GE Power

Products & Solutions for the Power Generation Industry

GE's Power Conversion Business

gepowerconversion.com

Challenge & GE Value

GE is active in every segment, power block type and global region – from the most advanced integrated gasification combined cycle to the largest supercritical coal-fired power plants and hydro dams.

We put our extensive experience to use every day – devising new solutions for emerging industry challenges, adapting best-in-class technologies to unique segment needs and creating a power supply that's engineered to perform.

Whether you're planning a new power plant or seeking to modernize existing assets, GE's Power Conversion business can help you to meet the requirements for base or peak load operations.

Our products and solutions are designed to bring you increased efficiency, greater operational flexibility and seamless integration between your process and the grid.

Equipment Supply

Cleaner, More Efficient Technology

We provide leading technology motors, generators, MV and LV drives combined with automation and controls. Our focus is on:

- Reliable, proven products and components
- System engineering that meets our customers' specifications
- System solutions that may include additional electrical balance of plant products
- Optional equipment installation services
- Adaptable, robust and dynamic test systems for efficient and reliable equipment operations such as motors, generators, turbines and gearboxes

Outage Excellence

Electrical System Optimization During Planned Outages

To manage timing, execution and performance of services for critical assets, we provide customized services, upgrades and life extensions for generators and auxiliary systems in powerplants. Going beyond GE's core offering, they:

- Extend from component level up to the broader electrical system
- Include standard packages and customized solutions for simplified outage management
- Deliver increased performance of auxiliary systems and overall plant part load efficiency
- Reduce operating costs – for example through addition of variable-speed drives or LCI control upgrades
- Cover the maintenance, upgrade or replacement of Power Conversion's legacy and other OEM equipment

Asset Performance Management

Productivity Solutions to Minimize Unplanned Downtime

- Equipment insights that flag failures before they occur
- Access to the right information at the right time enabling you to optimize maintenance costs
- Process-based analytics at the plant level allowing you to optimize asset performance
- Outcome-based service agreements

Power Generation Solutions

Turbine Starters/Exciters

- Static excitation equipment (SEE)
- Start-up frequency converter (SFC)
- Compact units (SFC/SEE).

Auxiliary System Drives

- Variable-speed drive systems
- LV and MV Drives
- MV Motors
- Control and Automation

