

# Custom Power Technology Development

A continuing goal of the Custom Power Task Force will be to centralize information concerning the development of custom power technology and the installation of devices that utilize this technology. This list presents the most current information available regarding custom power technology as of May 26, 2000.

Note that this is an application-oriented listing of projects. With these new technologies, companies are very reluctant to apply them until there is some field experience. Sharing of information about applications helps to generate acceptance for the technologies in the marketplace, identifies benefits and potential problems with the technologies in specific applications, and helps identify areas for future technology improvements. All of these are important overall benefits that can be achieved without the sharing of proprietary information about particular products and technologies.

A similar approach has been used for years in the HVDC Subcommittee and its associated working groups (more recently expanded to include FACTS technologies). The HVDC groups published a number of papers and bibliographies that documented HVDC installations around the world, helped develop guidelines for equipment specifications, and significantly enhanced the visibility of these new technologies in the marketplace. These are the kind of objectives that we would like to accomplish with the activities of the Custom Power Task Force.

This list is categorized by the various emerging technologies within customer power: static transfer switches, static series compensators, and static shunt compensators. Ongoing research and studies are also described in a miscellaneous category.

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## Transfer Switches

### *American Electric Power*

AEP is in the process of installing an indoor 15kV, 600A static transfer switch at an industrial park in Columbus, Ohio. The switch was placed in service during the fourth quarter of 1998. As of this last update the switch has had no operations in the field. (Last update December 1998)

### *Baltimore Gas and Electric*

BGE has demonstrated an indoor 15kV, 600A static transfer switch at an office building in downtown Baltimore. The switch was placed in service in September 1995 and has operated successfully since that time.

BGE has also placed an outdoor 15kV, 600A static transfer switch in service at a customer's chemical manufacturing plant in the Baltimore metropolitan area. The switch was placed in service in September 1996 and has successfully prevented over twenty service interruptions due to power quality events since that time.

Additionally, BGE has demonstrated a mobile 15kV, 600A static transfer switch at a customer's chemical manufacturing plant in the Baltimore metropolitan area. The mobile switch was placed in service in May 1997 and provided short-term power quality protection from 7 power disturbances until December 1998 when a permanent switch was installed in its place. The permanent installation is a 15kV, 1200A split-bus static transfer switch, and has prevented over ten power interruptions from the customer. (Last Update: January 1998)

### *Chubu Electric Corporation*

In 1991, Chubu Electric Corporation of Japan installed three 7.2 kV, 300 A static transfer switches in a loop line configuration. The devices are reported to have a high reliability rate since installation and require a maintenance check every year. (Update: January 1998)

### *Commonwealth Edison Company*

ComEd installed a static transfer switch rated at 12.47kV, 600 A on August 14, 1996 at a plastic film manufacturer. Between January 1 and October 15, 1997, there were 50 events with 40 successful transfers with no loss of production and 10 events that resulted in production interruption. Of the 10 events, 5 events can be explained because voltage sags were present on both feeders.

It performed very well in 1998 and the customer seems quite satisfied. The performance numbers for 1998 were 95 transfer events with the customer experiencing a loss of production during two of those events. This data shows an increase in the

number of transfer events over that reported for 1997. That increase was largely due to a settings change in the switch controls that made the switch more sensitive. For instance, 18 of the transfer events were caused by energization of capacitor banks at the substation that feeds the switch. The switch settings were changed due to the monitoring data obtained from the events recorded in 1997. The data indicated that some of the events where the customer lost production in 1997 could be prevented if the switch response was a little faster. The data also indicated that there is little effect on the alternate feeder when the switch transfers the load over to it. (*Last Update: January 1999*)

### ***Detroit Edison Company***

Detroit Edison installed a static transfer switch at the Ford Motor Company Sheldon Road Plant. Sheldon Road is a components plant that provides parts to all of Ford's North American assembly plants on a just in time basis. The switch was placed in service on November 10, 1996. This plant is fed from a 40kV subtransmission system and has a load has a load of 9MVA. The switch is installed on the 13.8kV side of the transformers.

