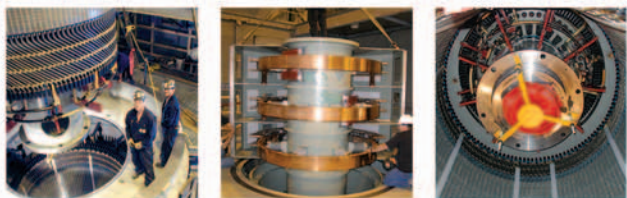


Variable Frequency Transformers

Grid Inter-tie



Variable Frequency Transformers

GE Energy revolutionizes the world of transmission solutions with its new Variable Frequency Transformer (VFT). The VFT provides a simpler way to control power between electrical grids than has previously been available.

What Is the VFT?

The VFT system is based on a combination of hydro generator and transformer technologies. It consists of a rotary transformer, for continuously controllable phase shift, together with a drive system and control, that adjust the angle and speed of the rotary transformer, to regulate the power flow through the VFT.

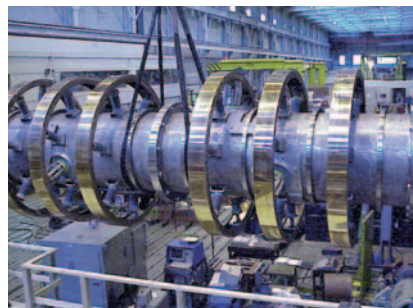
What Function Does the VFT Provide?

The VFT system provides a means to control power between two grids. The grids need not be synchronous. A common situation is where two grids of the same nominal frequency cannot economically be directly connected with ac lines. The VFT allows controlled power exchange between the grids, while retaining many of the inherent virtues of an ac interconnection.

Low Complexity and Low Maintenance

The simple design of the VFT components, based on established and widely used rotating machinery, ensures its long term maintainability.

- Use of common substation components; e.g., transformers, capacitors, breakers; allowing existing utility maintenance crews to be highly proficient.
- Low speed operation resulting in low maintenance requirements.
- Redundancy in auxiliary services; e.g., cooling fans.
- All main components are utilized for their low stress quality, resulting in high reliability.
- Independent operating channels allow maintenance on one unit while others remain operational.



VFT vs HVDC Back to Back

When compared to existing technologies, the VFT provides self-standing “Plug and Play” capability to provide controlled transmission solutions, independent of grid interconnection considerations. The low grid interaction of the VFT, in terms of harmonics, control interactions, and impact on nearby generators, allows the installation and operation to be decoupled from other grid issues.

Comparison of Technologies for Controllable Transmission of Electrical Power

	VFT	HVDC	VSC HVDC
High Efficiency	✓	✓	
High Availability	✓	✓	✓
Low Complexity	✓		
Low Maintenance	✓		
Small Space Requirements	✓	X	
Black Start Capability	✓	X	
Low Control Interactions	✓	X	X
Low Harmonic Generation	✓	X	X
Low Impact on Adjacent Generators	✓	X	X
Modular Design	✓		
Easy Integration with Grid	✓	X	
Bump-less Startup	✓	X	✓
Familiarity to Typical Power Engineer	✓	X	X

VFT – Variable Frequency Transformer
HVDC – High-Voltage Direct Current
VSC – Voltage Source Converter

✓ – Best in Class
BLANK – Industry Standard
X – Unable to Perform

VFT – Compact and Modular Design

VFT Offers Compact Substation Layout

The simplicity of the VFT, unlike traditional HVDC technology, lacks high-voltage filters and allows for a more compact substation design. The drawing illustrates this comparison, with a 200MW VFT station layout superimposed on a 200MW HVDC layout.

