

GE Power



Power Conversion

Products and Solutions Portfolio

gepowerconversion.com

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Industries We Serve

Ready for Tomorrow's Challenges

GE's Power Conversion business applies the science and systems of power conversion to help drive the electric transformation of the world's energy infrastructure. Designing and delivering advanced motor, drive and control technologies that evolve today's industrial processes for a cleaner, more productive future, it serves specialized sectors such as energy, marine, industry and all related services.



Oil & Gas



Marine



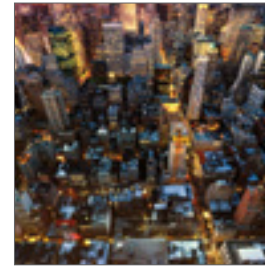
Material Handling



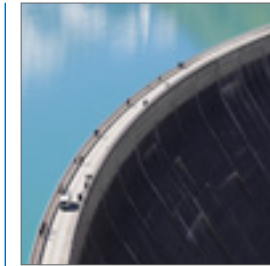
Metals



Power Generation



Power Quality and Supply



Pump Storage



Research and Test Systems



Water



Wind Services

Solutions Overview

Eco-System Solutions

We drive outcomes at the heart of efficiently connecting electricity to industry. We build industry-leading technologies and integrated solutions.

Digital Services

Our life cycle services offering combined with digital capability help you maximize operational efficiency and productivity with connected, responsive and predictive solutions.

GE as a Partner

We help you to enable, design, build and service electrification projects, worldwide, across industries.

Core Products

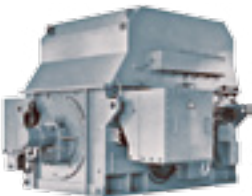
Rotating Machines for Motors and Generators

Motors

- Induction and synchronous
- Speed: up to 18,000 rpm
- Power: up to 100 MW
- Voltage: up to 15 kV (up to 22 kV on request)

Generators

- Induction and synchronous
- Speed: up to 18,000 rpm fixed or variable
- Power: up to 80,000 kVA
- Voltage: up to 15 kV (up to 22 kV on request)



Power Electronics for MV and LV Drives

MV Drives

- Output Power: 3–100 MW
- Output Voltage: up to 15 kV
- Output Frequency: up to 300 Hz
- Input Frequency: 50 or 60 Hz

LV Drives

- Output Power: from 0.5–8 MW
- Output Voltage: 400–900 V
- Output Frequency: up to 300 Hz
- Input: up to 1500 V



Control and Automation, and Digital Services

Drives and Systems C&A

- High Performance Controller (HPCi)
- Power Electronic Controller (PECe)
- Visor
- Vessel Control Systems, intelligent power management

Digital Marine

- SeaStream™ DP
- SeaStream™ Insight
- Remote monitoring and diagnostics

Digital Services

- Metals, Mining
- Drives and rotating machines Asset Performance Management



Digital Solutions

Bringing Together the Physical and Digital Worlds

We actively combine machines, intelligence and people to drive operational and business outcomes that matter. Our advanced digital software harnesses Big Data to connect people, assets, process, ecosystems and solutions like never before. In this way we help customers uncover plant-wide insights.



DIGITAL MINE | SEASTREAM INSIGHT™
MOTOR & DRIVE APM | DIGITAL SMELTER

Be Data Driven, Reduce Downtime, Optimize Cost

Our Asset Performance Management (APM) solutions help to make operations safer and more reliable - delivering better performance and a lower sustainable cost.

Key Products and Solutions Portfolio

- Power Electronics
- Rotating Machines
- Automation and Control
- Digital
- Services

INDUSTRIES	KEY PRODUCTS AND SOLUTIONS										
	MV3 SERIES	MV6 SERIES	MV7 SERIES	LV3 SERIES	LV7 SERIES	LV8 SERIES	SD7 SERIES	S FC (STATIC FREQUENCY CONVERTER)	STATCOM (STATIC SYNCHRONOUS COMPENSATOR)	SVC (STATIC VAR COMPENSATOR)	SEE (STATIC EXCITATION EQUIPMENT)
Oil & Gas											
Marine											
Mining											
Metals											
Power Generation											
Power Quality and Supply											
Pumped Storage											
Research and Test Systems											
Water											
Wind											

INDUSTRIES	KEY PRODUCTS AND SOLUTIONS										
	INDUCTION MOTORS	SYNCHRONOUS MOTORS	HIGH-SPEED MOTORS	PERMANENT MAGNET MOTORS	COMPACT INDUCTION MOTORS	VERTICAL INDUCTION MOTORS	ADVANCED INDUCTION MOTORS	PODS (PODED PROPUSSION UNITS)	ICL (INTEGRATED COMPRESSOR LINE)	GAS & STEAM TURBINE DRIVEN GENERATOR	DIESEL & GAS ENGINE DRIVEN GENERATOR
Oil & Gas											
Marine											
Mining											
Metals											
Power Generation											
Power Quality and Supply											
Pumped Storage											
Research and Test Systems											
Water											
Wind											

Complete Service Offering

To operate industrial processes profitably, your equipment needs to run as efficiently as possible. Concerns about the critical performance of assets often result in a capital expenditure-intense contingency reserve. There can often be overspending on data-blind operations and maintenance contracts, as well as a loss of productivity.

Our service focus keeps us actively engaged, both when things are going right and when they go wrong. A comprehensive global network of experts means GE is uniquely positioned to provide the knowledge, experience and skills to meet the full range of your industrial service requirements. This includes protecting assets and maximizing productivity, as well as optimizing operations and maintenance costs.

Responsive Support

Technical, automation and domain expertise on demand.

- Remote support
- Expertise in the field when required

Spares and Parts Replacement

Life-cycle management for performance, safety and reliability.

- New, re-manufactured and exchanged parts, repair and return, test and certification
- Parts obsolescence management
- Major repairs in GE shops

Modernization and Upgrades

Advanced technology inserted into existing assets.

- Life-cycle extension projects
- Performance and efficiency improvement
- Capacity enhancement

Digital APM and Service Contracts

Higher asset availability and increased productivity.

- Round-the-clock support with a guaranteed response time
- Scheduled maintenance and parts availability
- Asset Performance Management (APM) through remote monitoring and diagnostics

Field Service and Repair

OEM care to maintain assets in optimum condition at customer locations.

- Test and inspect
- Recondition and remanufacture
- Complete overhaul

Training

Helping to improve quality of customer systems and staff.

- Global training center and customer site



Oil & Gas Solutions



Challenge & GE Value

GE helps to enable reliable, safe and highly efficient processes across Oil & Gas operations by delivering high performance and compact electrical solutions.

Productivity and Operational Efficiency

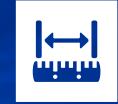
Space and Weight optimization in offshore projects

Challenge



Unplanned outages from motor failure can cost refineries millions in lost revenue for time offline

For a mid-size LNG facility, the average annual cost of unplanned downtime is estimated at \$150m



Average project capital expenditure for an offshore project can be between \$5b and \$20b

> *Complete stoppage of 1 LNG compressor train can cause lost production worth millions of dollars*

> *Weight adds cost to projects: For every single ton of equipment, three tons of additional support structure is required*

> *Deepwater projects need specially designed production facilities and large FPSO topsides can exceed 50,000 tons*

GE Value

> *Our high-power drive train technology can allow up to 48% higher uptime due to design simplicity, fewer parts and extended maintenance intervals*

> *Integrated solutions can reduce installation and commissioning time by up to 67%*

> *The integrated compressor line (ICL) solution saves up to 60% in space and footprint compared to conventional compressors*

Oil & Gas Solutions

Upstream

Offshore Production

- Fixed-speed motors with low starting current capabilities, direct on line motors and variable-speed drive solutions to power the compressor/pump
- High-speed integrated/standalone gearless solutions

- Power generation and Energy Management Systems (EMS)

- HVDC long distance electrical connection

Subsea

- Subsea gas compression variable-speed solutions
- Subsea pumping variable-speed solutions
- Subsea power solutions (to control, protect and distribute power to the subsea consumers)

FPSO

- Fixed-speed motors with low starting current capabilities, direct on line motors and variable speed drive solutions to power the compressor/pump
- High-speed integrated/standalone gearless solutions
- Power generation and Energy Management Systems (EMS)

Onshore Production

- High-speed integrated/standalone gearless solutions
- Variable-speed drive solutions
- Energy Management Systems (EMS)

Downstream

Refinery

- High-speed integrated/standalone gearless solutions to replace steam turbines
- Low-speed synchronous motors
- Variable-speed drive solutions with a high level of redundancy
- Energy Management Systems (EMS)
- Fully integrated HV/MV/LV electrical package, including turnkey HV substations, e-Houses and SCADA plus protection and control

Petrochemical

- High-speed integrated/standalone gearless solutions to replace steam turbines
- Variable-speed drive solutions with a high level of redundancy
- Energy Management Systems (EMS)
- High-torque induction machines to power hyper compressors LDPE and HDPE applications
- Fully integrated HV/MV/LV electrical package, including turnkey HV substations, e-Houses and SCADA plus protection and control

Midstream

Pipeline/Storage

- High-speed integrated/standalone gearless solutions
- Variable-speed drive solutions
- Fixed-speed induction motors
- Two-pole machines for larger pipelines
- Fully integrated HV/MV/LV electrical package, including turnkey HV substations, e-Houses and SCADA plus protection and control
- SCADA pipeline software for pipeline flow optimization

LNG

- Gas turbine starter/helper for refrigerant compression train
- Fully electric high-power solution for refrigerant compression train
- Variable-speed drive solutions
- Fully integrated HV/MV/LV electrical package, including turnkey HV substations, e-houses and SCADA plus protection and control
- Energy Management Systems (EMS)

Oil & Gas Solutions

GE is helping the oil and gas industry meet the challenges of operating safely and efficiently in an increasingly demanding and regulated environment. Our highly engineered equipment enables you to make well-informed decisions.

Integrated Compressor Line (ICL)

Advanced centrifugal compressor technology with an electric motor driver in a single, completely sealed casing

The ICL, jointly developed with BHGE, a GE Company, is driven by high-speed motor and high-frequency drive technology. The pressurized induction motor includes a laminated rotor with a squirrel cage – a design proven by more than four million operating hours in industry-wide applications.

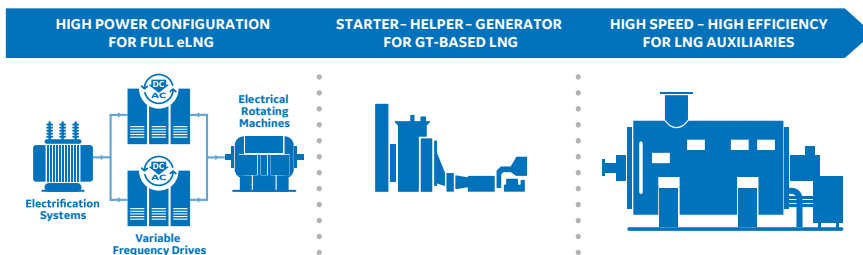
With Active Magnetic Bearings (AMB) technology, the rotor is levitated by a control system that precisely regulates the rotor spacing to avoid all parts contact and friction. This eliminates the need for lubricant thereby solving the problem of leak-prone lube oil systems used with conventional bearings. The AMB design maintains rotor levitation during starts, normal operation, and stops including emergency shutdowns. Ball bearing back-up allows the machine to stop without damage.

The drive is highly efficient over a very wide operating range, with the same hardware capable of driving the motor at low speeds and all the way up to 300 Hz.

Key features and benefits

- Harmonic study for harmonic mitigation
- Power factor study for generator optimization
- Resonance study for cable optimization
- Power management for high productivity
- DSVC/AFE for high grid stability
- Rotor dynamics study for torque quality
- Component optimization for improved site condition
- VFD/motor/compressor optimization for increased speed range

Unique Expertise in Electrification and Exhaustive Knowledge of LNG Processes



Electrical Equipment and Complete Solutions to Drive Compressors for LNG Applications

We offer a complete, single-source solution – using synchronous or induction motors powered by high-power drives based on IGBT technology – that helps deliver high reliability, availability and efficiency for LNG operators.

We offer a flexible and modular configuration with DFE or AFE enabler for transformer-less configuration fitting all the different LNG electrification needs:

- Small size LNG: soft starter for fixed speed compressors
- Starter-helper and generator for GTs single or double shaft end synchronous or induction motor
- Full electric LNG with direct compressor of the main refrigerant coupling

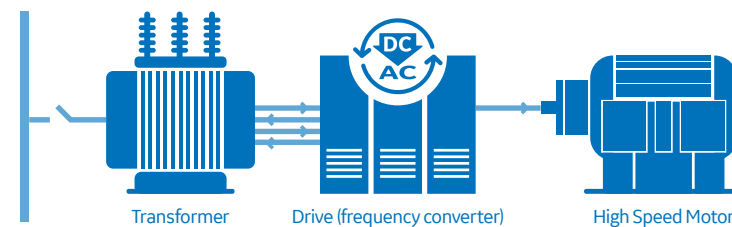
Steam Turbine Replacement

Electric motors and drive systems for compression process optimization

For processes that don't develop heat or only partially generate steam, like recycle hydrogen, feed gas, and in some instances wet gas applications, or plants located in areas where the power grid is stable, the use of electric motors can represent a better choice vs. steam turbine solutions. The recent advancement of electrification has made it possible and practical for electric motors and drive systems to be an option for powering standalone machines up to 100 MW and integrated ones up to 35 MW.

GE can provide a complete electrical turnkey solution for all compressor OEM types that includes a global guarantee of the motor compressor shaft due to adequate torsional analysis.

