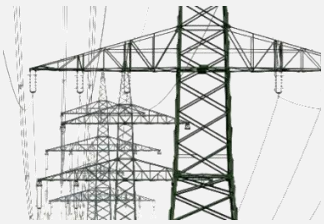
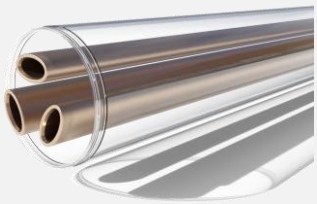
Technology comparison: Pressurized Air Cable vs. OHL

Pressurized Air Cable or Overhead Line? Here is a comparison table for system parameters, economy, society, and technical parameters[1]. All values provided are typical values for actual products or projects which may vary for every application.

Comparison: system parameters

Topic	Overhead line 	Pressurized Air Cable 
Main layout	Above ground along free corridors	Unterground: Microtunnel, Pipes, walkable Tunnels.
Space requirement	Corridor 145 kV: 45–55 m Corridor 220 kV: 55–65 m Corridor 380 kV: 65–75 m	Pipe 110 kV: 0.7 m Pipe 220 kV: 1.0 m Pipe 380 kV: 1.2 m
Construction along the line	Towers with foundation every ~300 m.	Pipe. Installation pit every ~300-500 m.
Line losses at I = 1000 A (Scales with I^2)	145 kV: ~400 kW/km 245 kV: ~200 kW/km 420 kV: ~100 kW/km	145 kV: ~46 kW/km 245 kV: ~25 kW/km 420 kV: ~19 kW/km
Transmission power (typical values)	145 kV: ~500 MW 245 kV: ~1000 MW 420 kV: ~2000 MW	145 kV: ~800 MW 245 kV: ~1600 MW 420 kV: ~3600 MW
Large scale use in the grid?	Yes. It's the actual standard. New lines difficult to built.	Not yet. Can replace all overhead lines.
Operational experience	Extensive operations experience in all voltage levels	New technology. Experience similar to GIL or GIS.
Localization of a fault	Distance protection, impedance method. Faults visible.	Integrated in pressure monitoring: Indicates compartment
Repair in case of fault	Simple repair. Faults visible. Standard spare parts.	Repair per busduct. Standard spare parts.
Duration of a repair case	Several days	Several days
Parallel systems	Required for redundancy and high transmission power	Required for redundancy
Parallel systems	Required for >1500 A	Not required up to 4000 A
Monitoring in operation	Extra monitoring systems. E.g. optical	Integrated pressure monitoring for all key parameters
Grounding	Ground wire along the line. Grounded at every tower.	Enclosure grounding at every available ground connection

[1] Focus on voltage levels >= 145 kV. However, PAC can similarly be used for MV as well.

Voltage upgrade 245kV → 420kV	Needed to reduce losses and increase transmission power	Optional to reduce losses and increase transmission power
Options for upgrade and grid enhancement	Thicker or more wires. A new line in ~ 20 years.	Continuous expansion of the grid possible
Exposition (as critical infrastructure)	Exposed against weather, nature, sabotage	Underground. Protected access. Rigid metallic enclosure.

Comparison: Economy

Topic	Overhead lines	Pressurized Air Cables
Investment cost: Line plus installation (without approval costs)	145 kV: ~ 0.9 MCHF/km 245 kV: ~1.8 MCHF/km 420 kV: ~ 2.8 MCHF/km	145 kV: ~1.5 MCHF/km 245 kV: ~2.9 MCHF/km 420 kV: ~4.3 MCHF/km
Cost for electricity losses during a 40-year operation at 1000 A	145 kV: ~8.5 MCHF/km 245 kV: ~4.5 MCHF/km 420 kV: ~2.0 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 Ferranti Effect to~1000 km	No limit in modern grids with battery storage
Costs for reactive power compensation	Only in special cases.	None up to ~60 km length. Needed >60 km if no batteries.
Delivery time: Wires, towers, pipes	~month's	~month's
Cost for tower foundations / installation pits	~ 80 kCHF/foundation	~ 20 kCHF/pit
Operation and maintenance	High effort for inspection, trees cutting, animals, weather	Little effort. Integrated monitoring system.
Installation process	Built foundations & towers. Roll-in the wires	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 – 80 years	> 40 years (like GIS)

Comparison: Environment and society

Topic	Overhead lines	Pressurized Air Cables
Approval process for line projects	Exhaustive. Long (15-20yrs) Naturally project specific.	Faster due to zero emissions. Use of existing corridors.
Acceptability by societies	Bad acceptance for existing lines. **None** for new lines.	No reference yet. But better due to zero emissions.
Outside electric fields	Extended electric fields	None. Metallic enclosures.
Outside magnetic fields at 1000 A	< 100 µT in > 2.0 m distance < 1 µT in > 200 m distance	<100 µT in >0.3 m distance <1 µT in >3.0 m distance
Safety risks	Exposed high-voltage conductors	Overpressure < 10bar in large pressure vessel

Exposition for vandalism, sabotage, terrorism	Countrywide exposure. Impossible to protect.	Minimized: Underground. Locked access. Rigid enclosure
Emissions to environment	EM fields, noise, optics, heat	Minor emissions.
Effects on neighborhood	High. Degrading properties and landscapes.	Minor effects.
Possible hazards	Birds, planes, flying objects, wildfires	None
Recycling at end of life	Metals (wires, towers) recyclable.	~ 99 % Aluminum. Fully recyclable.

Comparison: Technical parameters

Topic	Overhead lines	Pressurized Air Cables
Design and installation	Simple design. Installation at heights	Simple assembly. Installation in pits with special tools.
Insulation medium	Environmental air (~1bar)	Pressurized air (~10 bar, dry)
Conductor material	Aluminum with steel core	Aluminum
Field stress on conductor during operation	~1.5 - 2.0 kV/mm	2-4 kV/mm
Shielding / enclosure	None	Thick aluminum enclosure
Fire protection	Metallic wires and towers: Non-flammable.	Metallic enclosure: Non-flammable.
Conductor cross section (Single wire or bundles)	240 - 1600 mm^2	Minimum: 2200 mm^2 Maximum: 5000 mm^2
AC-resistance at operating temperature	145 kV: ~100 mΩ/km 245 kV: ~50 mΩ/km 420 kV: ~25 mΩ/km	145 kV: 12 mΩ/km 245 kV: 10 mΩ/km 420 kV: 8 mΩ/km
Capacitance per meter	145 kV: ~11 nF/km 245 kV: ~10 nF/km 420 kV: ~14 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: ~0.28 A/km 245 kV: ~0.44 A/km 420 kV: ~1.07 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: ~0.07 MVAr/km 245 kV: ~0.19 MVAr/km 420 kV: ~0.78 MVAr/km	145 kV: ~0.33 MVAr/km 245 kV: ~0.94 MVAr/km 420 kV: ~2.80 MVAr/km
Reactive power compensation	Only in specific cases	Required if >60 km length
Changing directions (lateral, vertical)	Straight wires between towers. ≤ 60° angles at towers.	Continuous bending or 90° angles if required
Fault arc resistance	Yes. But arcing, noise, and heat emission.	Yes. Arc remains internally. Pressure < Bursting pressure
Temporary overloading	Very good. High temperature wires < 350 °C with huge losses.	>1h at 1.5* I_r. Good heat dissipation by metal enclosure