Since going in service, the switch has avoided costly downtime. Without the STS, the Sheldon Road Plant would have experienced nine disturbances in the past year; five due to outages of the preferred feeder and four due to voltage sags. These disturbances would have had substantial impact on this plant that has large injection molding processes, as well as welding processes for heat exchangers and radiators. (*Last Update: January 1998*)

### ***Kyushu Electric Corporation***

Kyushu Electric of Japan has installed eleven static transfer switches between 1990 and 1997 for the purpose of high-speed line transfer. They are each rated at 7.2kV, and for 200A to 300A. The devices use a hybrid switching device made up mainly of a thyristor switch and a high-speed parallel switch. The high-speed parallel switch can open and close in less than one millisecond using an electromagnetic repulsion scheme. Thus, through the use of the parallel switch, the thyristor elements are bypassed during steady-state operation, and only conduct during a transfer or other such operation. This eliminates the need for any type of cooling equipment. (*Last Update: July 1998*)

### ***PG&E Energy Services***

PG&E Energy Services installed two static transfer switches in September 1996. Both are rated at 25kV, 300A and are in commercial operation. PG&E Energy Services is progressing with development of a fast voltage regulator rated at the same voltage and current. They have completed all tests in the first commercial unit and the unit is scheduled to be in service the third quarter of 1998. This will protect the customer from sags even on radial taps. Circuit simulation and scaled-down prototype testing has been completed for many line-load conditions. (*Last Update: July 1998*)

***Texas Utilities***

TU has demonstrated an outdoor 15kV, 600A static transfer switch at an electric operations building in Fort Worth, Texas. The switch was placed in service in October 1996 and has operated successfully since that time. (*Last Update: January 1998*)

***Toyo Oil Industry Company***

The Toyo Oil Industry Company of Japan installed a static transfer switch in 1997 for a generating unit transfer application. (*Last update: July 1998*)

## Static Series Compensators

### *BC Hydro*

BC Hydro has installed a prototype platform-mounted series compensation device. The device was installed in May of 1999 and reached a milestone after 6 months of successful field operation with 100% availability. (*Last Update: November 1999*)

### *Duke Power*

A series compensation device was placed on-line carrying critical customer plant load in late August 1996 on the Duke Power Company system in Anderson, South Carolina. The device is now in service at Orian Rugs, Inc. where the unit is protecting the automated yarn manufacturing plant from voltage sags and disturbances coming from the Duke Power distribution system that serves the plant. The unit is rated at 2MVA, can store 660kJ, and operates at 12.47kV. Normal load current is approximately 120A. The series compensation device is continuing to perform as designed, and is still being closely monitored. This was the prototype device of its kind, and thus reliability has been a challenge. However, 1999 proved to be a successful year with very reliable operation. (*Last Update: February 2000*)

### *ESKOM*

A series compensation device utilizing the SMES technology for energy storage was installed at the Sappi Limited, Stanger Mill in South Africa in April 1997. The Stanger Mill provides pulp for Sappi's paper making process. Power for the mill is generated by an ESKOM facility nearly 500 miles north of Stanger. It travels through areas of some of the highest lightning density in the world. The local municipality delivers power to the mill over a 33kv distribution line. The SMES based series compensation device was installed, and within 6 months had protected against 45 sags, half of which would have taken the plant down. This device is rated at 750kVA and provides 2.4MJ of energy storage. (*Last update: April 1998*)

### *Florida Power Corporation*

The 2MVA inverter-based static series compensation device continues to successfully demonstrate improved power quality on one of six 12.47kV feeders at the Econ Substation (230/12.5kV) in a high commercial/residential load density area of Orlando. This unit was placed in service in 1996. (*Last Update: December 1998*)

### *Powercor Australia, Ltd.*

A 50 Hz series compensation device was commissioned at the Bonlac Foods plant at Stanhope, Victoria in Australia where it protects the sensitive dairy food process plant load from disturbances originating on the Powercor Australia overhead rural distribution system. The Bonlac plant produces powdered milk and other related dairy products from milk supplied by nearly 800 dairy farms in the area. The unit is rated at 2MVA,

can store 660kJ, and operates at 22kV. Placed in service early in 1997, the 2MVA static series compensation device is providing voltage sag protection to a major dairy food production facility. The plant is served from an extensive overhead 22kV distribution system that is fed from a distant 66/22kV substation. The dairy plant has calculated a one-year payback for the custom power equipment. Annual savings from power disturbances are estimated at approximately \$1M US. (*Last Update: December 1998*)

### ***Salt River Project***

Two series compensation devices have been installed at a critical industrial site on the SRP system in the metro Phoenix area. Each series compensation device is rated to protect approximately half the plant load. The two units will protect the entire manufacturing plant from voltage sags that occur on the SRP system and the interconnected WSCC grid. Each device is rated at 6 MVA boost, 12.47 kV, 60 Hz, 1800 kJ energy storage, and can boost a 20 MVA load as much as 30%. The series compensation devices are configurable with multiple load/boost taps to a maximum load of 1200 Amps. They have been in full operation since July 1, 1998. Since its installation, it has compensated for numerous power disturbances that would have caused the end-user a process interruption, and has shown excellent reliability. (*Last update: December 1998*)