A smaller footprint and less necessary auxiliaries make it possible to preserve the plant layout in more constrained environments and allow a smooth plant integration, resulting in savings for the associated infrastructure cost. GE's Variable-Speed Drive Systems (VSIDS) feature a unique combination of Voltage Source Inverter (VSI) and a high-speed motor to help increase reliability and availability of your systems



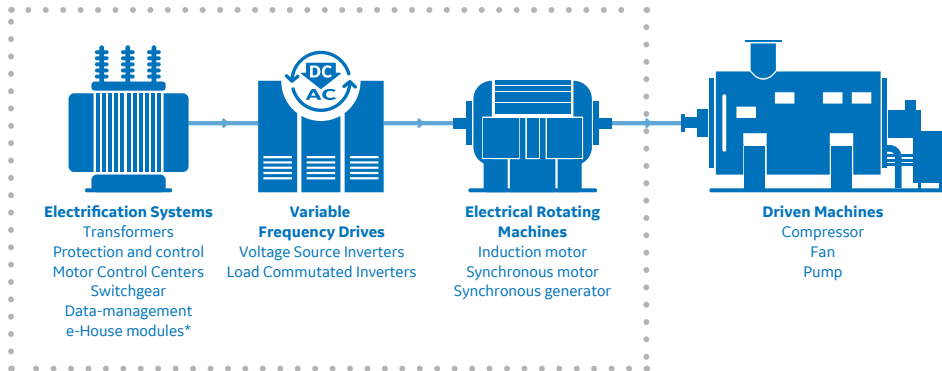
System Integration

We provide a full suite of integrated electrical and power data management solutions to help you extract, deliver and process oil and gas more effectively.

System Network Optimization Capabilities: Single Line Diagram Study and Optimization

From power generation through HV, MV and LV distribution to load package, we have extensive capability and experience in network simulation and calculation. This includes:

- Harmonic study for harmonic mitigation
- Power factor study for generator optimization
- Resonance study for cable optimization
- Power management for high productivity
- DSVC/AFE for high grid stability
- Rotor dynamics study for torque quality
- Component optimization for improved site conditions
- VFD/motor/compressor optimization for an increased speed range



Containerized e-House Solutions

e-Houses or shelters are pre-fabricated modular structures that protect critical power and electrical equipment. Designed for both on and offshore installations, and suitable for all conditions (both hazardous and non-hazardous), e-House modules are particularly beneficial when project space, on-site access or build time is limited. They're also useful in remote locations or when pre-existing structures are unavailable.



Optimizing space and design means faster delivery and installation times plus cost savings on labor. It also simplifies projects and reduces risk.

Power Management System

GE's Power Management System (PMS) provides real-time automation for managing the electrical power availability of industrial plants, minimizing both production losses and safety concerns. Acting as an 'anti blackout' system for islanded plants (FLNG, FPSO and platform), as well as those connected to non-reliable grids, our PMS helps to ensure optimal load balancing at all times, under any circumstances.

PMS is a hot redundant and integrated system that fully manages:

- Power generation coordination with load sharing between running generators – even if heterogeneous (for example: gas turbine, diesel, waste heat recovery unit)
- Power distribution and control with a high-speed load shedding response time – regardless of load number and location
- Supervision and data logging with real-time handling for troubleshooting analysis efficiency
- The communication gateway between all external interface devices
- Reducing Mean Time to Repair (MTTR) in case of electrical device failure

Real-Time Electrical Power Availability

High Performance

- Fast load shedding < 60 ms/all automation fcts < 60ms/Stamping at source 1ms
- Proven full hot standby redundancy
- Time stamping at source, 1 ms/RT handling
- Self-healing networks at segregated data flux

Open-Ended and Modular Architecture

- Ability to communicate with main brand devices
- Decentralized while maintaining performance
- Synchronizing system of energized bus-bars
- Simulator unit

Electrical Power Generation

- Grid
- Turbine Generator
- Diesel Generator

Electrical Power Distribution

- Grid
- Turbine Generator
- Diesel Generator

Control & Safety

- Fire & Gas System
- Process Control System

Motor Control

- Motor & Control Center



Oil & Gas Key Product Portfolio

Power Electronics

Core components of electrical VSIDS. These include Voltage Source Inverters (VSI), and IGBT-based and Load Commuted Inverters (LCI) using thyristor technologies.

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 $\pm 5\%$



Electric Motors

A full range of solutions for pump and compressor applications, both onshore and offshore.

Models

- Induction motors
- Synchronous motors
- High-speed motors (both integrated and standalone)

Technical Capabilities

- Speed: up to 20,000 rpm
- Power: up to 80 MW
- Voltage: up to 13.8 kV
- Hazardous zones



Generators

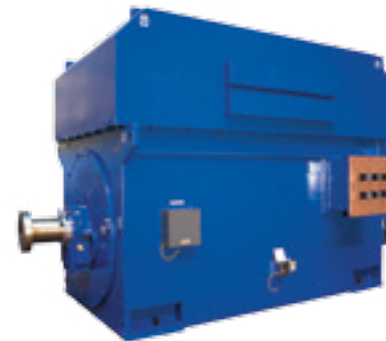
Setting the standard in generator manufacturing for over 130 years.

Models

- Turbo generators (gear-less)
- Synchronous gas and steam turbine-driven
- Reciprocating engine-driven

Technical Capabilities

- Speed: Two to 22 pole range
- Power: 2,500–80,000 kVA
- Voltage: up to 22 kV
- Frequency: 50 or 60 Hz
- Hazardous zones



Automation and Controls

A comprehensive suite of advanced protection, control, automation and communications designed for harsh environments. This enables customers to optimize application capability and cost – helping to generate new revenue sources.

Functionalities

- Motor management and control
- Protection and automation
- Wired and wireless communications
- Industrial internet controls
- Edge analytics and fleet data to optimize operations
- Centralized deployment of apps and firmware upgrades
- Remote monitoring and diagnostics



Medium Voltage Variable-Speed Drive Systems (VSDS)

High-Quality Product Lines

GE combines cutting-edge power electronics technology and decades of process expertise in our medium Voltage Source Inverters (VSI) portfolio.

Our Variable-Speed Drives Systems (VSDS) are used for a wide range of industrial applications – notably where energy efficiency, reliability and safety are key customer expectations.

Whatever our customers' industry setting – onshore and offshore oil & gas, renewables, power generation, marine propulsion, water, metals, or mining – we provide solutions engineered to meet the most demanding requirements. For example, we can address power cycling, low-speed application, power range, harmonic constraints or precise torque control.

Product Range

MV Drives Product Map

Our MV drive family is composed of VSI and Load Commutated Inverters (LCI). It offers a wide power range at various voltages, covering a variety of applications.

GE Advantage

- One of the industry's highest power densities, up to 1.4 MVA/m³ for the water-cooled range
- Outstanding efficiency, up to 99.1% for DFE applications
- High reliability thanks to low component count
- Installed base: 15 GW+, 1,700+ units

MV6 Medium Voltage Drives

Leading Next-Generation Technology

MV6 series VFD is one of the most versatile medium voltage drives on the market, with configurations covering a voltage range of 4.16 kV to 6.6 kV and power range of 210 kW to 6 MW. It's all based on GE's extensive experience in general industry and mission-critical applications.

You can configure MV6 VFD as Diode Front End (DFE) with an integral transformer in two-quadrant operations, re-generative Active Front End (AFE) with a transformer in four-quadrant operations, or a transformerless AFE using a common set of building blocks.

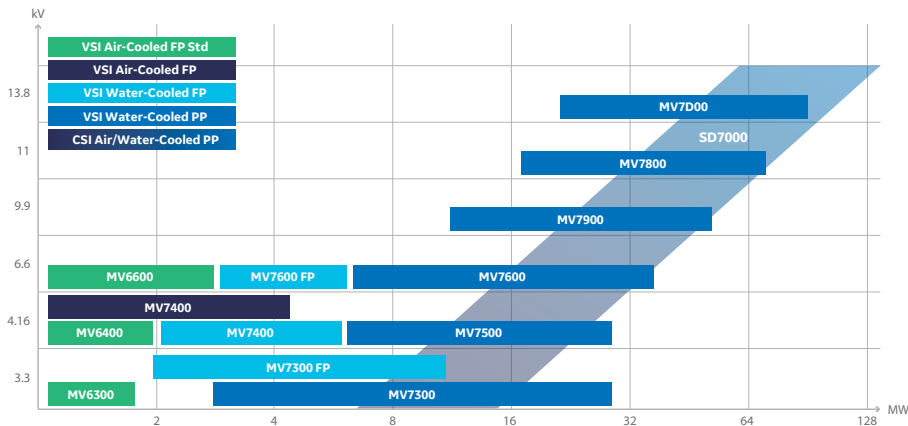
MV6 series VFD is suitable for worldwide applications and is certified to IEC 61800-3/4/5, IEEE 519, UL 347a, CSA C22.2, IEEE 693 and GOST.

Key Features and Benefits

- Bumpless fault tolerance at power device level
- Ease of system integration and grid friendly
- Modern industry design for safety and style
- Ease of integration with e-houses
- Friendly user interface and rich control features
- Quick and easy installation
- High availability
- High efficiency and low losses



	Ratings
Output power	210–3,000 kW (up to 6,000 kW on request)
Output voltage	4.16, 6, 6.6 kV
Output frequency	0–75 Hz
Input voltage	DFE: 4.16 up to 24 kV AFE transformerless: 4.16, 6.0, 6.6 kV
Input frequency	50 Hz, 60 Hz
Cooling	Air-cooled



MV7000 Medium Voltage Drives

Our drives can substantially improve the quality and efficiency of your process or production. GE's MV7000 drive technology delivers efficient and flexible control of electric power to a wide range of equipment. The drives can feed both induction and synchronous machines with high-performance vector control across all speed ranges. For multiple applications, with both motoring and regenerating drives, a common DC link fed by a single active front end can reduce the overall equipment cost and footprint.

Key Features and Benefits

- **Power quality:** Low harmonics and a high power factor help minimize the effect on the supply network
- **Energy optimization:** PWM active front end enables regeneration of the energy to the network
- **High efficiency:** Up to 99% performance
- **Reliability:** With press-pack IEGT technology, fuseless protection and a low component count, MV7000 offers longer life expectancy – even under load cycling
- **Power density:** Up to 1.1 MVA/m³ for the complete drive
- **Redundancy:** Secured continuous conduction of the PPI in failure mode
- **Safety:** Case rupture and arc ignition-free due to pressed contacts and no wire bonding
- **High efficiency:** Thanks to low losses



Key Features

- **Air-cooled (AC):** Easy installation and maintenance
- **Water-cooled (WC):** Compact and reduced heat losses through air
- **HV Flat pack IGBT:**
 - HV flat pack integrated components
 - Very compact, especially in lower power range
 - Low part count for high reliability
- **HV Press Pack IGBT:**
 - High robustness for demanding systems (for example, low speed or cycling)
 - Low part count
 - Real N+1 hot redundancy thanks to GE's specific expertise on press pack IGBT
- **Multi-level configuration:**
 - Reduced stress on motors
 - Simplified filters

MV7000 Press Pack (PP)

- Three- or five-level inverters
- HV press pack IGBT
- Water-cooled



VFD ratings	
Output power	3–81 MW
Output voltage	up to 13.8 kV
Output frequency	15–90 Hz, 0 to 15 Hz and 90 to 300 Hz on request
Input voltage	3–13.8 kV ±10% for AFE Txless, 3–650 kV with transformer
Input frequency	50 or 60 Hz ±5%
Auxiliary voltage	3 phase, 400 V, 440 V, 480 V, or 600 V; 50/60 Hz 1 phase, 110 V, 230 V, 50/60 Hz

MV7000 Flat Pack (FP)

- Three-level inverters
- HV flat pack IGBT
- Air- or water-cooled



VFD ratings	
Output power	0.7–10 MW
Output voltage	3.3 up to 6.6 kV
Output frequency	15–90 Hz, 0–15 Hz and 90–300 Hz on request
Input voltage	3 to 6.6 kV ±10% Txless, 3–650 kV with transformer
Input frequency	50 or 60 Hz ±5%
Auxiliary voltage	3 phase, 400 V, 440 V, 480 V, or 600 V; 50/60 Hz 1 phase, 110 V, 230 V, 50/60 Hz

Common Characteristics

Power Quality	
Line side converter	DFE 12 to 36-pulse / AFE IGBT 6-pulse
Load side inverter	3- or 5-level VSI; IGBTs
VFD system efficiency	Up to 99%
Power factor	>0.96 (DFE) / 1 (AFE)

Energy Storage	
DC link	Self-healing, long life, film capacitors

VFD Control	
Mode of operation	Four-quadrant
Mode of control	Flux vector/without encoder/induction motor & synchronous (option)
Analog input/output	(3) inputs/(3) outputs +/-10 Vdc or 4–20 mA standard
Digital input/output	(6) inputs/(6) outputs standard
Speed regulation	<0.5% without encoder and <0.1% with encoder
LAN interface	Standard: Profinet, Modbus, Ethercat, IEC618150 Optional: profibus, devicenet, EGD
Protective functions	Over-current, current limit, over and under-voltage, motor stall

Environment and Enclosure	
Enclosure	IP31, standard, IP33, IP44, option, others on request
Ambient/elevation	0–45°C/1,000m above sea level; higher with de-rating
Insulation coordination	Pollution degree 2 per EN 61800-5-1 and EN 50178

Industry Standards	
Standards	IEC 61800-3, IEC 61800-4, IEC 61800-5, IEC 60068-2-31 (vibration) Qualification to industry-specific standards available

SD7000 Medium Voltage Drives

Next-Generation Technology

GE's SD7000 medium voltage drive is designed for high power and speed environments. It controls the power in loads where high performance is required, such as large compressors for gas injection, LNG plants and steam-crackers.