Generators

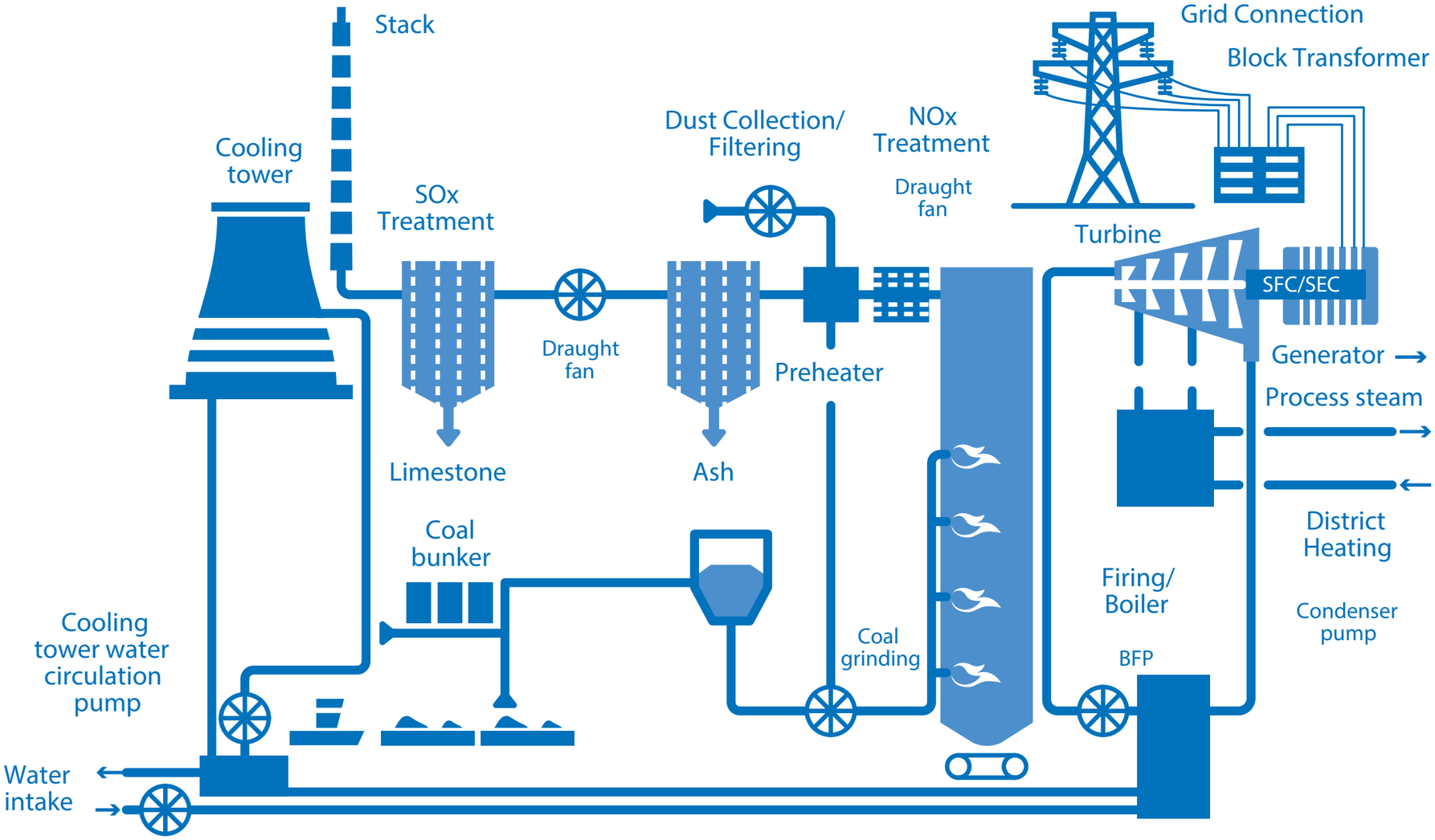
- Up to 70 MW
- For gas turbine, diesel or small hydro plants

Electrical Balance of Plant Solutions (EBOP)

- Electrical & control rooms
- Power evacuation equipment
- High-voltage switchyard

Outage Services

- Customized services
- Upgrades and life extensions for generators, motors, and drives in power plant auxiliary systems such as pumps and fans



Electric Variable-Speed Drive Systems (eVSD)

Thermal power plants typically consume a percentage of the power they produce, driven by the operation of auxiliary systems such as boiler feed pumps, circulation pumps, cooling water pumps, condensate pumps, exhaust and draught fans, conveyors, and coal mills. In the past, fixed-speed or hydrocoupling solutions were mainly used to control the speed of such pumps or fans – leading to power loss and costly process inefficiencies.

eVSD vs. Fixed-Speed Systems

In fixed-speed systems, to control variation of the water and/or airflow of pumps or fans, typically valves and dampers are used to restrict pipes or air inlet and outlet areas. Compared to driving a car, it is like using the brake to reduce speed while pushing the accelerator at the same time.

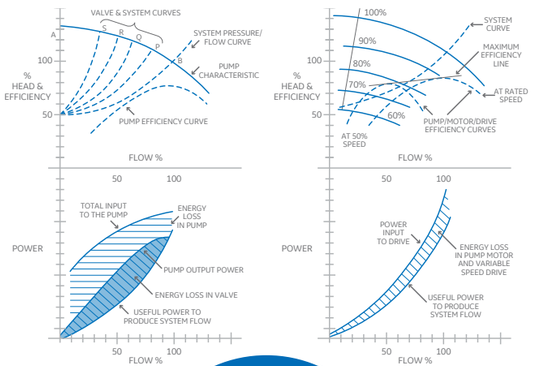
Fixed-speed systems would show:

- A pump or fan efficiency curve having a top value near to the design point with lower efficiencies at reduced flows
- A significant additional power loss in the valves or dampers under reduced flow conditions

GE's eVSD help to optimize the operating profile of pumps and fans by adjusting the motor speed to the required load profile, and realizing energy and cost savings.