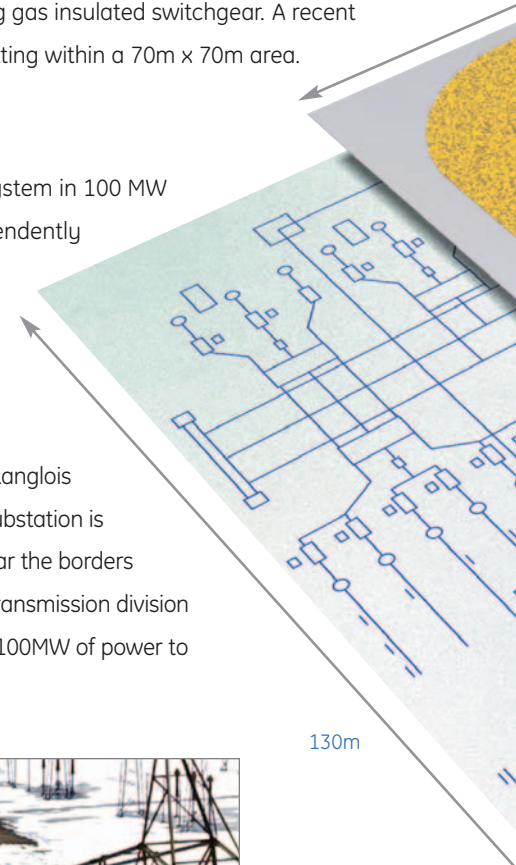
VFT systems can be made very compact by using gas insulated switchgear. A recent project was designed for a 300MW VFT system fitting within a 70m x 70m area.

