum
Field stress on conductor during operation	~10 - 18 kV/mm	2-4 kV/mm
Shielding / enclosure	Thin, conductive sheet	Thick aluminum enclosure
Fire protection	Insulation: Can burn and produce smoke.	Metallic enclosure: Non-flammable.
Conductor cross section (Single wire or bundles)	240 - 2500 mm ²	Minimum: 2200 mm ² Maximum: 5000 mm ²
AC-resistance at operating temperature	145 kV: ~26 mΩ/km 245 kV: ~24 mΩ/km 420 kV: ~20 mΩ/km	145 kV: 12 mΩ/km 245 kV: 10 mΩ/km 420 kV: 8 mΩ/km
Capacitance per meter	145 kV: ~160 nF/km 245 kV: ~140 nF/km 420 kV: ~140 nF/km	145 kV: ~50 nF/km 245 kV: ~50 nF/km 420 kV: ~50 nF/km
Charging current per km per phase at rated voltage	145 kV: ~4.2 A/km 245 kV: ~6.2 A/km 420 kV: ~10.7 A/km	145 kV: ~1.30 A/km 245 kV: ~2.22 A/km 420 kV: ~3.81 A/km
Reactive power for 3-phases	145 kV: ~1.1 MVar/km 245 kV: ~2.64 MVar/km 420 kV: ~7.76 MVar/km	145 kV: ~0.33 MVar/km 245 kV: ~0.94 MVar/km 420 kV: ~2.80 MVar/km
Reactive power compensation	Required if >20 km length	Required if >60 km length
Bending radius	Typical: 20-30 * D _K . ~ 2-3 m bending radius	Continuous bending or 90° angles if required
Fault arc resistance	None. Internal arc fault leads to cable fire.	Yes. Arc remains internally. Pressure < Bursting pressure
Temporary overloading	Bad due to thermal insulation by XLPE layer.	>1h at 1.5* I _r . Good heat dissipation by metal enclosure
On-site testing after installation	High inductivity required to test a longer cable section.	