Operation of a pump or fan at variable speed enables the user to match the pump or fan's characteristic head or flow curve to the needs of the system:

- Flow is proportional to speed of rotation
- Head generated is proportional to speed
- As the speed changes, so the efficiency curve changes: i.e. the point of max. efficiency reduces with the speed which enables operation at the highest pump or fan efficiency over a wide flow range



eVSD enables
up to 30%
energy savings on a main boiler feed pump in a 600 MW coal or oil fired power plant

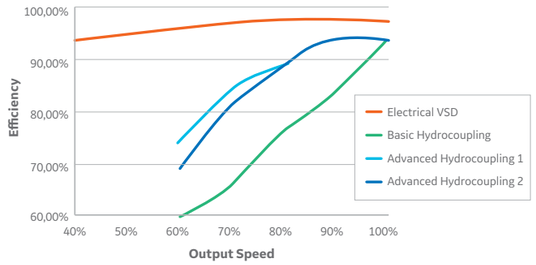
Key Benefits

- Reduced production costs through energy savings, and reduced emissions
- Enhanced plant heat rate through increased process efficiency
- Higher power output per energy input, for increased profitability and faster ROI
- Improved operational flexibility during low and peak demands
- Improved accuracy and faster response time of electrical solutions (speed, torque, acceleration, etc.)
- Voltage dip supportability of eVSD systems to control torque during voltage dip, and restart capability after full voltage interruption
- Reduced short-circuit level in the network (under fault conditions, the eVSD will isolate the motor from the network)

eVSD System vs. Hydrocoupling

Compared with hydrocoupling solutions, electrical VSD systems have clear energy-efficiency advantages on the entire speed range. For example, they further expand the plant's operative flexibility by enabling a smooth start-up, meaning no inrush current, no operation restriction and longer lifetime for the shaft train. No inrush current also means no voltage drop onto the grid, which greatly reduces the power supply requirement. In addition, by offering operational capability on the full speed range, adaptation to process changes are mad easier; and with fewer components, no rotating parts and less mechanical stress, maintenance requirements are significantly reduced.

Comparison of drive efficiencies



Example Calculation for Boiler Feed Pump BFP

Up to **11%** energy savings†

12 x 5 MW –3 x 50% average operational load

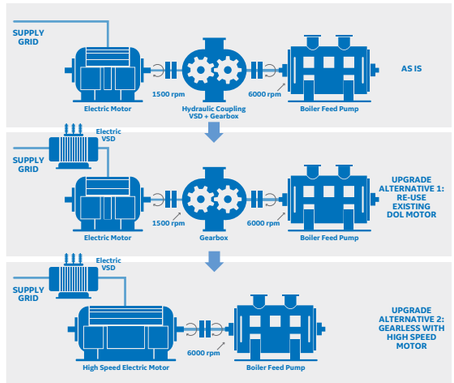
Moving from hydraulic coupling to electrical VFD could result in estimated energy savings per year† of

- up to 11% of the BFP energy consumption
- i.e. 28k MWh out of 255k MWh = savings of up to 2.9M$/year†

†Savings estimation based on general load profile. BFP power consumption and water flow/pressure profile are required for accurate saving calculations)

Key Benefits

- High operating flexibility and the ability to run at any speed (from 0 to 105% of nominal speed)
- Improved accuracy and faster response time of electrical solutions (speed, torque, acceleration, etc)
- Voltage dip supportability of eVSDS to control torque during voltage dip, and restart capability after full voltage interruption
- Reduced noise and vibration
- Ability to share variable speed on several motors or the option to run motor at fixed speed in routine mode for economies of scale and operating flexibility
- Reduced overall power plant size and equipment and no inrush current consequence
- Higher security of supply and reduced network disturbance



Upgrade options:
- Option 1: re-use existing DOL motor
- Option 2: Gearless with high speed motor

- Higher range of power – see the broad track record of electrical VSD applications vs. very few references of Mec/Hydat high power
- Reduced civil engineering costs and smaller footprint for space savings on the shaft-line
- Reduced short-circuit level in the network (under fault conditions, the eVSD will isolate the motor from the network)
- Reduced maintenance, no moving parts

Power Generation Product Portfolio

Power Electronics

Core component of electrical variable speed drive (VSD) train. Voltage source inverter (VSI) IGBT-based and load commutated inverter (LCI) thyristor-based technology.

