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When Cables Won’t Do

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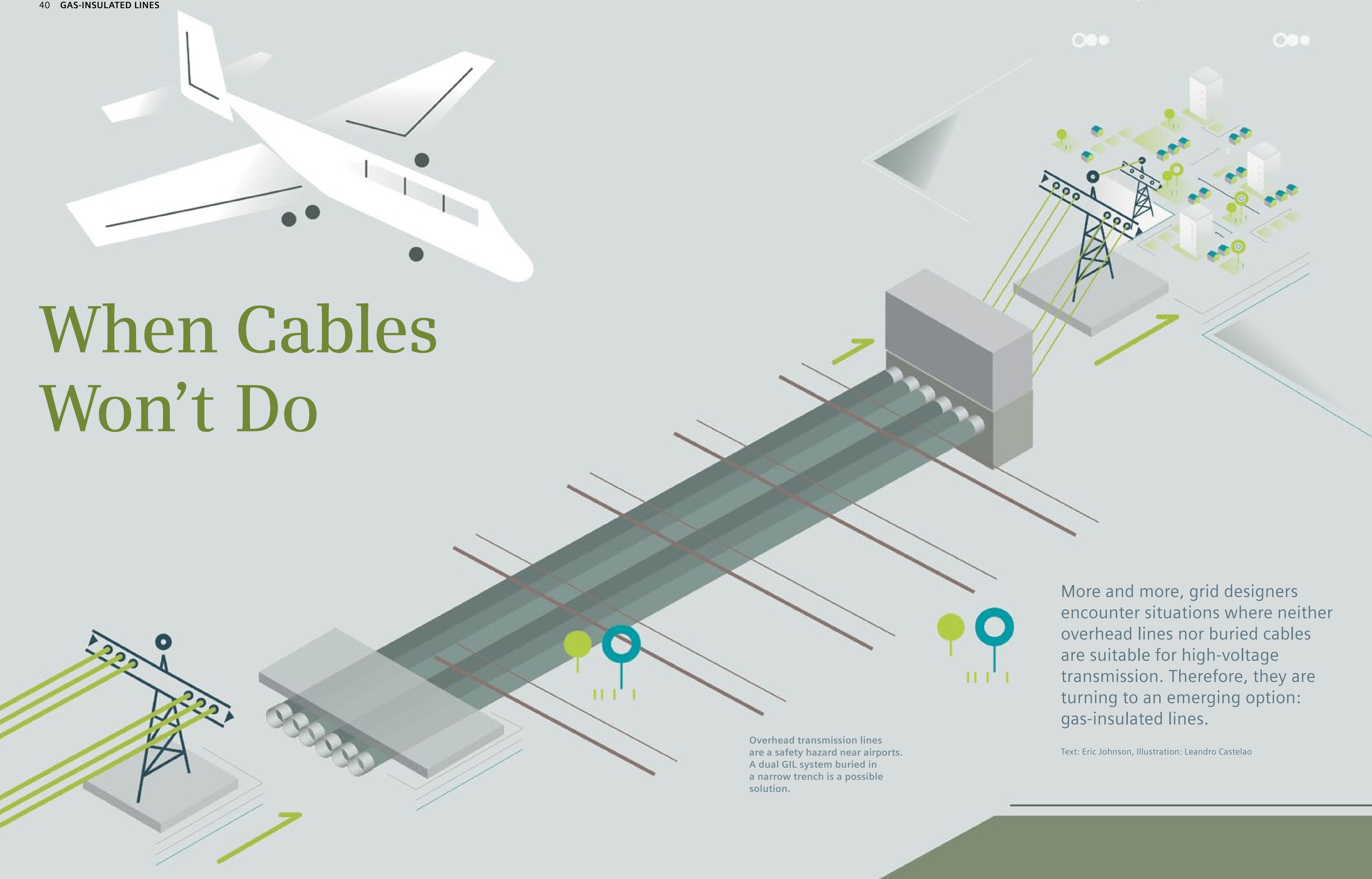
Answers for energy.

When Cables Won't Do



More and more, grid designers encounter situations where neither overhead lines nor buried cables are suitable for high-voltage transmission. Therefore, they are turning to an emerging option: gas-insulated lines.

Text: Eric Johnson, Illustration: Leandro Castelao

Overhead transmission lines are a safety hazard near airports. A dual GIL system buried in a narrow trench is a possible solution.