Key Features and Benefits

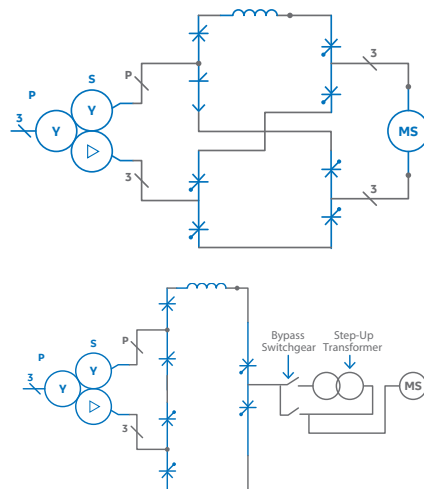
- Flexible design adaptable to any rating, frequency and cooling configuration
- Control redundancy
- N+1 configuration for increased reliability and availability
- Soft motor start configuration
- Perfect fit for customers requiring new installations or retrofit of existing drives
- Increased reliability in case of control default

Ratings

Power	3 to 100 MW
Voltage	1.5 to 15.75 kV
Frequency	Up to 110 Hz
Cooling	Air- or water-cooled

Two Main Configurations for Soft Starters and Variable Speed Drive

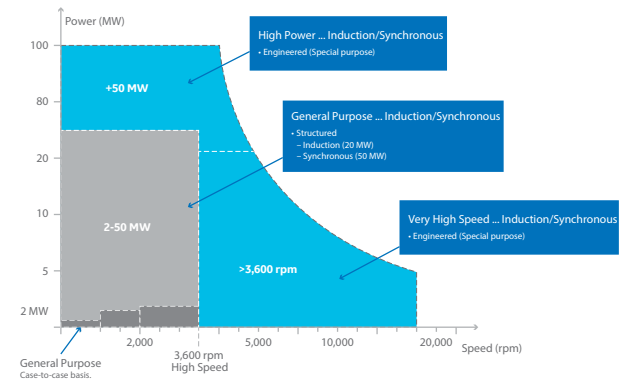
Network side arrangement	Machine side arrangement	Main Application
12 pulses	12 pulses... requires double starter motor	Mainly used for variable-speed drive 12/12 cross connection... limit voltage constraints to ground... enabling longer life duration
12 pulses	6 pulses	Mainly used for soft-starter Step-up transformer allows to reduce voltage on drive... lower number of thyristors For higher output, drive sized to full voltage... no need of step-up transformer Used as well for variable-speed drives in low power and high voltage



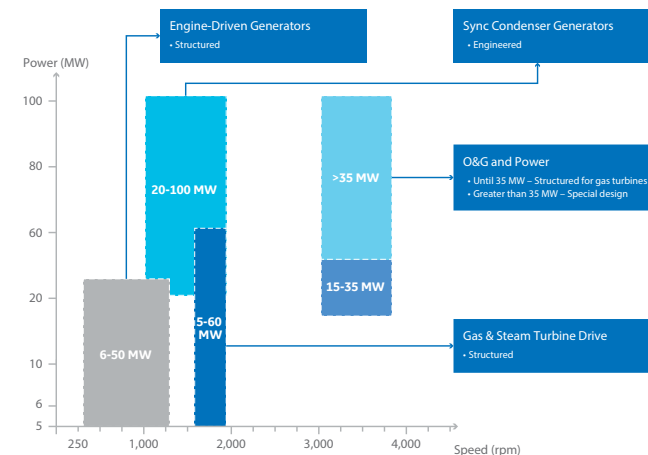
Motors and Generators Overview

GE has set the standard in manufacturing rotating machines for over 130 years and continues to deliver innovative mechanical power solutions worldwide. Our rotating machines are designed to operate efficiently and reliably in challenging and severe environments where ease of maintenance is critical.

Motor Range



Generator Range



Induction Motors

Compact But Powerful

GE's induction machines provide the highest power density in their class. What's more, the innovative compact frame upgrade to our well-established legacy motor line doesn't compromise on efficiency or reliability.

When Space Matters Most

With a lower frame size than conventional induction motors, this new and compact design translates to space savings and lower weight. This is essential both for onshore and offshore applications where space is at a premium and when platforms require reduced weight motors.

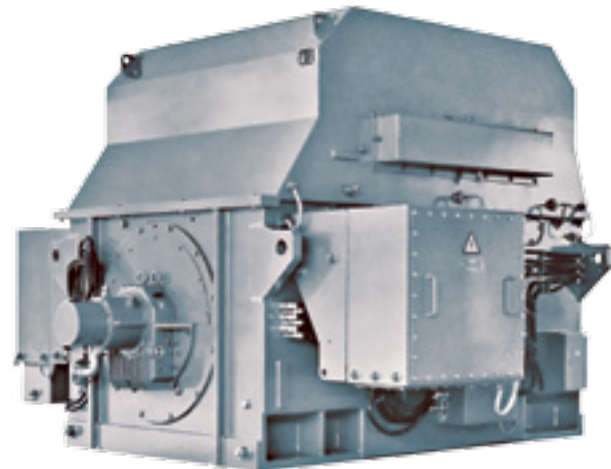
Ratings	
Frame Size	400 to 1,400
Poles	2 to 30
Frequency	50 Hz, 60 Hz, VFD
Cooling	TEWAC, TEAAC, WP11, WPI
Power	2 to 30 MW eq. 4 poles
Voltages	3.3 to 13.8 kV

Helping to Maximize Customer Outcomes

- Reduce operating expenses with longer durability and lower vibration
- Cut capital expenditure with lighter machines that require fewer foundations and associated costs
- Lower energy consumption from machines that are also safer

Key Features and Benefits

- World-class compact design
- High efficiency
- Low noise
- Reduced weight
- Proven design with innovative components
- State-of-the-art manufacturing equipment
- Test facility up to 40 MW (upon request)



Applications

- Reciprocating compressors
- Centrifugal compressors
- Pumps

Synchronous Motors

GE offers a full range of horizontal and vertical synchronous motors. These range from direct-drive high-torque density designs (at speeds as low as 20 rpm) to turbo-type motors for compressor applications.

Synchronous Motor Rotor Platforms

- Salient pole rotors
- Two-pole turbo rotor
- Wound rotor

Key Benefits

- High reliability
- Greater efficiency
- Reduced operating expenses
- Less maintenance
- Smooth start-up

We can rapidly adapt our standard product platforms to cater for most applications or proposed starting methods including:

- Fixed-speed started by asynchronous means – for example direct-on-line, series reactor, capacitor, reactor/capacitor or auto-transformer (single or multi-stage)
- Fixed-speed started by pony motor, electronic soft starter or mechanical gear system (i.e. variable speed planetary gear)
- Variable-speed drive system controlled

Ratings	
Frame Size	900 and above
Poles	2, 4, 6 and above
Frequency	50 Hz, 60 Hz, VFD
Cooling	TEWAC, TEAAC
Power	5 to 100 MW eq. 4 poles
Voltage	3.3 to 13.8 kV



Applications

- Reciprocating compressors
- Centrifugal compressors
- Pumps

Synchronous Generators

GE has been a world leader in generator manufacture for over 130 years. Having created and implemented some of the first large-scale electrical generators, today we continue to innovate and deliver global power solutions.

Reducing LCOE With High Efficiency

Our generators are designed and built to operate reliably in challenging conditions and severe environments – especially where ease of maintenance is critical. We help to reduce LCOE through:

- High electrical efficiency across the full power range
- Efficient systems solutions incorporating our range of full and partial power converters
- Using components proven in diverse industries
- Ease of maintenance enabling lower operating costs
- Noise levels as low as 77 dba (achievable in closed type machines with operating speeds of up to 1,200 rpm) that help to reduce cost and environmental impact

Key Benefits

- 98%+ efficiency – helping to reduce running costs
- Modular approach – reducing initial investment costs and allowing design flexibility
- High availability and reliability – increasing revenue and reducing risk

Ratings

Output range	5,000 to 75,000 kVA (up to 60 MW 0.8 p.f)
Voltage	up to 13.8 kV and above
Frequency	50 Hz or 60 Hz
Cooling	Air or water cooled



Applications

- Gas/steam turbine-driven
- Diesel/gas engine-driven
- Prime and standby power
- Peaking
- Multi-pole generators for FPSO

High-Speed Induction Motors up to 100 MW

With the growing electrification of many industries around the world, Electric Motor Driven (EMD) solutions are now increasing in power and speed. This is creating new opportunities across multiple applications. Large EMD systems traditionally included large Load-Commutated Inverter (LCI) drives and synchronous motors. However, several innovative breakthroughs, such as the introduction of large power Voltage-Source Inverter (VSI) drives, have improved these configurations. GE's Power Conversion business has delivered further layers of innovation, including high-speed induction motors of up to 100 MW.

Key Benefits¹

Improved Network Stability and Grid Interaction

- Low harmonics content, no network filter required
- No risk of inter-harmonics
- Easy management of the network power factor, even in case of network configuration change

Simplified Compressor Configuration

- Larger speed range and higher Maximum Continuous Speed (MCS) mean greater flexibility in compressor design, improved efficiency and smaller units
- Reduced torque ripple at shaft level

More Efficient Process

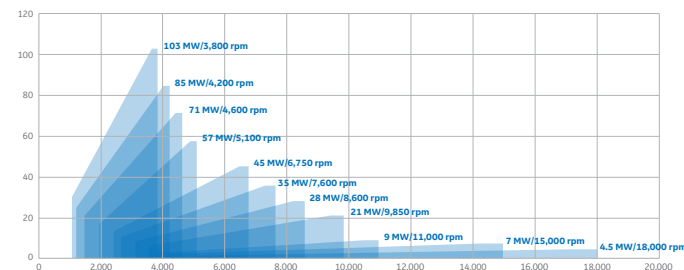
- Higher speed and larger range for various applications, such as test benches
- No need for a separation margin with network frequency, thanks to the absence of inter-harmonics
- Low vibration, stable when passing through the first critical speed, simpler rotor, reduced number of critical speeds (no exciter)
- Higher reliability and availability (up to +48% uptime) due to the simplicity of the rotor (non-insulated squirrel cage) and motor compactness

Reduced CAPEX

- Reduced filtering for high-power applications
- Smaller compressor
- Smaller motor with less equipment (for example, there are 10 times fewer rotating parts on the induction full laminated rotor compared to a synchronous rotor)
- Reduced size and lighter supporting structure needed as the induction motor is more compact: smaller footprint (-30%), less weight (-33%)

Reduced OPEX

- Higher drive-motor-compressor system efficiency, saving 1% on energy consumption. For example, it can be evaluated at \$2.8m for an 80 MW machine running full-time for five years
- Better power-factor management and lower operating energy costs
- Less maintenance and fewer spare parts required owing to the simplicity of the induction motor



Applications

- Centrifugal compressors
- Pumps

¹ Comparison between traditional synchronous motors fed by LCI and GE's new turbo induction motors fed by VSI.

80 MW High-Speed Induction Motor

Proven Technology

In 2018, GE tested the world's largest induction motor for the LNG industry at 80 MW.



Key Features

- Power: 80 MW
- Speed: 2,500 to 4,000 rpm
- Voltage: 11 kV
- Efficiency: 98.1%
- Weight: 150 tons (330,000 lbs)
- Footprint 4.5 x 6 m (15 x 20 ft)
- Cooling: water-cooled with auxiliary motor fan
- Two oil-lubricated sleeve bearings
- Squirrel cage laminated rotor
- No exciter needed
- Low noise < 90 dBA for such impressive power and speed
- Rotor vibrations < 38 µm peak-peak up to 4,800 rpm overspeed
- Endurance: eight hours at critical speed with a very stable rotor

Testing Capabilities and Certification

We have the capacity to test all equipment at our manufacturing sites before we deliver it to you.

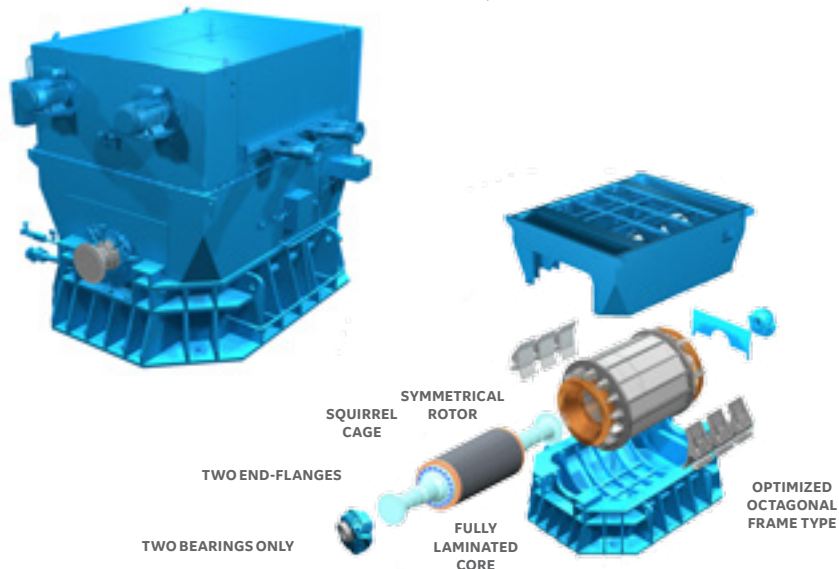
Our Solution

- Full load capability up to 18 MW
- Frequency from 5 Hz up to 300 Hz
- 40 MW loading induction machine
- Alternative method on induction forced cooled motors up to 50 MW
- Full load combined test up to 40 MW: transformer + drive + motor in back-to-back configuration (on request)
- Online data acquisition system
- Electronic database and reports
- Routine tests
- Type tests

Certifications

We can provide certification to the following standards:

- IEC60079 Exp Ex nA
- IEC60034
- Ex d Exe
- API541/546
- Atex (on request)
- IECEX
- Marine class rules
- Ice class
- UL
- Country-specific certifications, like CSA for Canada, BASEEFA for Europe, CU-TR Ex (GOST) for Russia, KOSHA for Korea, INMETRO for Brazil, RETIE for Columbia



Services Offering

Meeting the Needs of Your Operational Model

GE offers customized services to meet the needs of individual operational and maintenance models – from daily operation, routine and scheduled maintenance to outage services. These include:

- Remote monitoring and diagnostics
- Maintenance
- Spare parts and obsolescence management
- Warranty extensions
- Response-time guarantees
- Availability guarantees as risk sharing mechanisms

Fleet Data Analytics and Predictive Maintenance

Through our advanced digital platforms, GE delivers expert on-site and remote round-the-clock support and emergency interventions—all customized to meet unique customer requirements.

Multi-Year and Local Support

GE offers both on-demand services and multi-year contracts with a range of options, from “Keep me running” to “Partnership.” We have field service engineers operating in over 170 countries – GE has the capability to support our customers wherever they may be.

Enhancing Energy Harvest Across Project Life Cycles

Our services help to support continuous plant operation, driving higher energy yields and return on investment throughout the life cycle. For equipment benefiting from GE multi-year service agreements, product availability and uptime can also be significantly higher.

Reducing Risk, Enhancing Productivity

GE services cover a broad range of activities necessary to protect assets and keep critical processes running. This helps to reduce risk and enhance productivity while letting the owner/operator concentrate on their core business.

Drives Health Check

Minimizing the Risk of Unplanned Outages

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

GE has designed, built and commissioned thousands of drives and we continue to support many of them as part of a planned maintenance cycle. Plus, 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 failure risk. We offer structured inspections and planned maintenance programs geared to the operating environment, which help to minimize costs.

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 checks of drives and systematic component replacement.