Models
- MV6 Series
- MV7 Series
- SD7 Series

Technical Capabilities
- Output power: 0.25–120 MW
- Output voltage: up to 13.8 kV
- Output frequency: up to 300 Hz
- Input frequency: 50 or 60 Hz ±5%

Electric Motors

Full range of solutions for pump and compressor applications in harsh environments.

Models
- Induction Motors
- Synchronous Motors
- High-Speed Motors

Technical Capabilities
- Speed: 40–20,000 rpm
- Power: 1–100 MW
- Voltage: Up to 13.8 kV
- Hazardous Area: Zone 1 or 2 and Div 1 or 2

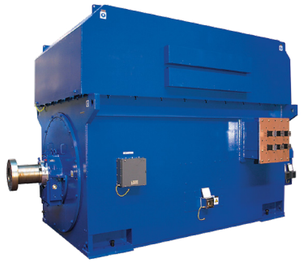
Generators

Operate effectively and reliably in challenging applications.

Setting the standard in generator manufacturing for over 125 years.

Models
- 2-Pole turbo generators (gearless)
- 4-Pole synchronous gas and steam turbine (alpha) – laminated or solid rotors
- Reciprocating engine driven (beta) industrial generators

Technical Capabilities
- Speed: 2–22 pole range
- Power: 2,500–80,000 kVA
- Voltage: Up to 22 kV
- Frequency: 50 or 60 Hz
- Hazardous Area: Zone 1 or 2 and Div 1 or 2



Starter/Exciter

The combination of static excitation equipment (SEE) with static frequency converter (SFC) in compact units enables smooth turbine starting while managing grid power variation, with one single interface to the power plant control.

Models
- Static Excitation Equipment (SEE)
- Start-up Frequency Converter (SFC)
- Compact units

Technical Capabilities
- SFC output power: up to 15.5 MW (air-cooled) and up to 40 MW (liquid-cooled)
- SFC voltage: up to 3.5 kV (air-cooled) and up to 18 kV (liquid-cooled)
- SEE current: up to 8,000 A (12,000 A peak)
- SEE voltage: up to 780 V (1,000 V peak)

Automation and Control

Maximize System Availability and Process Uptime

The controls executing across our automation and drive systems platform are built using a mature suite of reliable and secure automation components assembled into modular, flexible and scalable automation solutions. Our solutions use modern interfaces like OPC-UA, IEC 61850 and web technologies to facilitate integration with customers' existing OT/IT infrastructures.

Key Components
- HPCi: High-performance system controller for process control and automation
- PECe/PECeLite: Drive controllers with associated power interfaces (PIBs) and specialist control libraries
- P80-Pilot: Engineering toolbox and its associated system engineering tools
- Visor: Remote monitoring and diagnostics system to provide safe and secure remote service capability and connection to Predix for remote analytics

e-House

GE's integrated e-house solutions combine electrification, motion and control systems with GE's engineering expertise, offering optimized solutions for power supply and control across intensive industrial and power generation applications.