### ***ScottishPower***

A 4MVA 50Hz series compensation device is being installed at the Caledonian Paper Mill at Irvine, Scotland to protect the paper machine from voltage sags originating on the 132kV system feeding the mill. From monitoring carried out on ScottishPower's transmission and distribution system, and also within the paper mill, it was confirmed that the paper machine process could be affected by disturbances of only 10% variation from normal. Other solutions that were considered but ruled out at the plant were on-site generation, DC driver alteration, uninterruptible power supply (UPS) systems, static var compensators, and superconducting magnetic energy storage (SMES) systems. The DC drives were made more resilient after consultation with the vendor, but did not protect the paper machine from all sags. The UPS and SMES solutions were considered inadequate because of their higher cost and limited capacity. The static var compensator was ruled out because of the lack of active power flow control. Installation involved segregating the critical load 11kV bus protected by the series device from the rest of the plant load. The device has been in operation since April 1998 and has successfully compensated numerous voltage disturbances that could have disturbed the customer's process. (*Last Update: December 1998*)

## Static Shunt Compensators

### *American Electric Power*

AEP has installed a distribution static shunt voltage compensator at a rock crushing facility. This facility has two existing rock crushing operations with a third going into service. The operation produces minerals that are used in construction and agriculture. Simulations and site power quality monitoring demonstrated that unacceptable voltage flicker of approximately 8 to 12 percent would occur if the third operation were connected. This level of flicker would exceed the acceptable utility criteria of approximately 4 percent and adversely effect other customers on the feeder. The rating of the device installed at the facility to control the voltage flicker is  $\pm 2$  MVA at 12.47 kV. It was placed online in January 1998 and commissioned on February 12, 1998. The unit utilizes two 1 MVar capacitor banks that allow operation with output from 0 to 4 MVar capacitive. This mode allows the customer's load to grow and provide increased capacity at lower cost. The unit is considered successful by AEP and has allowed the customer to grow its business and operate all three stone crushing operations at the same time with minimal impact of voltage flicker to other customers on the circuit. (*Last Update: December 1998*)

### *British Columbia Hydro and Power Authority*

This all-power electronic static shunt compensation device has successfully completed the one-year demonstration project at the Adams Lake Lumber Company in Chase, British Columbia where it provided voltage regulation and voltage flicker mitigation caused by a large whole log chipping operation. This device is capable of adjusting the line voltage  $\pm 4.2\%$ . Field experience has shown that overall flicker was reduced from 5-8% to 2.5-4%. The  $\pm 2$ MVA inverter-based trailer unit is now being readied by BC Hydro for relocation to another site where voltage flicker is creating major problems for customers on the 25kV distribution system. (*Last Update: December 1998*)

### *Central Japan Railway Co.*

A static var compensator (60 MVar capacity) was applied at 77kV as a countermeasure against voltage fluctuations and unbalanced load due to an electric railroad. It was installed for the Shin-kansen (super express train) line at the Shin-Biwajima substation in September 1993. Its successful operation was followed by three static var compensator installations for the Central Japan Railway Co., as follows:

- 60 MVar, 154kV installation at the Shimizu substation in May, 1994,
- 34 MVar, 77kV installation at the Shin-Maibara substation in June, 1994,
- 48 MVar, 154kV installation at the Shin-Takatsuka substation in July 1994.

(*Last Update: July 1998*)

**Chubu Electric Corporation**

A static shunt compensation device was implemented in October 1990 using a 20 MVAR GTO inverter for arc furnace flicker compensation on a 22 kV feeder. The successful operation and experience of this first installation encouraged the steel manufacturer to further increase arc furnace operation, and was followed by another static shunt compensation device installation using a 21 MVAR GTO inverter for the same purpose in May 1995. The GTO inverter cubicles of the second static shunt compensation device were specifically designed to be more compact in size in order to provide benefits for industrial application use. (*Last Update July 1998*)

**Kansai Electric Power Co.**

The first experimental prototype of an advanced static var compensator was installed on the 77 kV sub-transmission line at the North Osaka substation of The Kansai Electric Power Co. in Japan in August 1979. The device's voltage source inverter was comprised of conventional thyristors with self-commutated circuits. The objective of this project was to prove the operational characteristics (i.e., generation and control of capacitive/reactive power) of a 20 MVAR class voltage source inverter at the sub-transmission level for the first time in the world. This first experience of this experimental static var compensator resulted in the successful installation of an 80 MVAR, 154 kV unit connected at Inuyama switching station in Japan in May 1991. (*Last Update: July 1998*)

