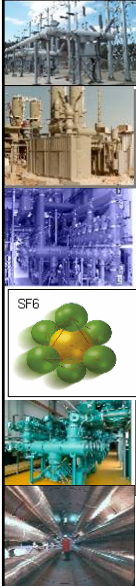




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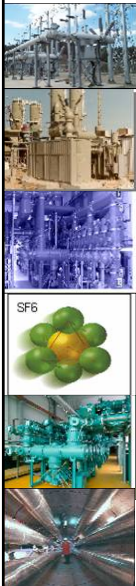




**IEEE**

**Substations Committee  
GIS Subcommittee K2  
Module  
Gas Insulated Transmission Line (GIL)  
Applications**

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## Contents GIL Applications




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### A Reference Projects


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## Applications Reference Projects




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Projects Name or Type	Country	City	Year	Data	Special
Schluchsee	Germany		1976	Tunnel laid	First SF <sub>6</sub> installation
Palexpo	Switzerland	Geneva	2001	Tunnel laid 2 <sup>nd</sup> generation	First N <sub>2</sub> /SF <sub>6</sub> installation
Joshua Falls	USA	Lynchburg, VA	1978	Directly buried	First buried installation
Baxter Wilson PP	USA	Mississippi	2001	Above ground	Water
PP9	Saudi Arabia	near Riyadh		Above ground	Desert installation
Hams Hall	England	West Midlands		Above ground 2 <sup>nd</sup> generation	Mixed installation

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## Applications Schluchsee


- Schluchsee, Germany
- Ratings
 

$U_r$	420 kV
$I_r$	2500 A
$U_{BIL}$	1640 kV
$I_s$	53 kA
- Single line, physical arrangement  
 GIL laid in a tunnel through a mountain  
 Connection of cavern power plant to the overhead line


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T&D Chicago GIL







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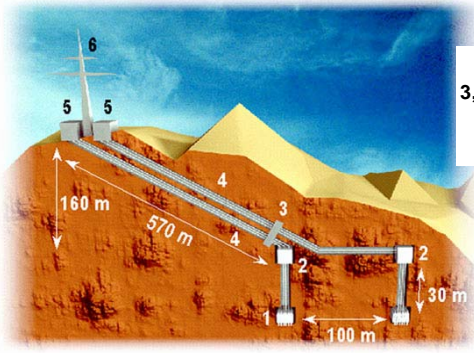


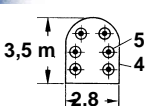
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## Applications Schluchsee

1. 600 MVA Transformer
2. Encapsulated Surge Arrestors
3. Transfer Switching units
4. GIL Connection
5. Open Air Surge Arrestor
6. Overheadline







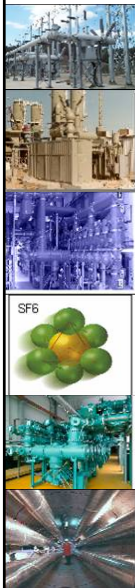
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## Applications Schluchsee



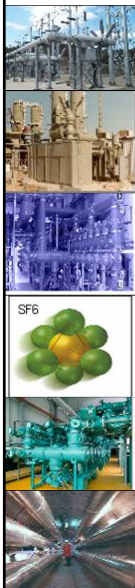
- The installation is connecting a hydro power plant to the 420 kV network as a peak load generation.
- GIL installed in a tunnel and operated at rated currents for pumping and peak load generation.
- More than 25 years in continuous, reliable operation since 1976.

T&amp;D Chicago GIL

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## Applications PALEXPO N<sub>2</sub>/SF<sub>6</sub> Type



- PALEXPO, Switzerland
- Ratings
 

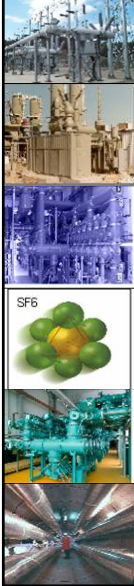
$U_r$	300 kV
$I_r$	2000 A
$U_{BIL}$	850 kV
$I_s$	50 ka
- 2 circuits totaling 3680 meters using N<sub>2</sub>/SF<sub>6</sub> gas mixture.
- The station was installed in 2001 and remains in service today.