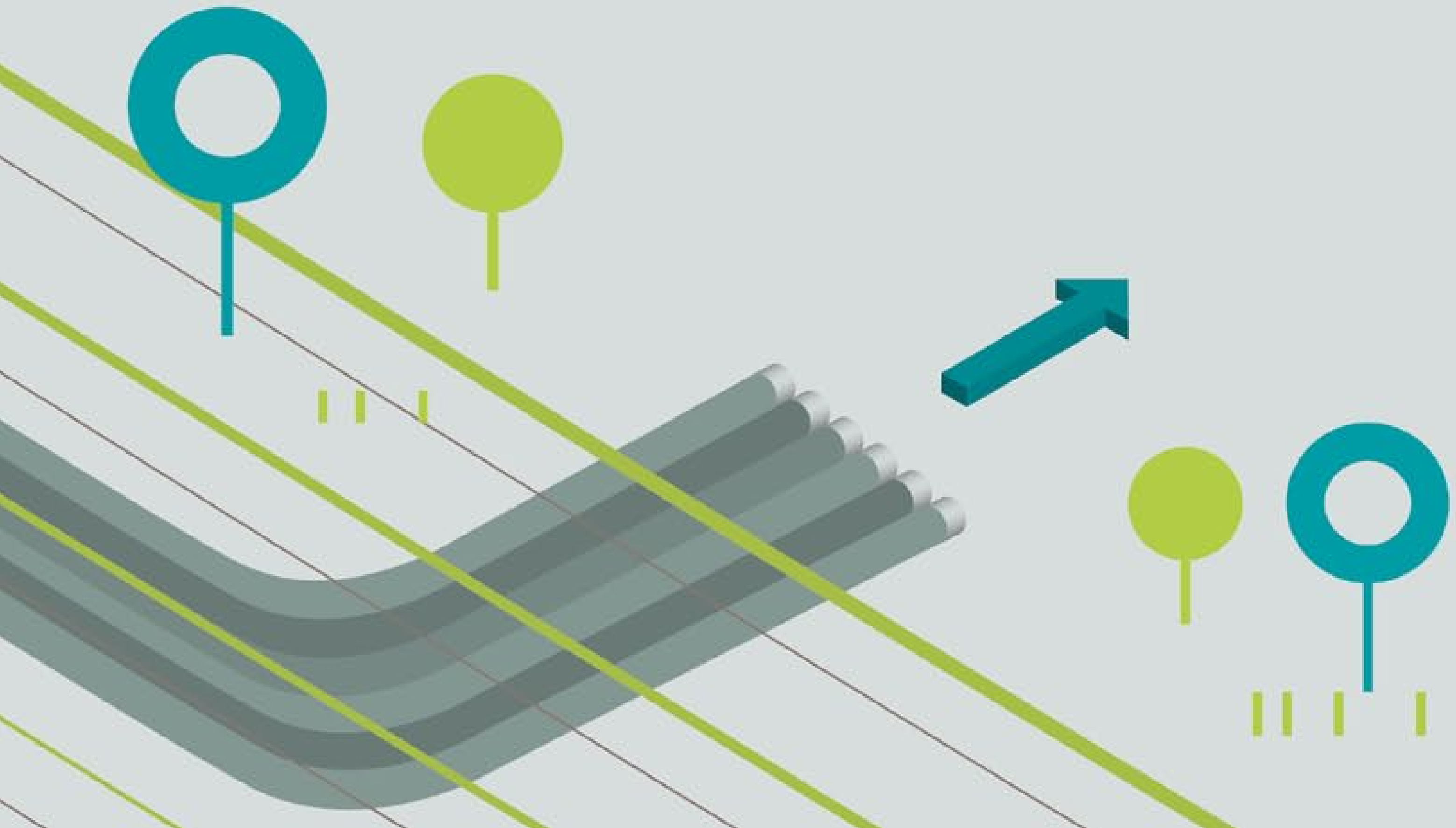
Pylons – these high-voltage highways grid landscapes around the globe. Marching across mountains, cutting across prairies, their stiff, robot-like figures guide massive loads of power from one place to another. So ubiquitous as to be iconic, pylons are the face to the public of the electricity industry.
Nonetheless, there are many places pylons cannot go. And sometimes, even their most common stand-in – underground cables – are also problematic. Take, for example, the main artery of a hydropower plant, the high-voltage line between the generating cavern and the external switchgear. Or the intra- and interconnections of gas-insulated switchgear (GIS). Or, for that matter, anywhere high-voltage power must share confined space with people and valuable equipment. Siemens has a homegrown solution: the gas-insulated transmission line (GIL). Since its 1974 debut at a southwest German hydroplant (still ticking along, without interruption), GIL has gone on to become part of Siemens-built installations in 30 locations.