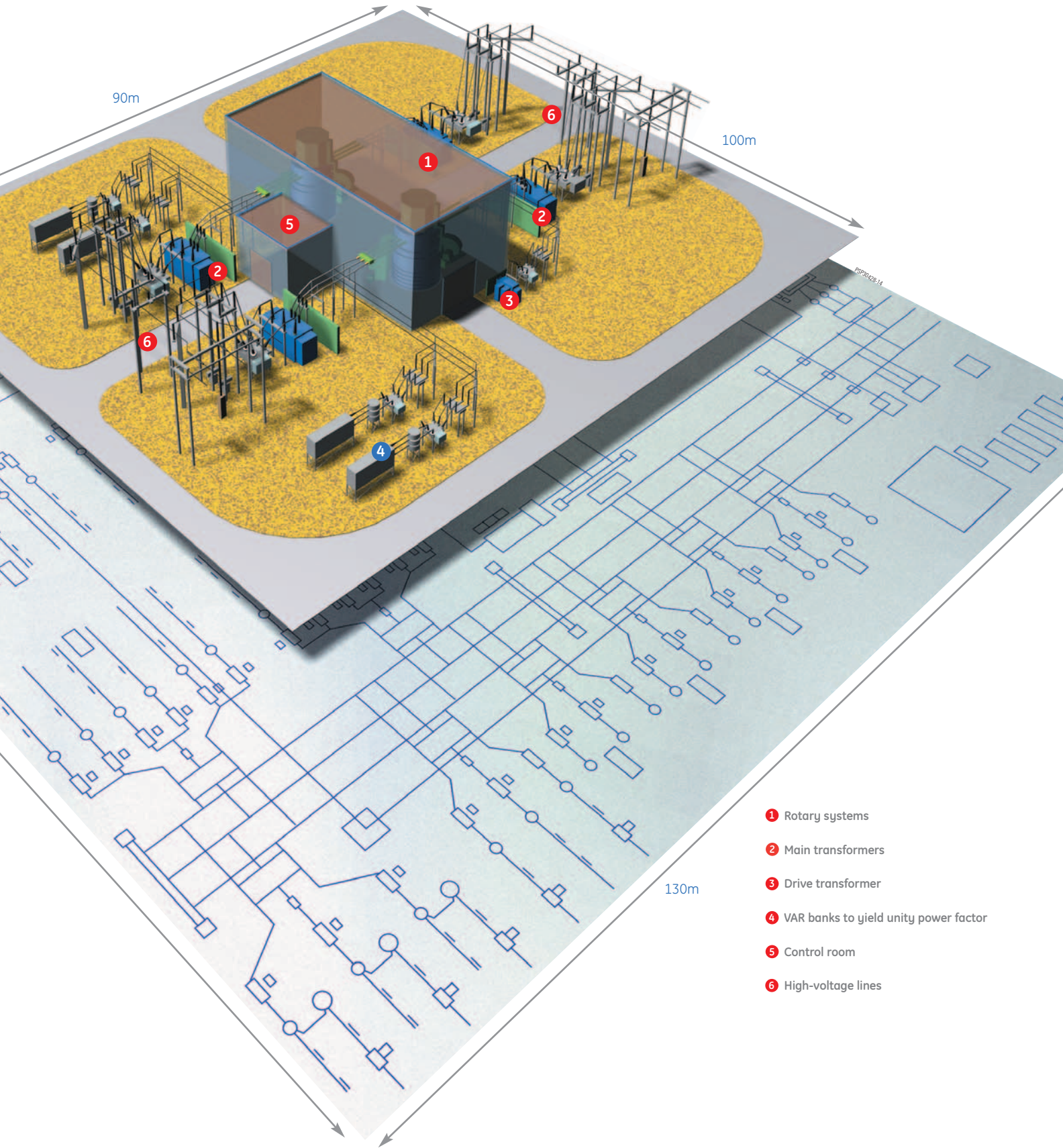
Modular Design

GE Energy has designed the VFT as a modular system in 100 MW channels. Each 100 MW channel operates independently providing for maintenance flexibility.

First Commercial VFT Installation

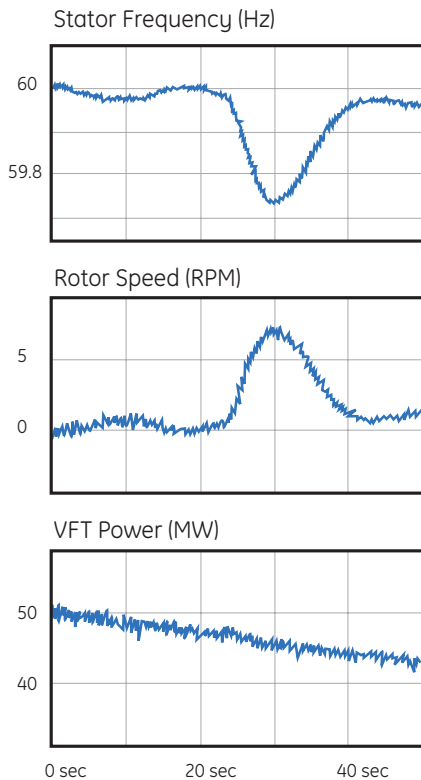
The first commercial installation of a VFT is at the Langlois transmission substation in Quebec, Canada. The substation is located in St.-Timothée, southwest of Montréal, near the borders of Ontario and New York State. TransÉnergie, the transmission division of Hydro-Québec, is able to transfer an additional 100MW of power to and from neighboring power grids.





- 1 Rotary systems
- 2 Main transformers
- 3 Drive transformer
- 4 VAR banks to yield unity power factor
- 5 Control room
- 6 High-voltage lines

Operation & Control



Nov. 1, 2003 – Langlois VFT response to a Hydro-Quebec generator trip, while VFT was ramping.

Steady-state power control is smooth and continuous, including at zero power. The remote operator sets the VFT's power command in a manner similar to dispatching generation on the system. Startup and shutdown are bump-less to the grid.

The VFT's inertia smoothes responses to grid faults and transients, and looks much more like a transformer to the grid than a sensitive power-electronic device like HVDC.

Grid studies and field tests show that the VFT inherently improves stability of adjacent electric power networks.