T&amp;D Chicago GIL

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## Applications PALEXPO

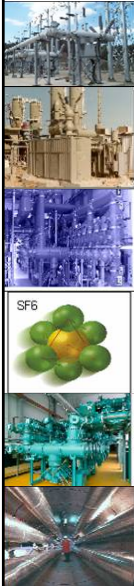


### Overview Picture

The GIL is laid in a tunnel using a 700 m bending radius. It is connecting an overhead line at the airport of Geneva.



## Applications PALEXPO

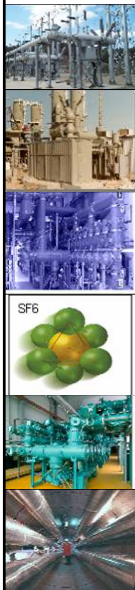


On site installation using a prefabrication tent





## Applications AEP Joshua Falls

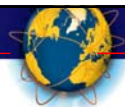


- AEP Joshua Falls station, Lynchburg, VA.  
145 kV GIS with direct buried GIL circuits to overhead lines.
- 2 circuits totaling 1640 meters.
- The station was installed in 1978 and remains in service today.
- Ratings

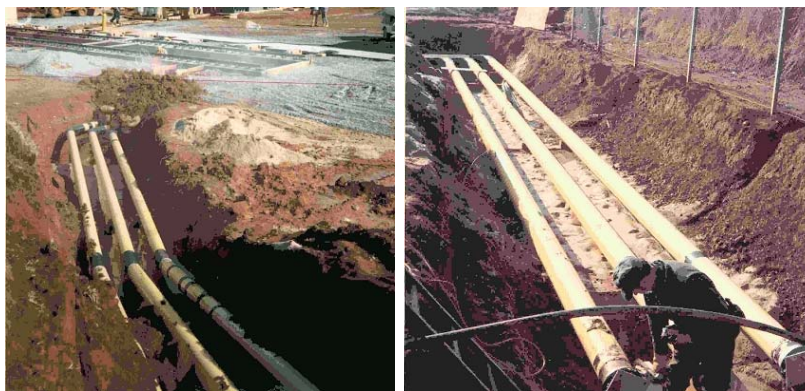
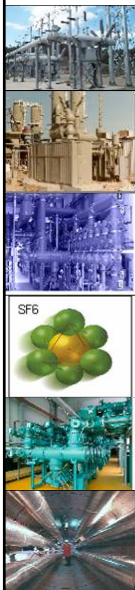
$U_r$	145 kV
$I_r$	2000 A
$U_{BIL}$	650 kV
$I_s$	63 kA/3 s

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## Applications AEP Joshua Falls



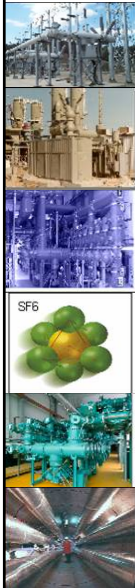
To minimize the overall visual impact of a new station, GIS was chosen for the switchgear and two GIL line exits were direct buried to overhead line access points away from the main GIS equipment.

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## Applications Baxter Wilson Power Plant



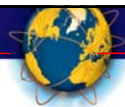
- Entergy - Baxter Wilson Power Plant, Mississippi
- Installed in 2001
- Ratings

$U_r$	550 kV
$I_r$	4500 A
$U_{BIL}$	1550 kV
$U_{SIL}$	1175 kV
$I_s$	63 kA/3 s (80 kA capable)

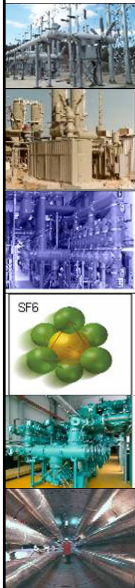
- A single circuit GIL with SF<sub>6</sub>/air bushings at each end of the line
- Total length – 1250 m

T&amp;D Chicago GIL

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## Applications Baxter Wilson Power Plant



GIL looking south. GIL runs across a flood plain.