Momentum has grown steadily; half of those structures have been commissioned over the last decade, and more are on order.
Although GIL's volume is not about to threaten pylons' iconic status nor to replace underground cables wholesale, the technology clearly is on the rise. To find out why, *Living Energy* talked to Stephan Poehler, an expert in GIL technology with the Siemens Energy Sector. In short: GIL is clearly a prime option for hydroplants, it is often worth considering in other crowded environments, and it can be applied in four ways (see sidebar).

Tell Me Why

The advantages of GIL, as it turns out, are myriad and often subtle.

■ Large capacity
At a maximum, GILs can transmit up to 3,700 MVA, but as Poehler points out, this is truly the high end, requiring forced cooling to dissipate the heat. A more typical load for a GIL is around 2,500 MVA.
This capacity competes easily with that of a pyloned line (at two to three times lower losses), and well exceeds what a mono-underground cable system can offer. This was a critical factor



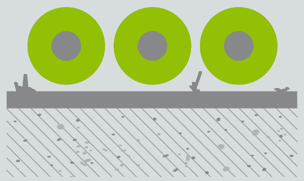
Illustrations: Leandro Castelao, independent

in a GIL that in the spring of 2011 went online at the international airport of Frankfurt, Germany. Carrying a power load of two times 1,800 MVA to a substation close to a new runway was impossible with overhead lines, because they would have posed a hazard to air traffic, so the choice came down to a GIL or an underground cable. GIL was selected because, among other reasons, its required trench is about half the width of what a double-underground cable system would need.
With lower-voltage systems, Poehler notes, underground cables are usually up to the job. However, in the 300- to 500-kV range, GIL starts to become very competitive.

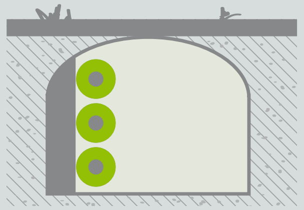
■ Nonflammability
"Think of heating a pot full of water in your kitchen," Poehler muses. "Now think of heating the same pot without water." The first analogy applies to GIL and the second to conventional cables insulated with XLPE (cross-linked polyethylene, a plastic compound). The massive metal content in GILs absorbs much more heat than an XLPE line, allowing it to maintain lower operating temperatures, even in overload mode. Thanks again to its massive, robust construction, a GIL is also much less prone to internal-arc faults and short circuits, and like overhead lines, it is amenable to automatic reclosure.
Nonflammability was among the key considerations in several recent hydropower installations. In Kaprun, Austria, for instance, a 150-meter GIL system is in action, and a 650-meter line consisting of 13 kilometers of GIL tubes is being built in China's Sichuan Province. In both cases, power is piped from the generators deep down in the mountain up to the top, where the pylons pass it on to end users. Using a nonflammable GIL rather than a conventional cable that could catch fire has two major design benefits: The tunnel no longer requires fire barriers, which block convection and therefore make cooling more ▸

Apps for Downloading Power

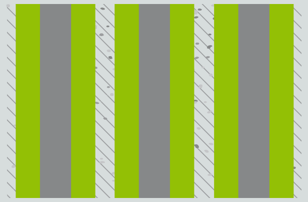
GILs are not new, but an attractive alternative to conventional cables, though unlikely to replace them. GILs come in four different application types:



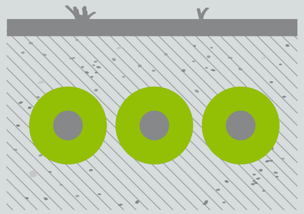
Aboveground
GILs are largely unaffected by extreme conditions. Particularly high transmission power can be achieved with aboveground installation.



Tunnel
GIL systems installed in a tunnel remain accessible for inspection. They pose no fire risk and allow the tunnel to be used for ventilation purposes at the same time.



Vertical
GILs can run at any gradient, even vertically, making them attractive in cavern hydropower plants.



Direct burial
Lines wrapped with polyethylene to safeguard the enclosure, and land above can be restored to agricultural use. Buried systems are expected to last over 40 years.

