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Gas-Insulated Transmission Line (GIL)
Today and Tomorrow

1. Today's Use of GIL

The GIL is transmission technology is based on the technology developed for Gas-Insulated Switchgear (GIS) more than 35 years ago. In substations beside the purpose of breaking, switching, disconnecting and grounding also transmission of electrical energy gas insulated technology is used. In transmission cases GIL is applied for example to connect a GIS with the high voltage power transformers, which are usually placed in a distance of 10 – 20 meters and sometimes 300 – 400 meters away from the switchgear. In cases of GIS connected to the overhead line where the distances between the phases are much wider in GIS. Another field of GIL application is cross connections inside of substations, where directly buried GILs or GILs laid in concrete trenches are used instead of overhead lines.

In many cases GILs are laid in a tunnel in cases of cavern power plants. In 1974 the world wide first the GIL was build at the hydro power plant Schluchsee in Germany, shown in Figure 1.

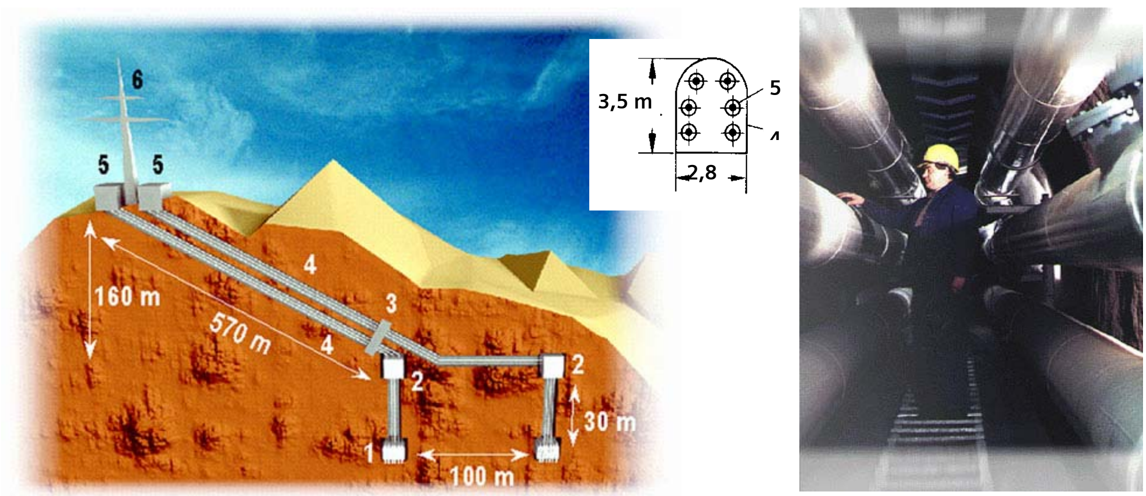

Figure 1: GIL installed at the Hydro Power Plant at Schluchsee, Germany

1	600 MVA Transformer	Rated Voltage	420	kV
2	Encapsulated Surge Arrestors	Rated Impulse Withstand Voltage	1640	kV
3	Transfer Switching units	Rated Current	2000	A
4	GIL Connection	Rated Short-Time Current	53	kA
5	Open Air Surge Arrestor			
6	Overheadline			

This GIL is still in operation without any problems. The GIL connects the high voltage power transformer (1) placed inside the cavern in the mountain with the overhead line (6) outside the mountain.
At the top entrance open air surge arrestors (5) and in the cavern encapsulated surge arrestors (5) are protecting the GIL against overvoltages. A transfer switch (3) allows the connection of the 600 MVA power transformer to the GIL in the tunnel (4). Such applications are typical for GIL, and have been applied world wide in a total length of more then 200 kms. Reliability by this GIL has been proven high in more than 35 years of operation under all kind of environmental conditions. GIL may be laid directly in the ground covered with soil, installed in tunnels or in concrete trenches or ducts or above ground by using steel structures.