**Mitsubishi Steel Co.**

A static var compensator of 3.5 MVAR capacity using a bipolar transistor inverter for arc furnace flicker compensation was installed on the Mitsubishi Steel Co. 33 kV feeder in December 1989. This installation was implemented in conjunction with an existing 60 MVAR SVC that had been installed in April 1984. The additional 3.5 MVAR D-STATCOM enabled an increase in steel productivity of the arc furnace without any increase in the previous flicker level.

At another Mitsubishi Steel plant, a static var compensator using a 21 MVAR GTO inverter for arc furnace flicker compensation was installed on the customer's 22 kV system in April 1994. This installation also provided a successful reduction in flicker level, and enabled a further increase steel productivity from the existing arc furnace. (*Last Update: July 1998*)

**Oglethorpe Power**

Oglethorpe Power Corporation and Oconee Electric Membership Corporation, a member system of Oglethorpe Power, are host utilities to an installation of an distribution static var compensator installed on a 12.47kV feeder serving a building products plant in Dudley, Georgia. The plant uses many large induction motors that cause flicker when starting and operating. In addition to flicker, a low power factor is

present when the motors are idling, which is often the case. This installation continues to mitigate flicker as designed. (*Last Update: December 1998*)

### ***Public Service Electric and Gas***

A 1.2 MVA static series compensation device has been service on the PSE&G system in New Jersey since September 1994. The unit has delivered reliable service and has provided high reliability during that time. Numerous field tests have demonstrated boost operation as well as through-fault protection for load-side faults. (*Last Update: July 1998*)

### ***Seattle Iron & Metals Corporation***

The installation and of a 5 MVA, 4.16 kV distribution-level static shunt compensator was completed in July, 1999 at the Seattle Iron & Metals Corporation's new steel recycling facility in Seattle, Washington. The static shunt compensation technology was selected as the preferred option for voltage flicker compensation of a 4,000 Hp shredder motor, which is being operated at the new facility. The static shunt compensator inverters have a rated output capacity of +/-2,000 KVAR (continuous rating) and +/-3,000 KVAR (overload rating for 1 minute). The system is designed such that it can control the reactive power from 0 to 5,000 kVAR in combination with the inverters and the capacitor banks used for both the shredder motor (1,200 kVAR) and the static shunt compensator system (1,000 kVAR). In this application, the static shunt compensator system is operating at 4.16 kV and provides reliable power quality for both the new steel recycling facility and the interconnecting utility, Seattle City Light, which provides power to the plant at 26.4 kV. Final field testing and commissioning of the static shunt compensator system was completed in February, 2000. (*Last Update: May 2000*)

### ***Sumitomo Steel Co.***

A static var compensator using an 8 MVAR GTO inverter for arc furnace flicker compensation was installed on the Sumitomo Steel Co. 22 kV feeder in July 1995. This installation successfully provided a reduction in flicker level, and enabled an increase in steel productivity from the arc furnace. (*Last Update: July 1998*)

## Miscellaneous

### *Chalmers University*

Chalmers University of Technology in Gothenburg, Sweden is running a project on obtaining high power quality for a wind farm connected to a weak system. Using a voltage-source converter for the interface of one of the wind turbines reduces harmonics and voltage fluctuations due to the wind farm. This VSC replaces the normal grid-commutated converter. It controls the voltage amplitude through the injection or consumption of reactive power, limits the harmonic currents injected by this wind turbine, and absorbs the harmonic currents produced by the other turbines. The same methodology can be applied to a group of adjustable-speed drives. (*Last Update: December 1998*)

### *Clemson University*

Clemson has been involved in specifying characteristics of voltage sags that are critical in evaluating the sizing of static series voltage compensation devices. (*Last Update: January 1998*)

### *Hydro-Québec*

During the last two years, Hydro-Québec has performed electromagnetic transient simulation of technologies related to static transfer switches, static series compensators and static shunt compensators. The next step of their program is to test the actual control system of those systems in their real-time simulator at IREQ. They hope to be able to test the control system of some commercial transfer switch in November 1997. Their main goal is to verify the dynamic response of the system to realistic disturbances on a typical Hydro-Québec distribution network. During 1998, Hydro-Québec will probably make a field test of a 25kV transfer switch at a customer site depending on the real time simulator results. (*Last Update: September 1997*)