Key Components
- Modular control building with protection, control, metering and communications panels
- Switchboard
- Power transformers
- MV/LV switchgear and transformers
- Integrated SCADA system
- Monitoring and diagnostic systems for transformers, motors and breakers
- Motor control center
- UPS and battery systems
- HVAC
- Lighting

Turnkey Solution
- Multi-level, multi room
- 100% continuous welded panels
- Automatic fire detection and suppression system
- Fire and smoke dampers
- Reports for structural, seismic, air conditioning, illumination and fire
- Installation guidelines
- MV/LV Cables
- Cable routing and laying

Medium Voltage Drives – MV Series

Solution and Scope

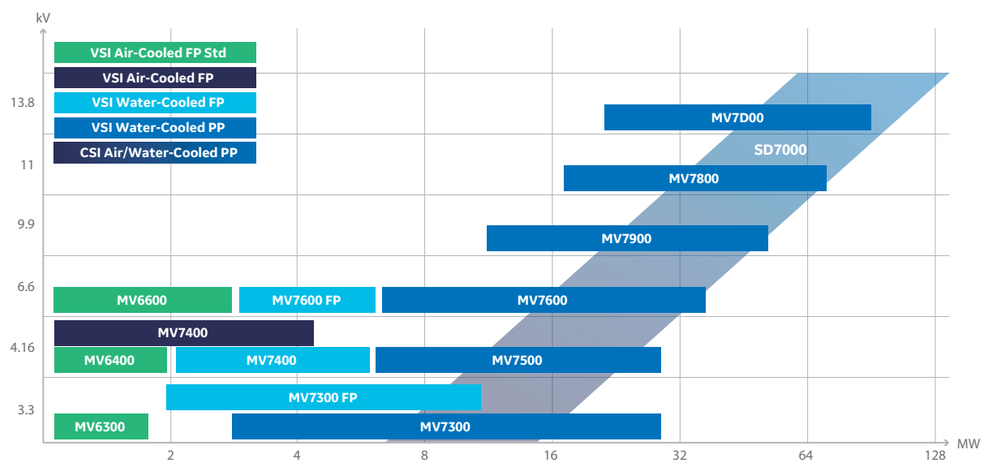
Advanced technology power electronics and decades of process expertise come together in GE's medium voltage drive series – a portfolio of proven performers. Easy to install and maintain, the series offers high reliability and availability and helps improve the uptime of electrical drive systems. It also can provide the flexibility required to achieve a customized solution across different pump or fan configurations. Building upon our power conversion expertise, GE's PWM medium voltage drive delivers high efficiency at both full and partial loads within a compact design and delivers an accurate and perfect-quality torque to pump or fan motors.

Output power	Up to 81 MW
Output voltage	Up to 10 kV
Output frequency	15-90 Hz, 0 to 15 Hz on request
Input voltage	3 to 10 kV ±10%
Input frequency	50 or 60 Hz ±5%
VFD system efficiency	Up to 99%
Power factor	>0.96 (DFE) / 1 (AFE)
Input harmonics	IEEE 519 compliant

Benefits

- Peak power density – our single drive can deliver up to 15,000 kW with just 18 IGBTs, which is equivalent to a power density of 1.5 MVA/m^3
- Proven reliability and availability with over 10 million hours in operation across an installed base of over 8.5 GW
- Power scalability with à la carte option packaging that can be adapted to a wide range of loads
- A full family of drives – GE's broad portfolio makes us your one-stop provider
- Up to 99% efficiency
- Encoder-less vector control thanks to the high-performance control system we developed which guarantees optimum torque quality, power and speed regulation

Power Plant Types:
- Gas-fired power plants
- Steam power plants
- Hydro power plants



Low Voltage Drives

GE's low-voltage drive series is suitable for a wide range of power conversion applications, providing customers with flexible solutions for their needs.

Solution and Scope

The LV7000 series is a robust low-voltage AC drives solution suitable for a wide range of requirements with a complete power range from 0.25 kW to 2000 kW.

The key design feature is the software and hardware modularity. Two types of control are available – the standard sensor-less vector control and the closed loop flux vector control for more demanding applications.

The LV7000 family comprises compact and high performance drives. LV7000-1 is a space-saving compact drive whereas the LV7000-2 and 3 are high-performance drives combined with powerful support for various software applications.

The drives are easy to program and use via a keypad. The keypad can easily be removed for hand held use or door mounting. The LV7000-1 has a detachable, seven-segment LCD keypad without memory capabilities which is used to communicate with the drive, set parameters and for monitoring.