GIL looking north. GIL runs along the road at ground level.

Several existing 550 kV and 242 kV lines cross the required right of way for a new line. Going over the existing 550 kV lines was not possible. GIL below the existing lines was the economical solution.

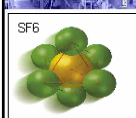
T&amp;D Chicago GIL

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## Applications PP9 Saudi Arabia

PP9 1200 MW Combined Cycle Plant in Saudi Arabia, near Riyadh

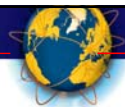


### Ratings

$U_r$	420 kV
$I_r$	1200 A at 55 °C
$U_{BIL}$	1425 kV
$U_{PF}$	630 kV
$I_s$	63 kA

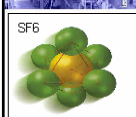
GIL

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## Applications PP9 Saudi Arabia

- Selected for:
  - High reliability
  - High power transportation capability
  - Low losses
  - Suitability for use in very stringent environment
  - Suitability for easy overhead installation



- 8 separate lines between the step-up power transformers and the plant's 420 kV GIS representing a total length of about 17 km.

- Installed at heights between 7 and 9 meters on steel supports.

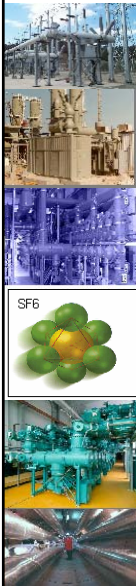
GIL

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## Applications PP9 Saudi Arabia



- Pure SF<sub>6</sub> insulating gas.
- Extruded aluminium alloy tubes with welded flanges for bolted connections.
- Conical insulators with long creepage distance for conductors support and compartments partitioning.
- Rollers fixed on steel supports to allow the free movements of tank tubes when exposed to thermal variations.
- Use of outdoor moveable tent to enable the enclosures to be assembled in the most reliable way even in dusty and windy external conditions.



GIL

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## Applications Hams Hall



- Hams Hall substation in West Midlands, England
- Connection through an existing AIS substation of an 275 kV up-rated to 400 kV line to the conventional feeder bay.
- Ratings

$U_r$	420 kV
$I_r$	4000 A
$U_{BIL}$	1425 kV
$I_s$	63 kA

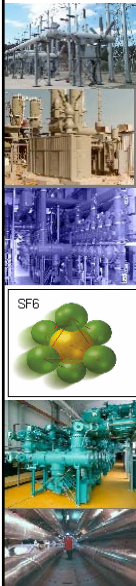


GIL

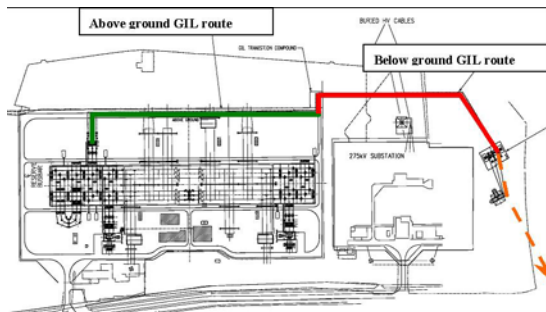
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## Applications Hams Hall



- Site crossing imposed either cables or GIL.
- Required continuous current rating would have necessitated 2 cables and 2 cable terminations per phase.
- Cost and technical feasibility in favour of GIL.
- GIL partly above ground (within the substation) in vertical formation and partly in covered concrete trenches (outside the substation).



GIL

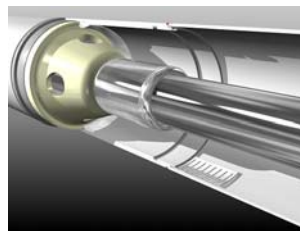
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## Applications Hams Hall



- Use of mixture of nitrogen and SF<sub>6</sub> (80/20).
- Special care to internal cleanliness by:
  - Low wear contacts
  - Use of particle traps around contacts and in the enclosures
  - No other friction between parts
- Conical insulators with long creepage distance for contact support and volume partitioning.
- Connection between enclosures by welding on site.
- Gas monitoring and internal arc location by electronic system using digital serial connections measurement.
- UHF sensors for partial discharge measurement.