Preventive Maintenance Program Features

GE's preventive maintenance programs are tailored to suit your needs. Our field service experts carry out inspections and performance checks on drives quickly and effectively, when it's convenient for you. We'll 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 appropriate checks
 - **Identify safety-critical issues** – bringing them to your attention immediately and proposing resolutions.
 - **Prioritize the dispatch of parts needed to resolve any such issues** – if necessary, the field service engineer will remain on or return to site to supervise
 - **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 which you may wish to plan to replace
 - **Upgrade packages** – appropriate for your equipment and circumstances

MV Drives Control Modernization and Upgrade

If you currently rely on vintage MV drive controls, you can't ignore the risk of obsolescence. However, you can avoid it. A reliable and cost-effective upgrade can save you the time and expense of a complete systems replacement.

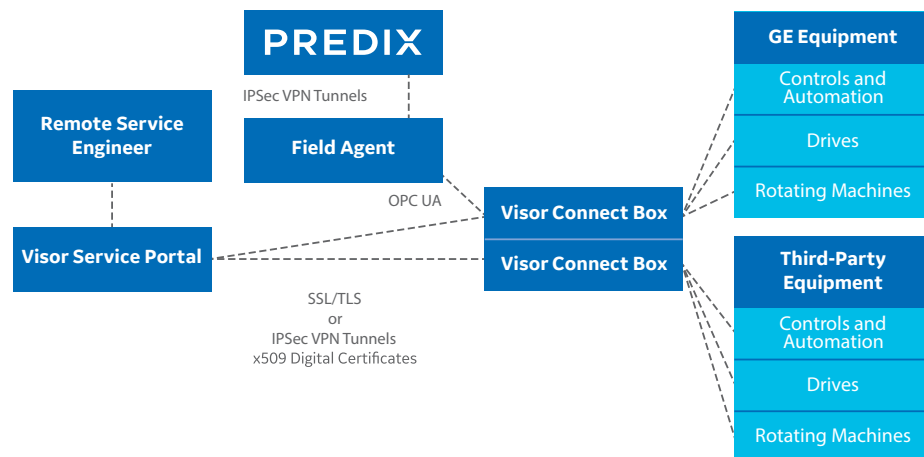
This simple upgrade will modernize your controls and data interfaces, substantially improving control capabilities and performance. Extensive diagnostics and self-testing can make systems easier to maintain, with GE's outstanding drive services helping you get the greatest possible value from your MV drives' controls.

The external control interface—GE's P80i Control System toolbox – is widely considered as one of the best tools for configuring, troubleshooting and maintaining legacy MV7000 drives and controls.

Features and Benefits

- Experts that fully understand your industry and will match our drive features to meet your specific requirements
- Consistent and cost-effective project execution from start to finish
- Phased upgrades and updates that fit your operating budget
- Improved process control resulting in lower operating costs
- Extended life cycle for your existing DC drive systems, delaying a move to AC drive technology until the time is right

Remote Monitoring System Architecture



Proven MV Drives Control Technology

Power Electronics Controller (PECe)

- Standard industrial PC
- Intel-based chipset
- VXWorks operating system
- IEC1131 Compliant Function block
- Deterministic Ethernet
- 5 x 10/100 Ethernet ports
- 1.2 to 2.5 GHz
- 60°C ambient
- Fanless operation
- Two or four PCI slots allows Profibus, Profinet, Reflective memory, CaNbus, Modbus, EGD, etc.

Power Interface Board (PIBe)

- 24 copper or 32 fiber optic outputs to power devices
 - 8 digital inputs
 - 4 digital outputs
 - 8 analog inputs
 - 4 analog outputs
 - 2 current transformer inputs
- Capable of 60 V, 10 amp outputs to power devices
- One encoder input

Field I/O

- Modular construction
- Digital inputs/outputs ... 24 VDC
- Analog inputs/outputs ... +/- 10 VDC
- Fast deterministic EtherCat interface from PECe

Touchscreen for operator control and maintenance

Replacing antiquated meters and push buttons with modern touchscreen controls will immediately improve your ability to operate and maintain your MV drives' controls.

P80i Toolbox – Drive Commissioning and Maintenance

- High-speed trending
- Unlimited signals per trending
- Up to 3,000 samples per signal
- Limited only by PECe memory capacity tool capabilities
- Configure trend (trigger, period, variables to be recorded)
- Trend can be set to be uploaded to a compact flash drive
- Upload records from the drive
- Display records in a trend
- Display 'live' or 'logged' data

Spare Power Stack and Stack Extractor for MV Drives

Help Minimize Risk of Failures and Improve Equipment Uptime

Despite every effort to maintain your drives, unforeseen outages are inevitable. Ensuring equipment availability is a priority and having the right spares is essential for maintenance purposes. Spare stacks and specialized tools are the key to quick recovery in the event of a drive failure. However, knowing which spares to keep in stock and where to source others can be a challenge. This is where GE can help.

MV Drive Power Stacks

Spare power stacks for MV7000 and SD7000 series medium voltage drives are available direct from our factory in Villebon. They include a full range of DFE, IGBT, IEGT, thyristor, diode and chopper types. A full list of part numbers and special promotions for multiple buys is available on request.

Easy Repairs Using GE's Stack Extractor

Power stacks are key components of drives and play a crucial role in keeping them running at the required power. It's often difficult to carry out inspections or replacements, which require time and effort. There are also safety risks during the manual disassembly of each stack. As a full-scale OEM with engineering expertise, GE has designed a semi-electric, fully retractable and easy-to-use stack extractor for use with any MV7 or similar drive. The extraction tool speeds up repairs and improves overall recovery time in case of drive failure.

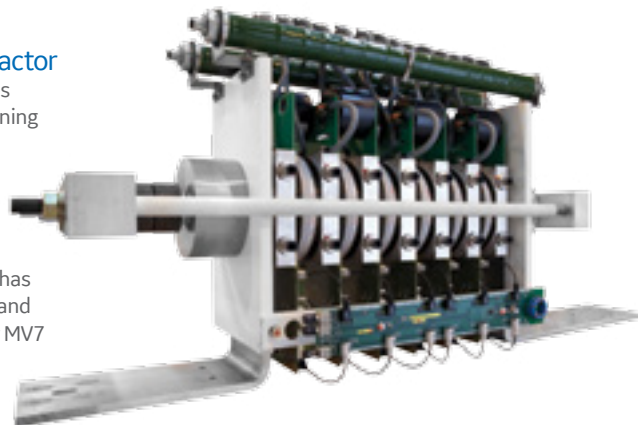
Power Stack Spare and Tool Kit Bundle

The offer includes:

- Spare stacks meeting standard factory serial routine tests to help minimize downtime
- Semi-electric, robust, easy-to use extractor tool that helps reduce MTTR to two hours
- Repair services for damaged stacks to help you reduce cost and extend the life of existing stacks

Reduce Lead Times with Spare Stacks

Holding spare power stacks in stock is crucial for keeping your equipment running. This is because lead times for their procurement can be long. In addition, unavailability of spares in your inventory may lead to extended downtime in the event of a failure.



Maintenance Toolkit for MV7000 and SD7000 Drives

Ensure Equipment Availability and Improve Uptime

Unplanned equipment outages cause significant loss of productivity and revenue. Ensuring equipment, spares and toolkit availability on site can help you recover quickly in the event of an outage. Even in cases involving planned outages, it is vital to get equipment up and running again as fast as possible.

Accelerate Your Drives' Maintenance

For quick and easy maintenance of your cooling systems, GE offers two types of compact, easy-to-use maintenance toolkits, corresponding to MV7000 and SD7000 drives. With a single toolkit, you can carry out maintenance on all drives belonging to the same series (MV7000 or SD7000), irrespective of the application in which they are being used.

These toolkits can be used without any additional components, with the compact design being easily handled and stored at any temperature or humidity rate.

Benefit From GE's Industry and Application Expertise

Most production processes run without interruption. By moving from reactive to proactive services and maintenance models, we can help you to elevate operations to the next level, improving productivity and asset performance.

Our focus on service keeps us actively engaged, both when things are going right and when they are going wrong. With a comprehensive global network of experts, GE is uniquely positioned to provide the knowledge, experience and skills for your full range of industrial service requirements. We can help to maximize productivity, protect assets and support you with optimizing operations and maintenance costs.

MV7000 Drive Cooling System Maintenance Kit

- Designed to support any MV7 cooling system maintenance
- Easy cooling system maintenance for pipes and connections
- Compatible with all MV7 with either 3.3 kV or 6.6 kV, AFE or DFE option, 12 or 24 pulses
- Compatible with legacy and new MV drives which include UPONOR piping technology
- Kit supports the four different sizes in the cooling system: 8mm, 10mm, 12mm, and 18mm. It includes male and female plugs and internal sockets for those four sizes. The length of the four pipes allows you to change any pipe in the converter
- Compact and easy to store
- No preparation required
- Meets all aspects of Health, Safety and Environment

MV7000 & SD7000 Drives Cooling System Maintenance Kit

- Designed to support any MV7 and SD7000 cooling system maintenance
- Easy cooling system maintenance for pipes and connections
- Compatible with either 3.3 kV or 6.6 kV, AFE or DFE option, 12 or 24 pulses
- Kit supports the three main different sizes in the cooling system 3/8", 1/2" and 3/4" and also composed by plugs for those three sizes
- Sufficient length of the three pipes sizes for any connection requirement
- Compact and easy to store
- No preparation required
- Meets all aspects of health, safety and environment

Automatic Voltage Regulators Replacement or Retrofit

Regulator systems from GE provide excitation current up to 35 A with high accuracy, exceptional control flexibility and powerful diagnostics. All in a cost-effective, easy-to-use package.

Applying Deep Expertise

At GE, we not only build Automatic Voltage Regulators (AVR), we offer support throughout the product life cycle. Our field experts are positioned to provide full support for EX2100e AVRs and perform upgrades with minimal system disruption. As a full-scale OEM with fleet knowledge and deep engineering expertise, we're your partner of choice for retrofits and replacing AVRs nearing the end of their life cycle.

Low-Risk Solution With a Simple Upgrade Path and Full Support

A reliable and cost-effective upgrade by our experts can help to:

- Improve reliability
- Enhance performance
- Reduce risk of unplanned outages
- Increase availability and help maximize productivity
- Improve serviceability
- Help ensure longevity of product life

In the last 40 years, GE has supplied more than 6,000 thyristor and regulator systems in over 70 countries. The EX2100e is GE's fourth-generation digital excitation control system and our advanced regulator for steam, gas or hydro generators – both for new and retrofit units.

EX2100e Excitation Control Regulator Systems Include:

- Industry-leading control limiter with a protection function to help maximize generator performance
- Flexible architecture, modern networks and versatile software suite to simplify operations and integration with plant level controls
- Powerful diagnostics and control simulator to support rapid installation, tuning of control constants and training
- Advanced algorithms and the latest control technology designed to improve performance
- Product life cycle support able to perform conversions, modernizations and upgrades
- 24/7 technical support to help resolve issues as quickly as possible, ensuring minimum downtime

Excitation Control Upgrade

Product Features

MOUNTINGS	
S	Open Panel (for customer's enclosures) 23"H x 22"W x 10"D
S	NEMA1 Wall-Mounted Integral Enclosure 29"H x 22"W x 10"D
O	Free Standing Cubicle NEMA1 (IP21) 90"H x 30"W x 24"D
O	Free Standing Cubicle NEMA4 (IP54) 90"H x 30"W x 24"D
POWER CONVERTER	
S	Isolating Transformer 120/240VAC, 1PH, 50/60Hz
O	Primary 480 or 575 VAC
S	Incoming HRC Fuses
S	Thyristor Converter, 1 Phase, (1-20Amp), NRX
O	Control Constant Voltage Transformer
PLC CONTROL	
S	GE Intelligent Platforms Rx3i PLC
DIGITAL REGULATING FUNCTIONS	
S	Field Current Regulator (Optional Autotracking)
S	Max/Min Exciter Field Current Clamps
S	Non-Volatile Setpoint and Ramp
S	VAr/PF Regulator (Optional Autotracking)
O	Bus Voltage Support
O	Multi Motor VAr Control
S	Redundant PF Feedback System
START/ RUN CONTROL	
S	Initiated by Starter Interlock
S	Field Application by Timer
S	Field Application By Motor Speed (If Motor Sensor Fitted)
S	Clutch/Loading Interlocking
O	Reduced Voltage Start Control (1)

Product Features

ROTOR PROTECTION	
S	Slipguard (PF) Pullout Function (Digital)
S	Incomplete Sequence
S	Under/Over Excitation (Independent of Feedback)
S	Stall Protection Using Motor Speed Sensor (if Fitted)
O	Brushless Exciter Diode Monitoring
OPERATOR INTERFACE	
S	Integral Field Analog Ammeter
S	6" Quick Panel HMI Interface
O	12" Quick Panel high-contrast HMI Interface
S	Mode and Reference Adjusting, Display of Key Variables
S	Event Log with Date/time Stamp
S	Lockable Access to Parameter Adjustment
O	Analog Power Factor Meter and/or Field Voltmeter
O	GE Multilin SR469 Motor Protection Relay
REMOTE INTERFACE	
S	Ethernet TCP/IP, Modbus TCP
S	Web server for remote viewing of HMI parameters
O	GENius, RS485 Modbus RTU, DeviceNet or Profibus

S = STANDARD, O = OPERATIONAL, (1) = CONSULT FACTORY.



Free Standing Cubicle Version (Shown with optional Multilin SR469, PF meter, and voltmeter)

Rotating Machines Health Check

Reduce Risk

We know that any unplanned downtime can be expensive, with costs between \$3,000 and \$30,000 per hour. We also know that good maintenance reduces the risk of an outage. But just how good does this need to be? Maintaining machines can be expensive, so you don't want to do any more than is needed.

Equipment Health Checks

GE has designed, built and commissioned thousands of rotating machines. We continue to maintain many of them as part of a planned service cycle. When customers have an unplanned outage we help get them back on line as fast as possible. However, prevention is better than cure, so we also offer equipment 'maintenance strategy reviews' or "health checks." These can identify potential issues and help shape an OEM-designed maintenance plan to help avoid any unwelcome outages.

Maintenance Strategy

After the healthcheck, customers benefit from an OEM-designed, knowledge-based, best practice maintenance strategy that is specific to their rotating machines. This will help to avoid unplanned outages and minimize maintenance costs.