The LV7000-2 and 3 have a detachable, alphanumeric keypad with built-in memory. In addition it can be used to copy parameters between different drives and store active parameters for future use. LV7000 drives are compact and user-friendly, and compared to constant speed solutions they can help you save up to 50% in energy consumption.

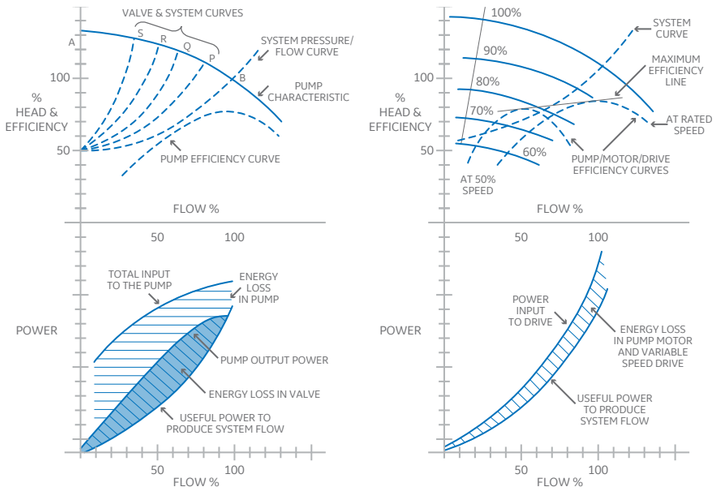
Output power	Up to 2000 kW
Input voltage	208–240 Vac/ 380–500 Vac/ 525–690 Vac
Input frequency	50 or 60 Hz ±5%
Enclosure	IP21–IP54
Power factor	>0.96 (DFE)/1 (AFE)
Control	Standard sensor-less vector control or advanced closed loop flux vector

Benefits

- Assured quality and reliability as each drive is tested at maximum temperature and full motor load prior to shipment
- Full modularity – choose from three control units (LV7000-1, LV7000-2, LV7000-3), each with various options
- Easy installation and commissioning using versatile PC tools for loading, setting and comparing parameters
- Quick set-up thanks to smart preset parameters
- Versatile control and integration with single-drive and complex process control applications possible
- Energy savings of up to 50% for improved environmental performance

Power Plant Types:
- Gas-fired power plants
- Steam power plants
- Hydro power plants

Variable-Speed Drives for Thermal Power Plant Auxiliaries



Solution and Scope

From an energy perspective, there are numerous similarities between the operation of pumps and fans. Pumps are specifically designed to operate at close to maximum efficiency and, under fixed-speed methods, flow is controlled by closing valves. For fixed-speed fan control, the inlet or outlet ducts are restricted by movable dampers to create a pressure drop. This is known as damper control.

In fixed-speed control, all systems will show:

- A pump or fan efficiency curve that has a top value near to the design point, with lower efficiencies at reduced flows
- A significant additional power loss in the valves or dampers under reduced flow conditions

These methods of control are equivalent to using the brake of a car to reduce speed while simultaneously keeping a foot on the accelerator.

Now contrast this with the potential energy savings of variable-speed systems.

The operation of a pump or fan at variable speed enables you to match the pump or fan's head or flow curve to the needs of the system. In applications where the movement of water or air is involved:

- Flow is proportional to the speed of rotation
- Head generated is proportional to the speed

As the speed changes, the efficiency curve also alters (as shown in the image left). The point of maximum efficiency reduces with the speed and it's possible to operate at the highest pump or fan efficiency over a wide flow range.

Thermal power plants typically consume a percentage of the power they produce. This is driven by the operation of auxiliary systems such as boiler feed, circulation, cooling and condensate pumps, as well as exhaust and draught fans, conveyors and coal mills.

In the past, methods used to control these pumps and fans have been chosen so that their motors operate at a fixed speed. Variation of the water and/or air-flow in these constant-speed applications has typically been through valves and dampers to restrict pipes or air inlets and outlets.

Our aim is to help our customers realize the energy and cost benefits of using variable-speed drives to achieve a flow that optimizes these processes.