2. Tomorrow Use of GIL

The use of GIL tomorrow and in the near future will be guided by the needs of long distance power transmission applications in cases where overhead lines can not be used and high power ratings are needed. This may be the situation in cities and large metropolitan areas, or if landscape protection reasons are given, or in conjunction with traffic tunnels. In a more far future also DC-GIL may be used for very long transmission lines to connect new remote generation areas with the load centres.

2.1 Long Distance AC-GIL

The needs of the future electric power transmission is influenced by the concentration and increase of power supply in cities and metropolitan areas, the use of new renewable energy sources (wind farms) and the improvement (or retention) of the supply reliability in a deregulated electricity market.

A few examples shall be given:

- TransEuropean Networks

In Europe the cross national border electric power transmission is limiting the electric power trade. Traditionally the cross border links are only built to act as a emergency supply in cases of supply problems in the neighbour country. Today the cross border links are needed to allow electricity trade and to bring competition to the energy market. Therefore the European Community has drawn a priority list of cross border transmission links to improve the situation.

The GIL will play an important role in cases where overhead lines can not be built and cables are not practical because of the transmission length and/or the transmitted power.

- Offshore Windfarms

New offshore windfarms are planned in many locations in the world, generating high amounts of electrical energy offshore, mean out of sight from the coast. This is usually the case in areas where the electrical load is low, so that new transmission lines to the load centres are needed. In Germany for example the offshore windfarms are planned to be in the North Sea and the load centres are in the west, middle and south with distances of 300 km to 600 km. The low public acceptance level of overhead lines may lead to problems in getting the right of way to build an overhead line, and it may leave the GIL as the underground solution available to transmit high amounts of energy over long distances at the maximum economical and ecological acceptance.

- Improved Reliability of Electric Power Supply of Cities

The world-wide concentration of electrical load in cities and metropolitan areas needs for the future new strong high voltage connections right into the centre of the load. At 400 kV or 500 kV rated voltages and with currents of 2500 A up to 3150 A the GIL offers the possibility to make electrical energy available in the needed quantity and quality of the load centre in the city or metropolitan area.

Two principle laying methods may be used for such long distance GIL: the directly buried version, where the GIL is laid similar to gas pipe lines, and the laying in a tunnel, which can be a tunnel only for electricity or together with street or railroad tunnels.

2.2 Long Distance DC-GIL

In a more far future the long distance DC-GIL might be used for underground transmission lines. Using the advantages of the high reliability of gas insulated systems and the much lower cost of steel pipes.

Some pre development works and first applications in DC-GIS have shown that DC-GIL is feasible, and might have the following basic design data:

The main insulating gas is Nitrogen (N_2) with a low (10 - 20 %) of Sulphurhexaflourid (SF_6). Such gas mixture can insulate the DC high voltage reliable for a long time. Such gas mixtures are used in low temperature applications for high voltage circuit breakers mainly in the arctic regions since more than 30 years.

The advantage of using a DC-GIL is, that the enclosure pipe can be manufactured by steel pipes, because the DC current does not induce eddy currents in the enclosure. This reduces the cost compared to AC-GIL where aluminium is used for the enclosure.

DC-GIL does not have capacitive loads so that very long distances may be installed. The laying of the DC-GIL will be the same way as AC and looks for directly buried version as shown in Figure 2 and for the tunnel laid version as shown in Figure 3.

Fig. 2: Directly buried version of GIL

Fig. 3: Tunnel laid GIL as operation at the Geneva Airport since 2000

3. <u>Conclusion</u>

Gas insulated transmission lines (GIL) have show their high reliability in more then 200 km of GIL in operation world wide, and over more then 30 years of successful use. The future requirements on the transmission network are increasing power transmission rating, economical and ecological acceptance, low transmission losses, high safety, high reliability and easy to install and operate systems. GIL offers all these features and will be used in future also for long distance applications.