Health Check Features

Our field service expertise covers both GE and non-GE equipment. We carry out non-invasive equipment inspection while it's operating, and work with you to understand historic maintenance, environmental conditions, budget constraints, operational constraints and business imperatives.

During the Health Check We:

- Identify safety critical issues – bringing them to your attention immediately and proposing a resolution.
- Prioritize the dispatch of parts needed to resolve such issues. If necessary, the field engineer will remain or return to site to supervise the solution.
- Identify operational-critical issues, reductions in performance or critical items affecting reliability—bringing these to your attention.

After the Health Check We:

- Recommend a maintenance plan, based on our experience of thousands of similar machines.
- Suggest an OEM-designed plan to help avoid unplanned outages.
- Identify critical spare parts, providing a list of spares you should consider holding and suggest details of obsolete parts you may wish to replace.
- Put forward upgrade packages appropriate to your equipment and circumstances.

Rotating Machines Inspection

To ensure efficient operational continuity, it's important to schedule regular rotating machine maintenance with a frequency that reflects the operating conditions. For example, dirty conditions and open ventilated machines will require more regular inspections and cleaning than closed circuit machines in a clean environment.

We offer a variety of cost-effective inspection programs, for both GE and non-GE equipment, to ensure proactive life cycle planning. Our expert team can share with you an in-depth understanding of maintenance requirements, helping you avoid unplanned downtime while improving performance and lifespan.

Tailored to Your Needs

Building on our OEM expertise and field service experience, we provide a selection of inspection programs tailored to your operating conditions.

These thorough programs are designed to provide early detection of issues throughout the rotating machine's lifetime. This helps to avoid potential failures and prevent unplanned downtime. As our programs are adapted to operating conditions, they help minimize the number and duration of required outages, while effectively assessing unit reliability and suggesting maintenance actions.



Expert Support

As an equipment manufacturer, we have extensive experience in maintaining a global installed base of rotating machines. Our team of field service engineers can undertake inspections, troubleshoot and repair on site. Plus, through the engineers, tools and equipment at GE factories, we can repair or overhaul your equipment in house.

Our OEM rotating machines support service is provided by the engineers who designed the equipment. This means they can advise you on the most appropriate OEM-designed upgrades to help manage obsolescence and maintain original equipment performance, as well as adding new functionality or controls.

This expertise is not only limited to our own products. Our rotating machines service business covers both GE and non-GE equipment, enabling us to deliver state-of-the-art services for most machinery in the industry.

Safety and Training

GE is committed to ensuring the highest levels of safety for both its employees and customers – training your maintenance teams to help you to carry out inspections safely and competently.

Rotating Machines Modification and Upgrade Services

Having supplied thousands of machines over more than a century, we appreciate that equipment is a considerable investment and one that can exceed its initial expected lifespan. Keeping machines well maintained in accordance with the recommended service schedule will prolong their life. However, you may also want:

- Improved efficiency, lower fuel burn or reduced operating cost
- More power or lower starting requirements
- Increased reactive power to cater for demand-side loading
- Greater noise attenuation or revised code compliance
- A revised mix of attributes for altered circumstances

If you are considering replacing your unit, we go beyond expectations – proposing re-engineered solutions that use cutting-edge technology.

Modification or Upgrade?

Drawing on our bank of design information, drawings and specifications – alongside our manufacturer's insight – GE can assist in maintaining your equipment. We also support the re-engineering of components or assemblies. This improves performance and can be more economical than a complete machine replacement.

Assembly	Typical Options	Benefits
Rotor	Integral Tip rotor Salient/solid pole Laminated rotor Squirrel cage	Inherently robust High power density High efficiency Asynchronous choice
Stator	Vented stator Pin vented stator	Older technology Increased cooling/efficiency
Frame	Retain	Avoid unnecessary cost

It may be possible to provide revised temperature class of machine alongside rating changes

Rotors, Stators and Machines

The main parts of an electrical rotating machine are the rotor, stator and frame. We can explore fully engineered solutions for replacing one or more of these components, restoring or even enhancing the available efficiency and power.

At GE, we use an integrated system approach that combines engineering expertise with our incomparable knowledge of rotating machines. For both replacement machines and upgrades, we support you from start to finish. This can include project management, application engineering, full design engineering, testing and technical direction of installation, commissioning and spare parts. As our experience spans most industries and sectors, we're able to understand your application, appreciate your challenges and help you get the highest performance possible from your equipment.

Phased Upgrades – Low Risk, Cost-Effective

If you've installed GE equipment, our engineered solutions enable a phased upgrade to the next generation of technology without having to replace complete machines. Benefits of phased upgrades may include:

- Lower total install costs by reducing the expense of purchasing, installing and commissioning an entirely new machine or system
- Reduced operating expenses and increased equipment reliability
- Extended life and mitigated obsolescence through phased installation and greater spare parts availability
- Reduced system operating downtime
- Planned upgrades or modifications that mitigate unplanned outages

Rotor Modification/Upgrade

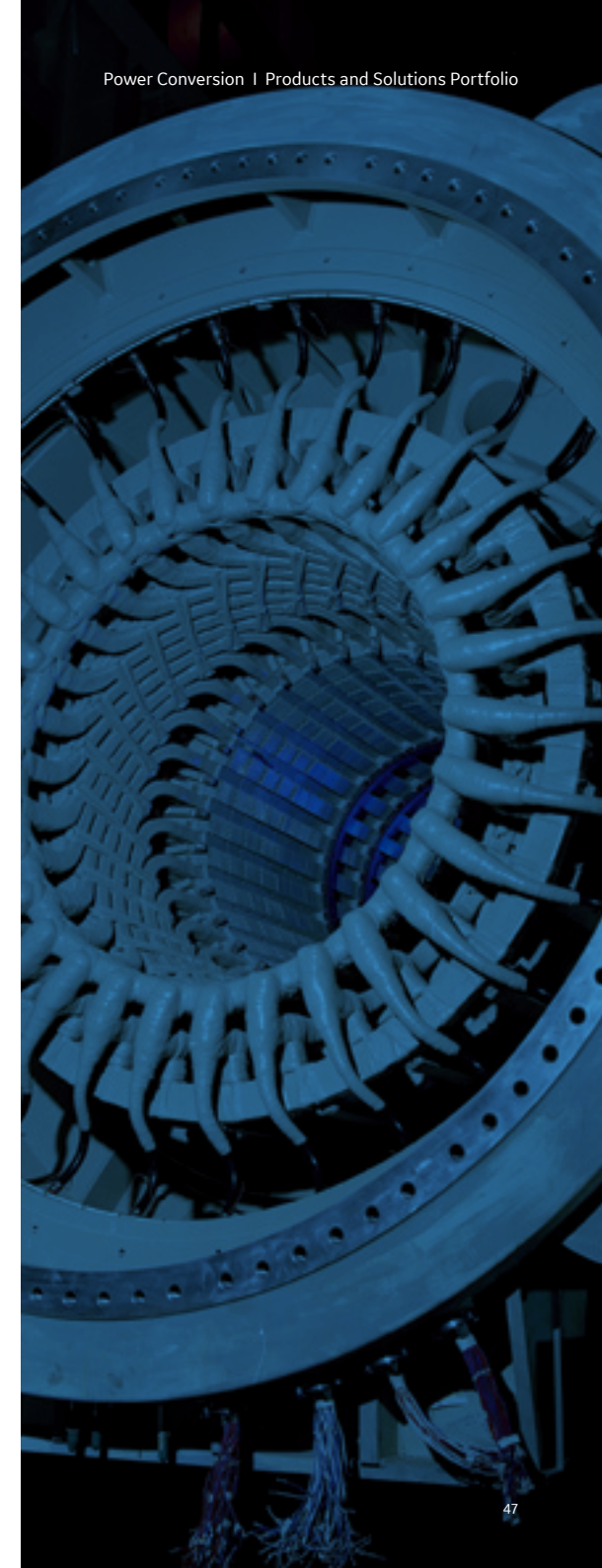
Rotor assembly replacement is the more straightforward option. At a planned time, we can substitute a replacement rotor for the existing one, using specialized rotor extraction equipment. The main machine bearings can also be easily renewed at this time.

A replacement modern rotor can help to provide higher efficiency (particularly important in 'rotor limited' machines), a higher power/reactive power rating or even revised inertia. Recent technological design improvements may even allow a switch of rotor type from solid to laminated, or vice versa.

Stator Modification/Upgrade

Stators possibly have the greatest influence on overall machine performance. A replacement stator made using current technology can help to provide greater efficiency, revised output power – or both. The stator replacement can be on its own or combined with a rotor replacement to deliver added benefits. Technological improvements in stator materials, insulating systems and the use of the GE-patented pin vent TM cooling scheme all offer advantages over older designs.

We can fit new coils to existing stators. However, a complete new stator assembly may enhance the machine and minimize downtime, improving the return on investment.



Induction Motors Spare Parts

Minimize Failure Impacts and Improve Equipment Uptime

Parts failure and unplanned outages are inevitable for electrical rotating machinery. Ensuring high equipment availability is a key priority, with access to the right spare parts essential for quick recovery. Knowing which spares to keep in stock and where to source others is therefore critical.

Deep Expertise and the GE Advantage

As an OEM with over 125 years of engineering expertise, we provide top-quality spare and replacement parts. We also offer the right advice when you need it. At GE, we pride ourselves on our exceptional level of customer service. It's of a standard that only the experts who designed, manufactured, installed, commissioned and continue to maintain these motors can provide.

Local Presence Supported by a Global Organization

Our advanced technology Global Customer Service and Support Center is available round the clock, every day of the year. Thanks to distribution centers located across the globe that carry extensive inventory for our products, we can support your part replacement needs at any time.

Reduce Lead Times, Stock Critical Spare Parts

Holding the right spares in stock is critical for keeping your equipment running. This is because lead times can be long for procuring parts and the unavailability of critical spares in your inventory may lead to extended downtime in the event of a failure.

We can help you to identify common parts across multiple machines and determine which spares to carry. We classify motor spare parts into three main categories, based on criticality:

- **HIGH Criticality**
Components including the stator, rotor and exciter, without which the machine will fail and cease to operate, resulting in downtime of up to six months, *plus:*
Components including bearings, seals, fan motors, pressurization units and brushes, without which the machine will fail and cease to operate, resulting in downtime of up to 15 weeks.
- **MEDIUM Criticality**
Components including cooler batteries and fan motors, without which the machine continues to operate at a reduced load. Associated downtime is up to 15 weeks.
- **LOW Criticality**
Components including space heaters, air and bearing probes and leakage detectors, which have no immediate effect on the machine. However, there is risk of failure of system protection. Associated downtime is up to 10 weeks.

Key Oil & Gas References

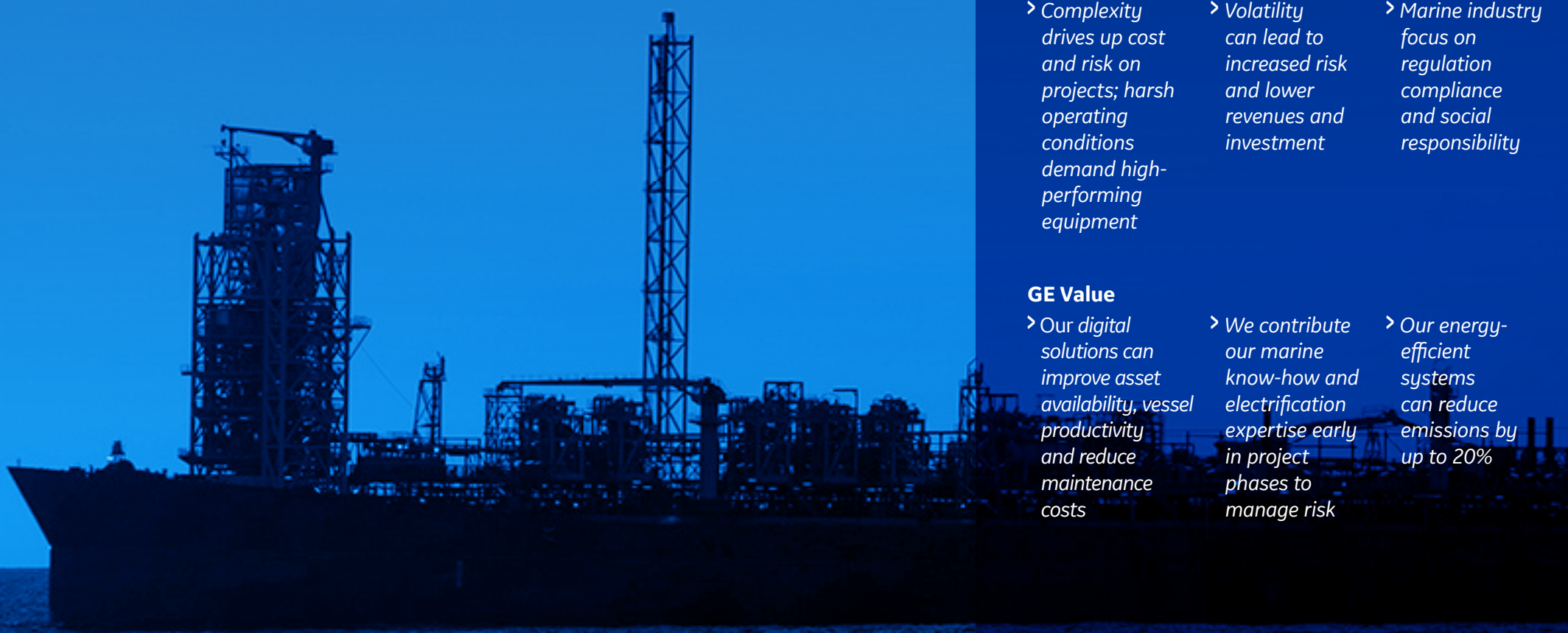
Sub-Segment	Application	Country	Main Scope of Supply
Upstream	FPSO	Angola	5 x VSDS for the high-pressure compressor units, incl. Step-down transformer, MV7000 drives, induction motors (9.61 MW/6 kV/1,717 rpm/4 poles) 1 x VSDS for low-pressure compressor unit incl. Step-down transformer, MV7000 drive, induction motor (4.89 MW/6 kV/1,717 rpm/4 poles)
	Offshore platform	Denmark	7 x VSDS incl. high-speed application and three generator sets, with two 16MW/8,000rpm induction motors offshore
	CPF & FPSO	Australia	6 x Alpha Synchronous Generators (39 MVA/11 kV/50 Hz) driven by Gas Turbines
Midstream	Shale gas and gas processing	Canada	10 x VSDS incl. Transformers, MV7000 drives, electric motors, e-Houses
	Gas transportation	Germany	4 x ICL incl. high speed induction motors (13.6 MW/8,280 rpm) and MV7000 drives
	Pipeline	Alaska	SGT400 driven Alpha Synchronous Generators (17 MVA/13.8 kV/60 Hz) packaging close-coupled epicyclic gearboxes on the generator frame
Downstream	Refinery	USA	1 x synchronous motor (33 MW/36 poles/200 rpm/soft starter)
	Refinery	Singapore	1 x VSDS for turbine replacement incl. high-speed motor (11,280 rpm/ 2,565 kW/Oil bearing) and MV7306 drive
	Refinery	Uzbekistan	2 x Alpha Synchronous Generators (53 MVA/10 kV/50 Hz) driven by Steam Turbines
LNG	eLNG	USA	10 x complete electrical systems incl. Step down transformer 96 MVA, Frequency converter LCI (80 MW/2x11 kV), 2pT Synchronous motor (75 MW/3,000 rpm), e-House
	Starter helper	Russia	7 x complete electrical systems incl. Step down transformer 32 MVA, Frequency converter LCI (35 MW/2x4.4 kV), 2 pT Synchronous motor (24 MW/3,600 rpm)
	Starter helper	USA	2 x complete electrical systems incl. AN Transformer (13.8 kV/6x1.85 kV/50 & 60 Hz), Frequency converter VSI (27 MW/9 kV), Two-pole induction motors (20 MW/3,600 rpm each)

Marine Solutions



Challenge & GE Value

GE's Marine ecosystem is a new approach to the challenges the industry is facing as it heads into a new era. We bring together electrification and digital technology with our systems know-how to be a life cycle partner for optimized, high-performing vessels.