GIL can traverse steep inclines (above: Limberg power plant, Austria) or pass underground (below: Kelsterbach near Frankfurt Airport, Germany, before refilling the trench.)

Photos: Siemens

difficult, and accessibility and staff safety are guaranteed at all times during operation.

Flexibility in routing
Due to their unique properties, GIL systems are now used worldwide wherever difficult transmission tasks require complex routings. They have been installed in every conceivable layout, with shafts covering straight vertical inclines of 200 meters over steep slopes, passing around buildings, including subterranean structures, and smoothly following serpentine routings without being joined at angles.
Distances of up to about 70 kilometers are possible, Poehler says, without any compensation of reactive power. XLPE cables, by contrast, would need reactive compensation about eight times higher along that same stretch. Not only does this add cost to the line, but compensation is notorious for causing ambient noise – and irritating neighbors – from its air cooling. Furthermore, it causes operational losses, which are also a significant factor to be taken into consideration.
At the same time, Poehler cautions against overblown expectations that GIL might become the main future form of high-voltage transport. Massive load shifts, foreseen for new, remote generating areas such as the southwestern USA (solar and wind) or the North Sea (wind and perhaps tidal/wave), will be carried mostly by pylons. "In sensitive areas, GIL may be used instead," he notes, "but the workhorse will be overhead lines."

Direct link to GIS
Like father, like son: GIL technology was born out of GIS (gas-insulated switchgear), and their ongoing relatedness makes them natural partners. They have similar or identical characteristics in terms of transmission power, overload capacity, automatic reclosure, and other technical factors, making joins easier, cheaper, and usually smaller in volume.

Lowest electromagnetic field
With its "line in a can" design that neutralizes inductive current, a GIL generates electromagnetic fields 15–20 times lower than conventional cables, even meeting upper limits as low as 1 μT. So it can easily be used where there is sensitivity to such radiation: hospitals, air-traffic control centers, or computer clusters. Or exhibition halls: The Palexpo in Geneva, Switzerland, installed a 500-meter, 300-kV GIL in 2001 that allowed a new exhibition hall to be built directly above the transmission line (a few meters below ground) without any disturbance of the sensitive exhibited equipment.

Lack of aging
Unlike XLPE, which can degrade with usage, the gas in GIL does not age. So performance does not degrade over time. Because it operates at lower temperatures than conventional cables, the GIL is also subject to less thermal stress.

So Which Is It?

It is impossible to say precisely which feature is most important. The weighting of reasons, Poehler says, varies from one customer to the next. "And GIL won't be for everybody," he adds. "But it's a transmission technology that is going to grow and grow." Not into a replacement for the pylon, but enough so that decision makers really need to know about it. ■

__Eric Johnson__ writes about technology, business, and the environment from Zurich. Formerly, he headed what is now a Thomson Reuters bureau and corresponded for McGraw-Hill World News.

Further Information
www.siemens.com/energy/hv-gil

GIL Specifications

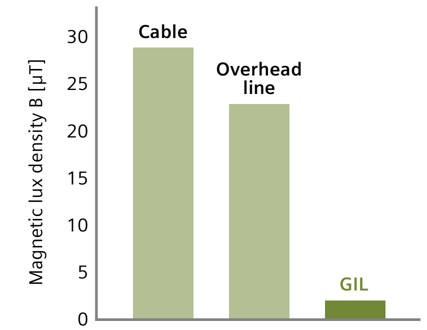
- Max transmission capacity per system:

3,700 MVA

- Max voltage: up to

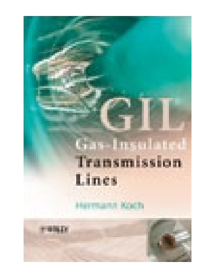
550 kV

- Max transmission distance without compensation of reactive power: up to 70 km
- Performance remains constant over time; no aging
- Fireproof
- High overload capacity
- High short-circuit withstand capacity
- Autoreclosure functionality
- Lowest electromagnetic field



A comparison of the magnetic fields for different high-voltage transmission systems for a 400-kV double system at 2 x 1,000 MVA load.

More information about GIL can be found in this book by Siemens engineer Hermann Koch, commissioned by the Institute of Electrical and Electronics Engineers (IEEE):



H. Koch: GIL – Gas-Insulated Transmission Lines (Wiley, 2011).

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