VFT Control System

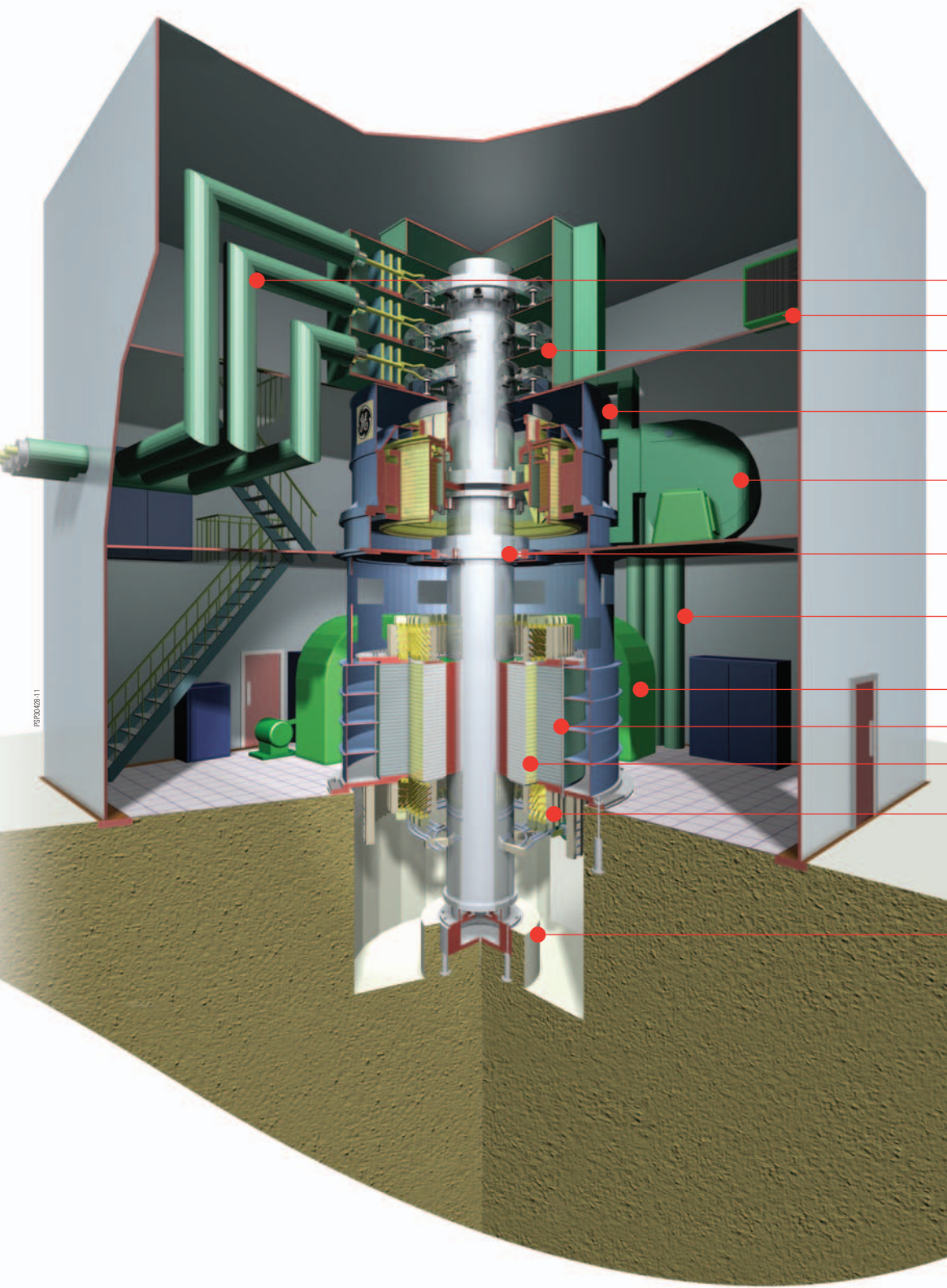
The VFT uses field-proven GE utility and industrial digital control technologies. The control system is simpler and has far less electronics than HVDC. This means easier maintenance and support. The control system includes:

- Redundant GE PowerLink Advantage™ HMI PC's provide for superior user interface & monitoring, multi-level dispatch, ramp rate setting and sequence of events recording
- Main control cabinet is based on a GE D200 substation automation platform for multi-unit functions, SCADA interface for unmanned operation, and data concentration from individual protective devices and unit controls.
- Individual unit control cabinet, for each 100 MW unit utilizes GE Fanuc PLCs, GE's Multilin Universal Relays, and GE's Turbine Static Starter Control for the fast power and torque regulators.
- GE's DC2000 Drive System for shaft torque control.

Each 100 MW unit can be operated at its individual unit control, without need for HMI, SCADA or main control cabinet



The rotary system is the heart of the VFT. It is comprised of an assembly of well-proven components and sub-systems to form this new offering. The machine design is based on a vertical, air-cooled concept for simplicity and reliability.



VFT Rotary System includes:

- rotating transformer
- DC drive
- collector

Rotor bus duct

Air housing

Three-phase collection

DC torque drive motor

DC motor ventilation fan

Upper bearing

Stator bus duct

Rotating transformer ventilation fan

Stator core

Rotor core

Windings/connections

Lower thrust and guide bearing

PG0428311

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web site at gepower.com.

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