Productivity and Operational Efficiency

Challenge



Complexity
Projects, operating conditions and rate of technology change.



Volatility
Economic, political and security turbulence.



Environment
Regulation and safety.

- > *Complexity drives up cost and risk on projects; harsh operating conditions demand high-performing equipment*
- > *Volatility can lead to increased risk and lower revenues and investment*
- > *Marine industry focus on regulation compliance and social responsibility*

GE Value

- > *Our digital solutions can improve asset availability, vessel productivity and reduce maintenance costs*
- > *We contribute our marine know-how and electrification expertise early in project phases to manage risk*
- > *Our energy-efficient systems can reduce emissions by up to 20%*

Marine Solutions

Trusted to Bring Electrification to More Than 1,000 Ships

Offshore Energy

- Drilling vessels
- FPSO and FLNG production
- Specialist and support vessels
- Survey and research
- Floating power plants

Navies and Coastguards

- Aircraft carriers and landing platforms
- Destroyers and frigates
- Logistic support
- Specialist patrol

Transportation

- Container ships and tankers
- Cruise ships and ferries
- Icebreakers and workboats



Marine Solutions

Marine Ecosystem Electrification

- Electric and hybrid power, propulsion and automation
- Energy-efficient systems reduce environmental emissions to help our customers stay competitive and comply with regulations

We specialize in vessel applications with high power, energy and thrust, as well as other complex needs.

Marine Ecosystem Digitalization

- Improved return on fleet assets
- GE brings together smart engineering, operational know-how and analytics to provide customers with data-driven efficiency across a ship's life cycle

Our strength lies in providing an integrated system to improve performance and reduce project risk.

From the heart of the ship's power network...

Propulsion Solutions

SeaJet™, SeaPulse™

- Advanced induction motors
- MV and LV propulsion drives
- Podded propulsion
- Hybrid power take-in

Power Generation

SeaGreen™

- Generators
- Hybrid power take-off
- Energy storage
- Process drives

...to the brains of the system

Integrated Platform Management

SeaStream™, SeaLyte™

- Vessel control and automation
- Dynamic positioning
- Intelligent power management

Digital Life Cycle Support

SeaStream™, SeaLab™

- Asset Performance Management (APM)
- Remote monitoring and diagnostics
- Vessel Performance Analyzer (VesPA)

Marine Naval Solutions

Surface Combatant, Logistic Support and Special Vessels

GE supports naval missions by delivering flexible and reliable solutions for integrated, full electric and hybrid propulsion. Vessels range from high-capability warships to the latest fast fleet support and coastguard ice-patrol.



Photo courtesy of U.S. Navy



Photo courtesy of ACA



Photo courtesy of U.S. Navy



Photo courtesy of Fincantieri

QE Class Aircraft Carrier, Royal Navy

The UK Navy's largest ever vessels – the first now commissioned featuring fully integrated electric propulsion producing 110 MW on-board power

DDG 1000, US Navy

The US Navy's first full electric propulsion ships producing over 78 MW installed electric power

PPA Frigate, Italian Navy

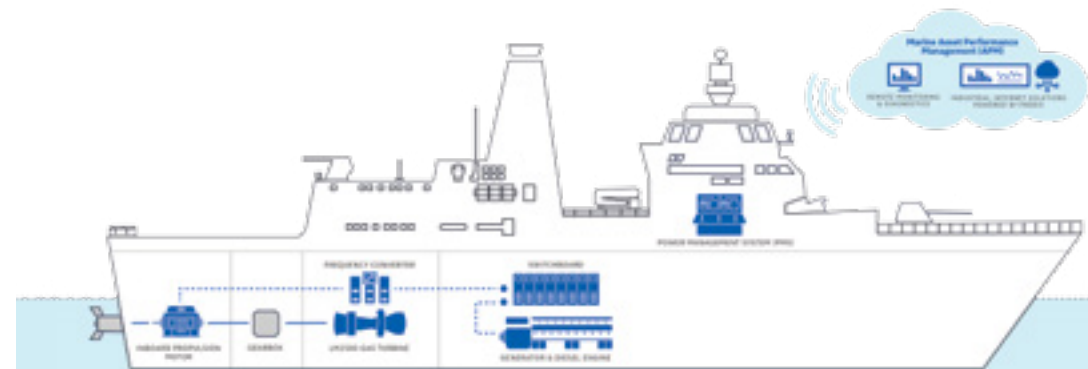
Hybrid electric with Power Take-Off/Take-In (PTO/PTI) and 2 MW shore supply power

GE's **powerful electrical networks** are capable of **supporting** a ship's major requirements, including **propulsion, high-power sensors, service loads** and **pulse power for defense systems**.

Options include **full-electric** or **hybrid-systems**, in **geared** or **direct-drive** configurations. The versatile design provides **greater flexibility** in vessel layout, survivability and maintainability.

Operating **electric and hybrid drive vessels** enables navies to attain cruise speed whilst realizing **fuel savings**, and reducing **operating and life cycle costs**. Reduced acoustic signatures also bring **low radiated noise** for anti-submarine warfare (ASW).

GE's **dependable** technologies are **proven** on **fully shock rated** naval applications and commercial fleets.



We Have References For Nearly 100 Electric And Hybrid-Electric Naval Ships

Marine Transport Solutions

LNG and Cargo Vessels, Cruise and Passenger Ships
Peace of mind, power and propulsion for precious cargos.



Photo courtesy of MSC



Photo courtesy of MSC

MSC Seaside
Powering the latest generation of passenger experience

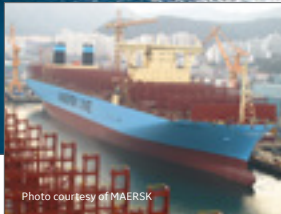


Photo courtesy of MAERSK

Maersk Line's Largest Container Ships
Fitted with e-efficient PTO/PTI



Photo courtesy of HOEGH

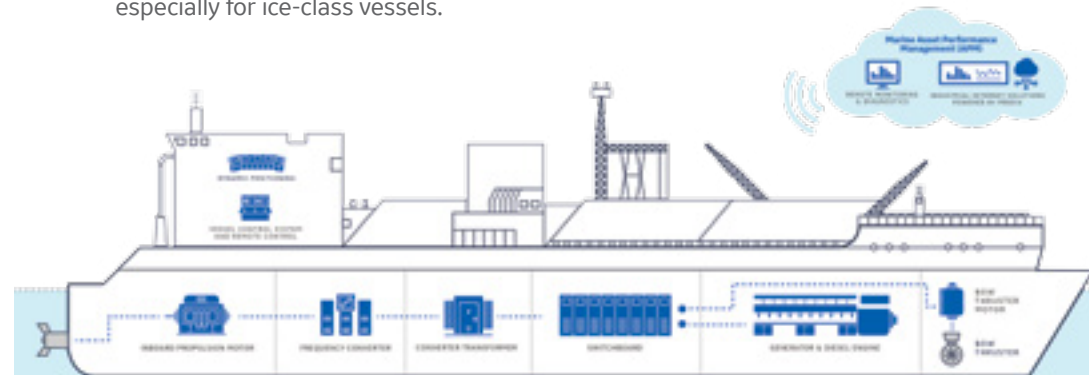
Höegh FSRU
Providing critical power to floating storage and re-gasification processes

In today's competitive market, fleet operators need to maximize vessel capacity and voyage performance for their customers.

However, ship owners also need to manage operating costs while complying with increasing environmental and emission regulations. That's why energy-efficient solutions are critical. Vessels using GE's electric propulsion can benefit from up to 10% fuel efficiency improvements for specific & complex operation profiles.

Power systems generate power for on-board operational needs, from gas processing to passenger comfort. A range of hybrid options from energy storage to Power Take-Off/Take-In (PTO/PTI) provides flexible options and solutions to reduce emissions.

Focusing on vessel performance, GE's **high-efficiency electric propulsion** induction motors and power electronics enable excellent maneuverability and thrust. **Podded propulsion units** provide exceptional performance in demanding conditions, especially for ice-class vessels.



We Have References for 200+ Transport Vessels

Marine Offshore Solutions

Specialist Vessels and Workboats

Meeting vessel power demands for on-contract performance, GE is always tough enough to get the job done. We work across offshore industries, from energy to fishing, marine science to communications.



Heerema
Integrated power system for the world's largest offshore construction vessel



Shanghai Salvage
The world's most advanced deep-water dive support vessels

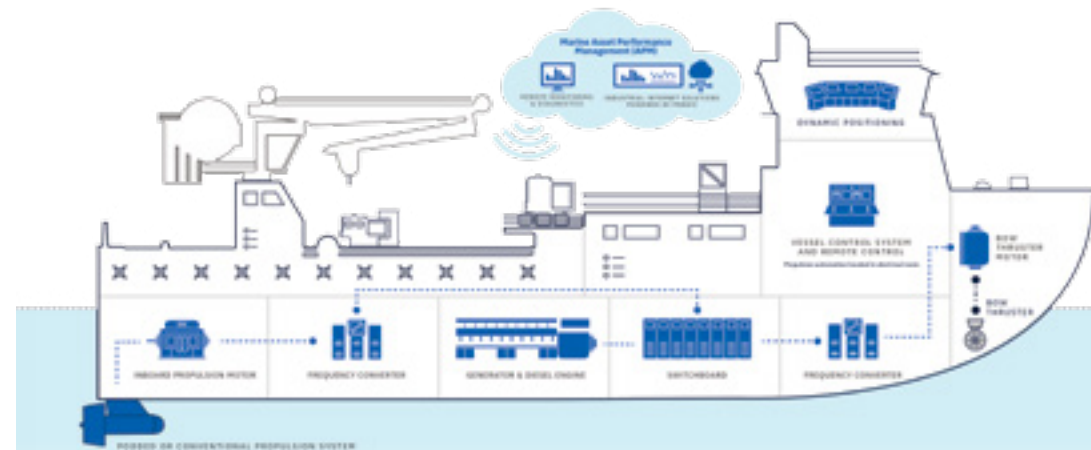


SeaJacks Wind Turbine Installation Vessel
Supporting a growing offshore wind industry

GE provides highly customizable modular solutions for electric and hybrid propulsion and power.

We specialize in vessels that require the power to carry out on-board operations or high levels of thrust to support large drilling and production assets.

Experts from our Marine Offshore Center of Excellence configure the best solutions, considering operating conditions and operating cost trade-offs.



We Have References for 800+ Vessels

Marine Offshore Solutions

Exploration and Production Vessels

GE technology meets the harsh requirements of offshore energy companies, providing integrated energy, control and automation, and digital solutions to power next-generation vessel operations.



Transocean Deepwater Drillship
Integrated vessel and drilling power, e-propulsion and DP



Noble's Globetrotter I
The world's first 'Digital Rig™' fitted with GE's digital asset performance management



FPSO for Libra Field
e-House electrical distribution module being installed on FPSO topside

At GE we're specialists in ultra-deep water, high-specification rigs and production vessels - delivering electrification that enables the latest offshore exploration and production technologies.

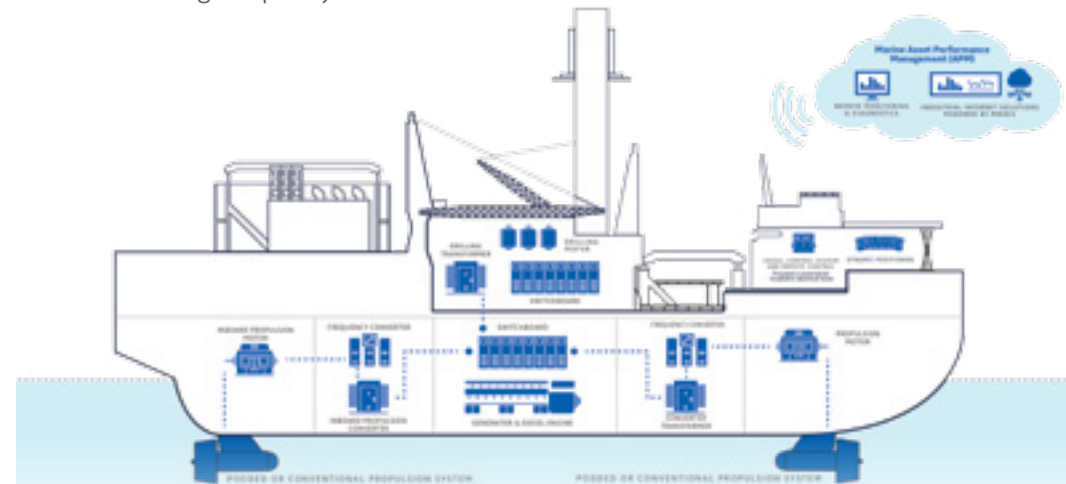
Our experienced engineering and project management specialists take the pressure off your project team. We add value and reduce project risks, using our expertise to provide a turnkey solution, from Pre-FEED phase concepts and advice to EPC capabilities for simpler interfaces and faster integration.