Benefits

- Reduced production costs – through energy savings
- Enhanced plant heat rate – through increased efficiency
- Higher power output per energy input – for increased profitability and faster ROI
- Reduced emissions
- Improved operational flexibility – during low and peak demands
- Improved accuracy and faster response time of electrical solutions – speed, torque, acceleration, etc.
- Voltage dip supportability of VSDs – to control torque and restart capability after full voltage interruption
- Reduced short-circuit level in the network – under fault conditions, the VSD will isolate the motor from the network

Power Plant Types:

- Gas-fired power plants
- Steam power plants
- Combined cycle power plants

Electrical Balance of Plant

Solution and Scope

GE's EBoP offering uses a reference design that addresses the electrical aspects of a plant, from power evacuation to control. The integrated system is scalable, flexible and designed to respond to customers' requirements. This is either as a fully engineered equipment package or procured and constructed solution – or provided as individual components.

We can tailor our solutions to meet project-specific needs, compliance to codes and standards, as well as local requirements. These combine our vast turbine fleet expertise with our comprehensive EBoP portfolio.

Today's power plants are becoming increasingly complex, especially when connecting disparate systems together seamlessly. This creates a number of challenges for the industry in demand management, back-up-power, emergency power, power quality and energy savings.

We combine one of the largest installed bases of turbine generators in the world with more than a century of experience delivering innovative, high-voltage solutions in generation, transmission, and distribution networks. We offer a versatile and robust suite of solutions for EBoP applications combining best-in-class manufactured products with engineering and installation services.

Major components of the solution include:

- High-voltage equipment
- Medium- and low-voltage electrical equipment including motors and drives
- Monitoring and diagnostic systems for starters and exciters, drive systems transformers and motors
- System protection and control
- Generator step-up transformers
- Auxiliary transformers
- Power metering systems
- Communications systems
- Plant control systems
- Power quality systems
- Comprehensive electrical studies

Power Plant Types:

- Heavy-duty turbine generation to hydro pump storage
- Renewable wind and solar applications
- Industrial applications

Benefits

- **Faster return on investment** – facilitated by on-time Commercial Operation Date (COD)
- **High reliability enhanced by proven design** – which is compliant with international standards
- **Complete monitoring and control of power plant electrical systems** – enabling better visibility and maintenance
- **Seamless installation and commissioning** – due to the integrated system with optimized interfaces
- **Increased visibility and maintenance** – due to complete monitoring and control of power plant electrical system
- **Smoother project execution** – due to the simple coordinating design and construction entity.
  This assures agreement between all designs and systems

Power Generation Services

Meeting the Needs of Your Operational Model

GE`s Power Conversion business offers customized services for electrical equipment and systems in thermal power plants matching the needs of customers' individual operational and maintenance models—from daily operation, routine and scheduled maintenance, to planned outage services.

Auxiliary System Motors and Drives

- Inspection, diagnostics and preventative maintenance
- Installation of Motor Asset Performance Management System (Digital-ESA)
- Motor spare parts for legacy brands
- Addition of eVSDfor speed control to improve efficiency of underutilized plants
- Synchronous motor excitation system replacement or upgrade
- Complete maintenance service and support contract for motors and drives
- Advanced diagnostics capability for early failure detection through drives thyristor health check
- Modernization of drives control and automation of any manufacturer
- Complete drive replacement

Power Island Equipment

For Alterrex Excitation System –Exciters

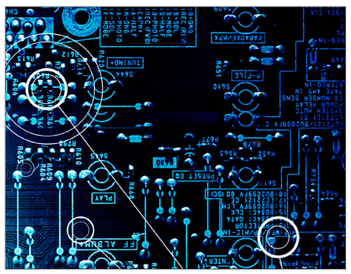
- Replacement rotor, stator or complete exciter
- Brush replacement and conditioning
- Uprate studies to support generator upgrade

For compact units SFC, SEE

- Inspection, diagnostics and preventative maintenance
- Spare parts, modernization, upgrades, replacements

For main generators

- Inspection, diagnostics and preventative maintenance
- Installation of Asset Performance Management System
- Spare parts for GE`s Power Conversion and Converteam generators
- Addition of eVSDfor speed control to improve efficiency of underutilized plants



Digital Solutions and Services

We connect electricity to industry efficiently, enable intelligent asset strategies and build solutions around your business model. GE's Asset Performance Management (APM) solutions help to make your operations safer and more reliable with better performance at a lower sustainable cost

The global energy landscape is transitioning, and the traditional business models of global power producers are being challenged by rising costs, carbon markets, policies and regulations as well as changing consumption behavior. Operational flexibility is now key to cost-efficient power production across the load range.