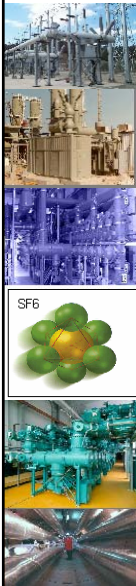


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## Contents GIL Applications



### B Type of Layouts

GIL

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## Applications Type of Layout



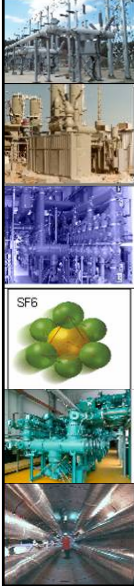
Typicals	Country	City	Year	Type	Special
Vertical GIL	Namibia	Windhoek	1977	245 kV, 800 m	
Tunnel	India	Nathpa Jhakri		550/420 kV	
Above Ground	Canada	Bowmanville	1987	550/420/245 kV	
Bridges				362 kV	
Power Plant				550 kV	
Transformer Connection				550 kV	
Trench				550 kV	
GIS Connection				550/420 kV	
Directly Buried				420 kV	
Overhead Line Connection	Switzerland	Geneva	2001	550/300 kV	

GIL

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## Applications Vertical GIL

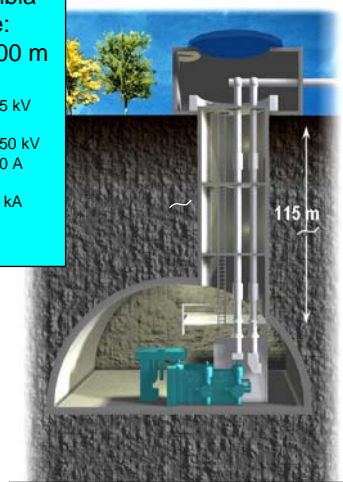


SF6



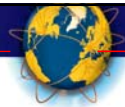
Windhoek Namibia  
Operation since:  
1977, Length 800 m

Rated Voltage	245 kV
Rated Impulse	
Withstand Voltage	1050 kV
Rated Current	630 A
Rated Short-Time Current	40 kA

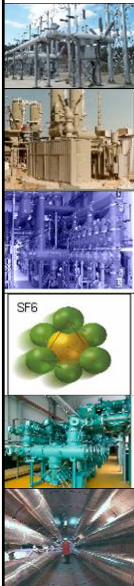


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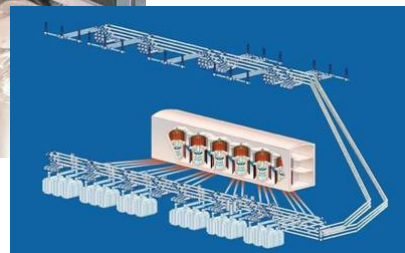
## Applications Tunnel (1)



SF6



Nathpa Jhakri 420 kV GIL (India)



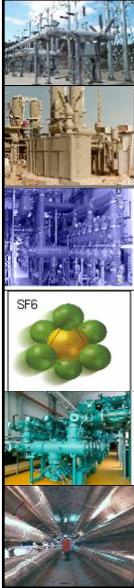
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## Applications Tunnel (3)



550 kV Double Circuit Hydro  
Power Plant

Field welded construction  
4000 Amps  
30 deg slope in the tunnel

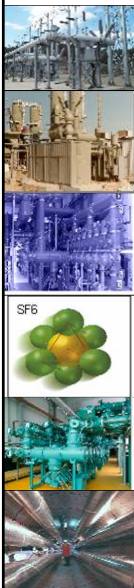
Connects the lower level generators and step up  
transformers to the GIS gallery.