Innovating the Digital Rig™

In a partnership formed by GE and Noble Drilling, the two companies have launched the world's first digital drilling vessel, targeting a 20% operating expenses reduction and improved drilling efficiency.

Powered by Predix™, the solution connects target systems, including drilling control and power networks, using data to apply predictive analytics. This provides an early warning to operators, mitigating problems before they strike.

Simple dashboards provide improved situational awareness and decision support, reducing complexity.



We Have References for 150+ Vessels And Platforms

Queen Elizabeth Class (QEC) Aircraft Carriers

HMS Queen Elizabeth and HMS Prince of Wales: World's Largest, Electric-Propelled Warships

The new QE Class is the UK Royal Navy's new aircraft carrier class. At more than three times the displacement of the Invincible Class it replaces, the QEC represents a step change in both size and capability, using proven architecture and technology from other naval and commercial platforms to help minimize both cost and risk.



Background

The first ship, HMS Queen Elizabeth, was commissioned in 2017 – the new carriers the biggest, most powerful surface ships ever built for the Royal Navy.

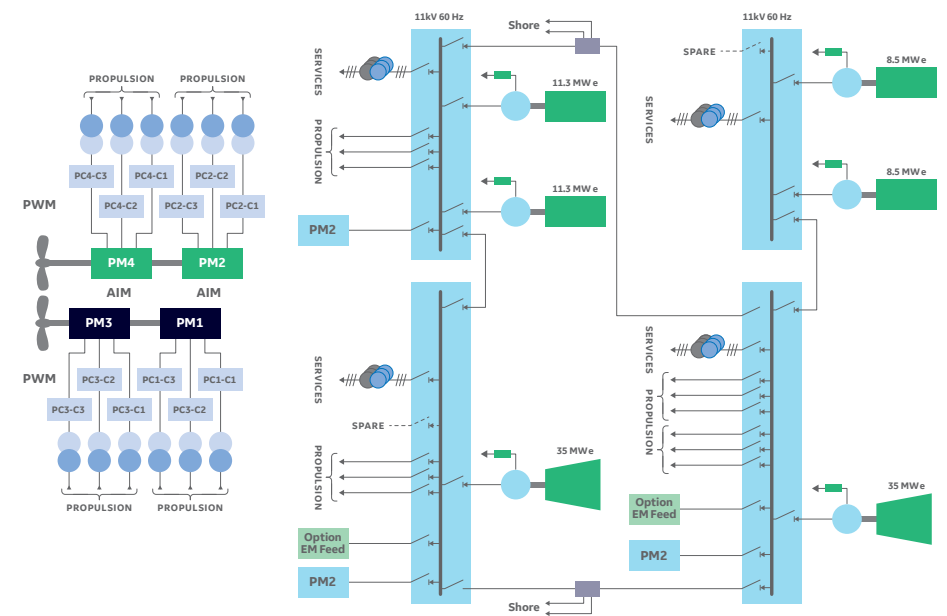
The QEC vessels are the first Royal Navy ships to have been designed from the outset with Integrated Full Electric Propulsion (IFEP), enabling the ship's mission and reducing life cycle costs.

Design Process

GE has been involved in the program since 2001 and has been a key member of the Aircraft Carrier Alliance (ACA) and Power and Propulsion (P&P) sub-alliance, selected for the critical HV, propulsion and system integration.

Case Study

Four Propulsion Motors in Twin Arrangement, One Behind the Other on Each Shaftline



At 11 kV and >130 MVA, This is Power and Propulsion on a Grand Scale

- An efficient electric propulsion system yielding increased range and autonomy via fuel economy
- 80 MW power from advanced induction motors
- Graceful degradation, rather than redundancy, maximizing availability
- Shore supply connection

Key Facts:

- Operator: Royal Navy
- Length: 280 meters (920 ft)
- Displacement: 65,000 tons
- Speed: Over 25 knots
- Crew: Accommodates 1,600

QEC HV P&P Configuration

- 4 x 20 MW Advanced Induction Motors (2 per shaft)
- VDM25000 drives
- 6 x generators (2 x 35 MW, 2 x 11.3 MW and 2 x 8.5 MW)
- 3 x HV harmonic filters
- 2 x MV switchboards (11 kV)
- Propulsion and service transformers
- Power Management System (EPCAMS)

Marine Product Portfolio

Power Electronics

Offering high power density, reliability, availability and power scalability, our Voltage Source Inverters (VSI) use IGBT-based technology and are a core component of electrical propulsion.

Models

- MV7 Series
- IV3 Series
- MV3 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

Our electrified propulsion systems for marine and offshore deliver high quality and performance in the most challenging environments. These include the:

- Main propulsion motor
- Thruster motor
- Shaft generator motor
- PTI/PTO
- AC/DC drilling motor

Models

- Compact Induction Motors (low and high speed)
- Vertical Induction Motors
- Advanced Induction Motors

Technical Capabilities

- Power: 3000 kW–40 MW
- Voltage: up to 13.8 kV
- Marine and offshore certifications



Podded Propulsion Units

These external integrated electric propulsion systems feature an energy-efficient induction motor, electrical steering and propeller unit, with ice-capable rating.

Models

- Seajet™ Pod
- Seajet™ Pod Polar Class*

Technical Capabilities

- Output power: 3–22 MW
- High thrust capability at high transit speed vessels
- High bollard capability for DP application
- Designed for maximum availability
- Noise and vibration optimization for comfort
- Digital twin solution

*The ice-class range of SEAJET™ is a joint technology development with AETC Sapphire.



Vessel Control System

Delivering centralized supervision, control and automation of all vessel systems.

Models

- C-Series Vessel Control System
- SeaLyte Vessel Control System

Functionalities

- Central alarm system
- Centralized power plant monitoring and control
- Propulsion, thruster and steering systems
- CCTV
- Auxiliary systems
- Fluid and cargo systems
- Power Management System (PMS)



Dynamic Positioning

Dynamic positioning for all vessel types using enhanced UX that puts the mariner back in control.

Models

- SeaStream™ DP
- SeaLyte DP
- Energy Efficient Mode
- Up to DP 3

Functionalities

Computer-controlled system used to maintain a vessel's position and heading. This works by automatically activating propellers and thrusters to counteract the displacing effects of the external environment.



Asset Performance Management

Covering the entire vessel, system and fleet operations.

Models

- SeaStream™ Insight

Functionalities

- Machine and equipment health lets you gain an advanced view of an asset's status and condition
- Reliability management allows you to predict and diagnose asset issues
- Maintenance optimization provides balance reliability, performance and costs to create better maintenance strategies



SeaStream™ Insight

Digital Asset Performance Management

Optimizing Maintenance and Processes

SeaStream™ Insight is GE's digital marine Asset Performance Management (APM) solution, powered by Predix.

SeaStream™ assists energy contractors and fleet owners to optimize their operations by shifting from gut-feel to data-driven decisions. It's part of a drive to reduce maintenance costs and improve operations efficiency by:

- Harmonizing industrial data from vessel equipment
- Generating analytics for early performance and predictive insights
- Providing repeatability and predictability in operational processes

Get Connected

Machine And Equipment Health

Better situational awareness through an advanced view of an asset's status and health.

Get Insights

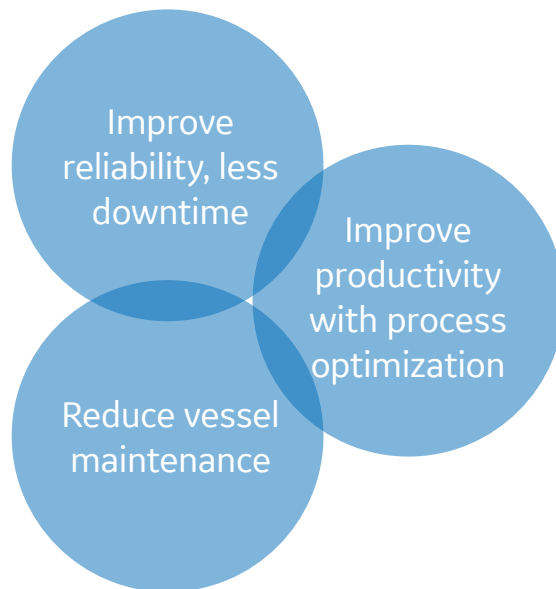
Reliability Management

Predict and diagnose asset issues.

Get Optimized

Rethink Maintenance

Balance reliability, performance and costs to create better maintenance strategies.



Step 1

Performance Indicators

Stakeholder dashboards offer rapid drill-down via an intuitive interface to access:

- Centralized data for single source of information
- Key performance indicators for operations processes
- Efficiency reports to automatically derive a current performance baseline.

Step 2

Performance Analytics

Data-driven insights and decisions enable operational anomaly detection

- Digital twin performance analytics highlight potential deviations in equipment use and process, providing guidance on how these can be prevented
- Detailed insights establish a baseline and assist optimization.

Step 3

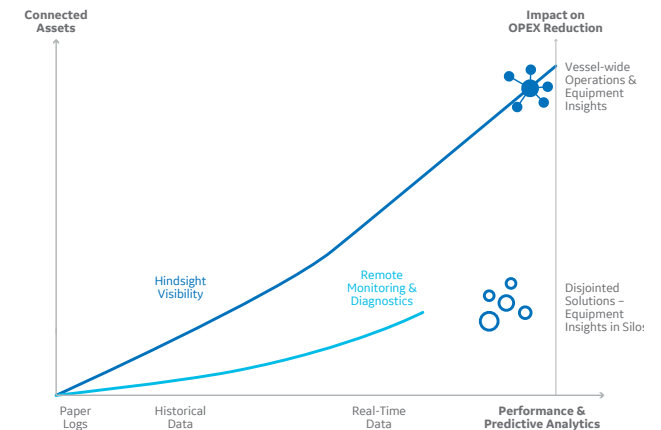
Predictive Analytics

Shift from **calendar-based to predictive maintenance** with early warning and alerts

- Access information on potential future degradations in equipment reliability and performance
- Drive continuous improvement using stakeholder-relevant dashboards to make informed decisions
- Systemize data-driven operational methods and enable digital transformation

The GE Difference:

- IT and OT expertise
- Real expertise and outcomes through connecting the world's first digital rig
- Organizational transformation experience
- Operator-friendly approach



Life Cycle Support



Energy Efficiency Design Optimization and Modeling

VesPA, GE's real-time configurator, helps design the entire electrical system to optimize thrust and power. It allows shipbuilders and owners, together with GE's SeaLab design team, to rapidly simulate and compare multiple configurations at the design stage. We can then select the best system based on the specific vessel's performance requirements and predicted operating cost.



Marine Power Test Facility

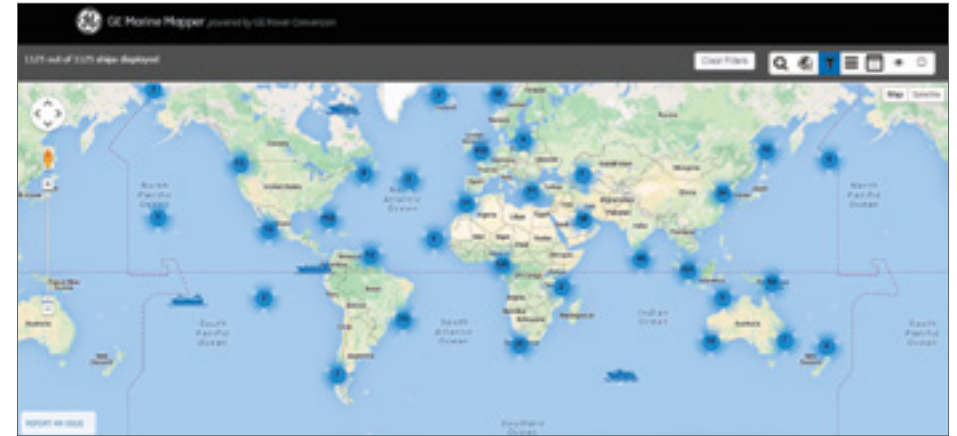
We have the world's only commercially owned facility that offers full-scale electric and hybrid power system testing. This helps to reduce risk prior to installation and sea trials for cost-effective program management.



Marine Training Centers

We offer hands-on training and simulation in our regional customer support facilities, including dynamic positioning operator training.

Services 360°



ServiceMax is our Operations Center system that provides thorough case management and history, automatic support scheduling and dispatch. GE's Marine Mapper helps our teams track vessel location and status from our Service Operations Centers. Responsiveness is our priority.

A simple installation of our ship **Visor** system connects you to our onshore global tech experts to remotely diagnose problems and advise on immediate next steps.

With Services 360°, you can take advantage of mobile tools and apps to connect quickly with our skilled and experienced services team. Our Online Manager puts you in control, generates your case and keeps you updated with your services expert.

GE's Marine Digital Roadmap

Asset Performance Management (APM)

- Reducing unplanned downtime by predicting equipment issues before they occur
- Increasing health and usage situational awareness

Voyage and Energy Optimization

- Delivering fuel and energy efficiency
- Optimizing route, speed and vessel systems to suit environmental conditions

Smart Automation

- Reducing manning through optimized and remote controls
- Enabling corrective action

SeaStart – Vessel Reactivation

Informed and Ready to Go

In the current market, vessel owners face critical decisions relating to their fleets, whether small or large.

Stacked vessels can't be put straight back into service. Yet you need to be ready when market opportunities do appear.

Bringing in an experienced OEM partner to support your core team and evaluate the impact of returning a vessel to work will provide the information you need to make the right decisions.

Showing clear and simple cost options, recommendations may include repair, upgrades or replacement – based on the state of the vessel.

Life Cycle Service Support

As a Full-Scale OEM, We Also Offer:

- Dedicated fleet managers
- Digital asset performance management solutions to improve availability and return on assets
- GE's Visor remote diagnostics with tech support and fast troubleshooting
- Long-term service agreements with life cycle support, based on your needs
- Modifications for charter needs.

Through the practical SeaStart Program, GE offers its expertise to help customers restart the operation of stacked, laid-up vessels in the best way possible.