The implementation of highly efficient and flexible technologies in new power generation plants, as well as the improvement of operational efficiency in existing power plants, is becoming increasingly important to keep pace with the growth in global electricity demand, grid integration requirements and peak load management.

With more than a century of acknowledged industry achievements and technological breakthroughs behind it, GE offers the power industry a wide range of electrical products from motors, generators, drives, transformers and switchgear to protection and control and cabling systems; as well as proven, modular solutions designed for both scalability and flexibility. GE can help you to meet the requirements for base or peak load operations, whether you are planning a new power plant or seeking to enhance existing assets.

We see the whole plant. That's because GE can supply so much of it, from gas turbines and diesel engines to rotating machines; variable-speed drives to automation and control systems, and all the electrical equipment in-between. But it is when we bring our capabilities together into integrated, engineered solutions that you see the full benefit of the GE synergy.

Preventive Maintenance for Drives

Minimizing the Risk of Unplanned Outages

We know that any unplanned outage comes with significant costs. We also recognize that good maintenance and equipment inspections reduce the risk of outages and enhance reliability. But maintenance can also be expensive, and you don't want to pay for more than is needed.

GE has designed and built thousands of drives, and we continue to support many of them as part of a planned maintenance cycle. When customers have an unplanned outage, we help them get back up and running as quickly as possible. That's why, as an OEM with over 125 years of engineering expertise, we're your partner of choice for preventive MV drive maintenance services.

Preventive Maintenance Programs

Regular maintenance ensures efficient drive operation and reduces failures. We offer structured inspections and planned maintenance programs geared to the operating environment. These ensure the cost of maintenance and risk of failures are minimized.

We offer two types of preventive maintenance programs:

- **Preventive Performance Maintenance** (annual) – includes basic visual inspections and drive performance checks
- **Preventive Major Maintenance** (once every five to ten years) – includes advanced visual inspections, drive performance drive checks and systematic component replacement

Preventive Maintenance Program Features

GE's preventive maintenance programs are tailored to suit your application and needs. Our field service experts carry out inspections and performance checks on drives quickly and effectively, when it's convenient for you. We also work with you to understand historic maintenance, environmental conditions, budget and operational constraints and business imperatives.

During the preventive maintenance service, we:

- Perform and record preventive actions – according to a prescribed schedule of checks appropriate to the drive
- Identify safety-critical issues – immediately bringing them to your attention and proposing resolutions. GE will prioritize the dispatch of parts needed to resolve such issues. If necessary, the field service engineer will remain or return to site to supervise the solution
- Identify operational-critical issues – bringing any deterioration in performance or critical items affecting reliability to your attention and recording them in the maintenance report
- Audit and record an inventory of spare parts

After the preventive maintenance service, we issue a maintenance report and recommend:

- **Critical spare parts** – providing a list of those you should consider holding
- **Replacement parts** – suggesting obsolete parts you may wish to plan to replace
- **Upgrade packages** – appropriate for your equipment and circumstances

For more information on GE Power Conversion's Power Generation Solutions, please contact your local sales representative.

APAC
Tel: +65 62 207022

CHINA
Tel: +86 216 198 2600

FRANCE
Tel: +33 3 83384000
Tel: +33 1 77312000

GERMANY
Tel: +49 3076220

LATAM
Tel: +55 313268 8000

NORTH AMERICA
Tel: +1 4129670765

UNITED KINGDOM
Tel: +44 1788 563563

gepowerconversion.com

GEAXXX - GE Power Conversion Power Generation Solutions (03/2019)