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## Applications Trench



550 kV GIL Trench  
2.4 m wide

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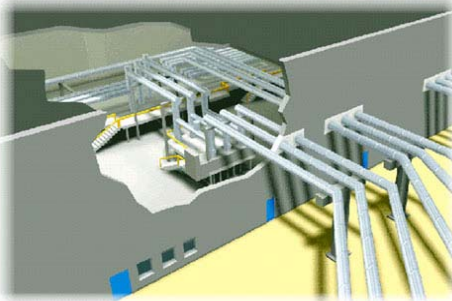


## Applications Above Ground (3)



Reference: Bowmanville, Canada  
 Operation since: 1985-87, Length 2.5 km

Rated Voltage	550 kV
Rated Impulse Withstand Voltage	1550 kV
Rated Current	4000 / 6300 / 8000 A
Rated Short-Time Current	100 kA

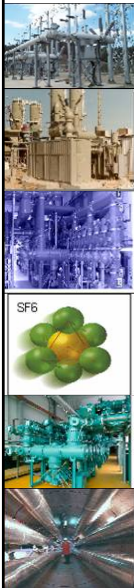


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## Applications Above Ground (4)



An alternative to OHL and cables for:



- Urban areas
- Protected lanscape
- Rough climatic conditions areas
- Power plants to S/S connections



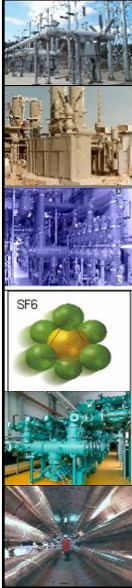
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## Applications Above Ground (5)



SF6





**242 kV Circuits**

Field welded construction  
80 kA short circuit rating  
3 kA and 4 kA circuits

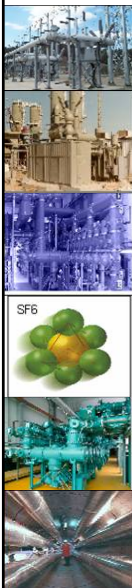
Very large GIS with many GITL bus exits. Lines are often situated away from GIS building and on opposite sides of the station. GIL bus is used to sort out the direction of the exits.

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## Applications Above Ground (8)



SF6



**550 kV 3000 Amp Line Crossing, Cross under Multiple 242 kV Lines**

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## Applications Above Ground (9)










Line Crossing Looking North

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## Applications Bridges












362 kV Bus Run

- Customer has problems with flood areas and poor soil quality. A truss bridge was constructed to hold the GIL run from the station out to where the line could be terminated.
- Shown during construction.

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## Applications Transformer Connection (1)

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SF<sub>6</sub>



550 kV GIL Typical  
Transformer Connection

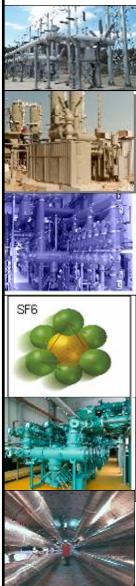
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## Applications GIS Connection (1)

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SF<sub>6</sub>









Circuit Breakers at  
Line Exit

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## Applications Directly Buried (2)










Laying into the Trench












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## Applications Directly Buried (4)

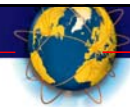









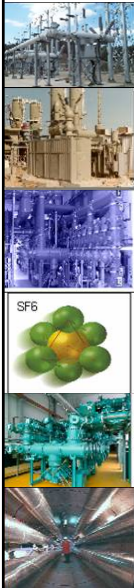
EDF SF<sub>6</sub>/N<sub>2</sub>  
 Test System  
 10 % SF<sub>6</sub> System  
 420 kV  
 3150 Amp  
 1425 kV BIL

6000 hr aging test at 1.5 per unit voltage & current to 4000 amps  
 GIL is available in either SF<sub>6</sub>/N<sub>2</sub> system or pure SF<sub>6</sub>

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## Applications Overhead Line Connection (1)



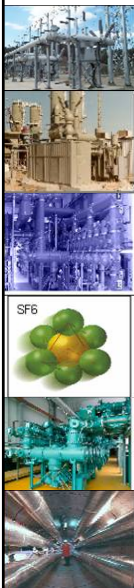
Line Exit Bushings  
Thermal expansion  
accommodated by  
allowing the bushings to  
slide ~ 150mm

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## Applications Overhead Line Connection (2)



PALEXPO, Geneva, Switzerland  
Overhead Line Termination

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