We can help ensure a smooth, timely and safe transition back to high-performing vessels. This enables you to be competitive and get back on contract as soon as the time is right.

Your SeaStart Package Includes:

- **A structured survey** tailored to your needs that helps you make informed decisions regarding your restart and assists with your financial planning
- **Recommendations** for restart of equipment or identification of reusable equipment from vessels to be scrapped
- Support for meeting **class society approvals**
- **Experienced marine field service engineers** to restart equipment and supplement your team, as and when you need us
- **Third-party equipment recommendations** on a case-by-case basis

Four Levels of Support

GE's SeaStart program offers four levels of support giving you options for each vessel before committing to work:

- 1) Survey and recommendation
- 2) Reinstatement package – back to work with **critical spare parts package**
- 3) Reinstatement 'plus' – **upgrade** packages with efficiency and latest technology enhancements
- 4) **Training refreshers** for your team **including NI and OSVDPA classification**

SeaStream™ Dynamic Positioning Upgrade

Enhanced Features and Managed Obsolescence

With years of experience in the design and development of Dynamic Positioning (DP) systems, we have applied our expertise to create the latest, mariner-focused SeaStream™ DP System with enhanced features. With excellent operator feedback for usability and energy efficiency, choosing to upgrade can improve operations and manage obsolescence with the latest Rxi-based hardware and software.

Power of Seastream™ DP

- Enhanced HMI, intuitive and user-friendly
- Energy-efficient DP control mode
- Enhanced serial link processing
- Advanced Position Measuring Equipment (PME) filtering techniques
- Enhanced PME checking and processing
- Wider range of PME interfaces supported
- Compass rose added to the motion screen
- Inhibit selection of DP mode at high speed
- Enhancements to thruster software to increase stability of the vessel's control



SeaStream Human Machine Interface (HMI)

- Award-winning design
- Configurable displays and intuitive graphic interface
- Structured areas making navigation easier
- Adjustable screen tilt angle
- Easy alarm management

Energy Efficient DP

- Reduces fuel consumption, emissions and mechanical wear and tear
- Predicts position over a two-minute window
- Configurable soft and hard zones for thruster engagement
- Optimizes thrust to stay within soft and hard limits
- Optimal energy use for different vessel operating modes

Upgrade Packages

- ### Customized for Your Fleet
- Seamless system upgrade, installation and commissioning
 - Peace-of-mind, up-to-date
 - Single vessel to fleet-wide
 - Expert, practical advice from services team
 - GE training centers for refreshers
 - GE DPS 900, A-series and C-series upgrades and third-party upgrades

Material Handling Solutions



Challenge & GE Value

Mines today can cover an area of many square kilometers and require working in ever deeper and more remote locations. These challenging environments demand increasingly large and more powerful equipment across the entire mining process. As the drive for power and scale increases, so the need for efficiency and reliability grows with it.

From Pit to Port – GE Makes Mines Work

Improving reliability, power density and efficiency, our advanced technology is integrated throughout the mining process from extraction through to grinding and crushing, mineral processing, refining and handling. It's all supported by over 100 years of application know-how and our proven track record.



We've Equipped, Powered and Automated 500+ Hoists/Winders Globally



Powering 400+ Mills in Ore Grinding, Crushing and Benefication



Driving and Controlling 100+ Conveyor Systems from Pit to Port

Extraction – Hoist/Winder

GE's Power Conversion business offers a complete range of hoist/winder systems for the underground mining industry (from Koepe to Double Drum BMR hoists). We use our overhung, low-speed and high-performance induction and VSI technology for greater reliability and productivity. Our systems are designed with power train operating life cycles of up to 30 years.

Our engineering experience enables us to perform winder rating calculations, feasibility studies, control system updates, compliance tests and site inspections. All this supports you to make informed decisions around productivity and safety requirements:

- World leaders in the application of reliable induction motor and VFD technology
- Strong expertise of hoist functionality, control and safety
- 25+ years of global references in AC hoists
- Comprehensive electrical solution capability
- Integrated and split stator hoist motor options
- Mine fan ventilation solutions (MV and LV)

Mineral Processing – Grinding Mills

GE provides flexible and innovative mill solutions across all types of grinding, from single and dual pinion AG, SAG and ball to HPGR. This helps you to meet high-capacity demands with less equipment. We supply both low-speed pinion drive and high-speed geared mill solutions offering greater flexibility and system efficiency plus:

- Strong global reference list
- Deep domain expertise of grinding electrical systems
- Advanced control features that reduce mechanical parts
- Low-speed synchronous and induction motor options
- GE's unique Quadramatic Dual Pinion Mill solution for the highest-efficiency fixed-speed applications

Materials Handling – Conveyors

To meet the requirements for reduced loading and unloading times, GE supplies complete electrical systems. These include fully integrated, pre-packaged e-house power and automation solutions, and a comprehensive range of drives for material handling systems.

We're pioneering the use of direct-drive technology with medium and large power, high-torque conveyors using high-performance, low-speed motors. We provide significant reductions in service and maintenance costs, and higher efficiency levels than geared solutions. Our medium-power solutions also lend themselves well to conventional conveyor designs for both new and upgrade markets:

- Numerous references for conventional conveyors including stockyard management
- World's first gearless conveyor (DC)
- Advanced, medium-large power gearless conveyor drive solutions
- Increased system efficiency (95%+) and MTBF (30 years+) enabling lower CAPEX and OPEX
- Standardized pre-packaged solutions
- Modular e-House designs
- Detailed analysis for monitoring and evaluating solutions

Mining Solutions

We build highly efficient motors, drives and integrated system electrification solutions for the mining industry.

Combining electrification technology with project life cycle services and digital capability, we provide connected, responsive and predictive solutions to help you maximize operational efficiency and productivity.



Material Handling

For large-scale, long-distance overland conveyors, GE's direct-drive, low-speed induction motor (and permanent magnet motor) technology helps provide significant reductions in service and maintenance costs. It also delivers higher efficiency levels than geared solutions.

GE power-trains comprise an optimized high-performance motor/drive system, incorporating specially designed, complex dynamic modeling application software. This is used for smooth starts and stopping using regeneration, and for high closed loop stability despite potential belt transients and traveling wave reflections. All of these features are standard in similar GE solutions and have a significant impact on improving power quality, productivity and OPEX. Furthermore, our digital capabilities provide many more benefits – ultimately increasing the belt and structural life cycles through monitoring alignment, tension, vibration, early break detection and more.

Mineral Processing

Increasing capacity demands, plus deeper mining in more remote locations, are leading to tougher ore grades and the need for larger power comminution plants. Additional CAPEX constraints mean the industry is also moving towards challenging times when it will require innovative solutions and technology.

For low-speed mill applications, GE offers highly efficient, synchronous and highly robust induction motor technology. These optimized powertrains provide improved power quality (due to our PWM drive and IEGT technology) and faster ROI. For high-speed, geared mill applications, we offer a variety of innovative and differentiating technology to suit the budget, including drives for slip energy recovery systems. These enable speed and process adjustment for mills using WRIM technology.

Our mill Master Sequence Control (MSC) has many automation embedded software features such as solidified load detection/prevention/recovery and mill inch/angle control.

Digital Mine

Digital Mine, the platform for the industrial internet, connects all mining assets to reduce unplanned downtime, optimize operations and enable proactive processes.

Our all-in-one, real-time, comprehensive 24/7 digital solution portfolio is fueled by the outcomes our customers are striving for every day. This enables timely and accurate decisions that balance process performance with equipment health – increasing operational visibility, availability, reliability and performance optimization.

For grinding mill circuit optimization, the mine performance solution calculates the optimal set-points to stabilize the circuit. It simultaneously provides real-time predictive anomaly detection and diagnostics – all of which can reduce the amount of re-circulation and energy consumption, improving grind quality and throughput.

Mining Product Portfolio

Power Electronics

GE's MV drive portfolio can help increase operating efficiency, power quality and availability, plant throughput, operational precision and process yield.

Its products form core components of electrical Variable-Speed Drive (VSD) trains, featuring voltage Source Inverter (VSI) IEGT-based and Load Commutated Inverter (LCI) thyristor-based technologies.

Models

- MV6 Series
- MV7 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%

The MV7000 PWM drive gives simpler power system topologies, and the AFE technology is more tolerant of supply variations, generates lower harmonics and assists in power quality control.



Rotating Machines

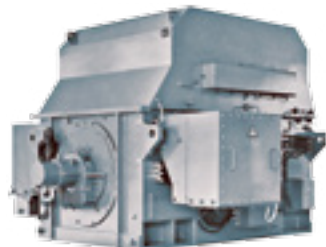
These include low- to high-voltage rotating machine technology with rugged and efficient motors from 100 kW to 100 MW. Engineered to perform and built to last, GE's durable motors continue to set the standard for reliability in grinding, hoist, conveyor and process applications.

Models

- Induction motors
- Synchronous motors
- Permanent magnet motors

Technical Capabilities

- Output speed: 40–20,00 rpm
- Output power: 100 kW–100 MW
- Output voltage: up to 13.8 kV
- Hazardous area: Zone 1 or 2, Div 1 or 2



Automation and Control

We build the controls across our automation and drive systems platform using a mature suite of reliable and secure automation components. These are then assembled into modular, flexible and scalable automation solutions. We 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 secure remote service capability and connection to Predix for remote asset performance monitoring and advanced process analytics

Digital

GE's Digital Mine solution helps you make timely and accurate decisions to balance process performance with equipment health. The solution increases:

- **Operational Viability** – to help you get the most out of your available resources and meet production targets safely and in compliance.
- **Availability and Reliability** – to maximize the time that equipment is available to produce RDA. The solution allows for quick planned repairs but only when needed.
- **Performance Optimization** – to improve operating results through better asset and process performance, utilization and planning.



e-House

GE has the in-house expertise to supply comprehensive electrical systems, including fully integrated containerized e-House power and automation solutions.

GE offers a wide range of e-Houses from standard ISO containers to custom multi-story designs, compliant to IEC and NEMA specifications. Fitted with a comprehensive GE portfolio of equipment and complete system integration and testing, enabling simpler, plug & play installation.



Mining Services Offering

Meeting the Needs of Your Operational Model

GE services cover site audits for installed base equipment health checks and surveys, including obsolescence, energy saving and preventive maintenance checks. We also offer three- or five-year LTSA with a dedicated customer service manager and 24/7 remote support.

For mines with obsolete equipment, our service team will provide upgrade advice – replacing DC with AC equipment, or LCI/Cycloconverter with PWM technology – complete with all the replacement system integration undertaking. If the mine's ore grade has changed and there's a need for process variation, GE can provide upgrade solutions that convert fixed to variable speed.

Proven LCI Control Technology

Power Electronics Controller (PECe)

- Standard industrial PC
- Intel-based chipset
- VXWorks operating system
- IEC1131 compliant function block
- Deterministic Ethernet
- Five 10/100 Ethernet ports
- 1.2 to 2.5 GHz
- 60°C ambient
- Fanless operation
- Two or four PCI slots allowing Profibus, Profinet, Reflective Memory, CANbus, Modbus, EGD, etc.

Power Interface Board (PIBe)

- 24 copper or 32 fiber optic outputs to power devices
 - 8 digital inputs
 - 4 digital outputs
 - 8 analog inputs
 - 4 analog outputs
 - 2 current transformer inputs
- Capable of 60 V, 10 amp outputs to power devices
- One encoder input

Field I/O

- Modular construction
- Digital inputs/outputs ... 24 VDC
- Analog inputs/outputs ... +/- 10 VDC
- Fast deterministic EtherCat interface from PECe

A touchscreen for operator control and maintenance replaces antiquated meters and push-buttons with modern touchscreen controls. This will immediately improve your ability to operate and maintain your LCI controls.

P80i Toolbox – Drive Commissioning and Maintenance

- High-speed trending**
- Unlimited signals per trending
 - Up to 3,000 samples per signal
 - Limited only by PECe memory capacity

Tool capabilities

- Configure trend (trigger, period and variables to be recorded)
- Set trend to be downloaded to a compact flash drive
- Upload records from the drive
- Display records in a trend
- Display 'live' or 'logged' data

Crane Solutions

GE crane systems include process control, drive systems, automatic targeting positioning, anti-sway systems, laser-controlled position detection, motors and encoders.

Pressures on loading and unloading times mean efficiency is essential for day-to-day operations. Crane monitoring systems process wind speed/direction, load, inclination, position feedback and more – resulting in safer crane operation under all conditions.

We design our solutions using active energy management and modular configuration which enables simplified status, diagnostics and fault detection.

Understanding 'customers and end-users' needs allows us to continually introduce more efficient operations with flexible and user-friendly designs.

Crane Refurbishment Means More Than Just Repairs

With decades of experience designing crane control and automation systems – dating back to 1946 – GE's history includes the combined experience of AEG, Alstom and Convertteam.

From the outset we've worked collaboratively with our customers, crane operators and manufacturers to create a highly customized interface between new and existing parts. This is based on the customers' needs, the crane's current condition and its main operating situation.

The spirit of this partnership is driven by the pursuit of a common target including performance, reliability and safety.

Our TDE crane management and ProCrane drive systems define the standard for crane technology today.

We provide advanced solutions and high-tech features that enhance the quality, precision and performance of your crane including:

- Improved throughput and performance
- Superior crane control and automation
- Reduced operating costs
- Restored availability and reliability

Cranes Product Portfolio

Power Electronics

We offer complete drive systems for DC and AC solutions to meet exact requirements and achieve the highest possible quality, precision and dynamic performance.

Models

- ProCrane
- 300 kW–6,400 kW
- Modular design
- Low weight and harmonics

Technical Capabilities

- DC thyristor stacks
- Drive controller for new or re-used power stacks



Automation and Controls

Enhanced Productivity

- Target position by crane operator or via remote access
- Automatic input of obstacle profile by laser or crane operator (interpolation points)
- Optional: Anti-collision-height (clear height)

Advanced control and automation solutions designed for high performance applications.

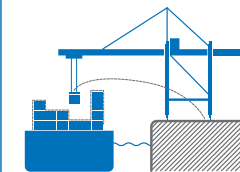
Technical Capabilities

The brain behind the crane

- Rack or computer-based
- Remote I/O network
- Integrated safety concept

Crane Management System

- Monitoring and reporting
- Post-mortem analysis 'black box'
- Crane check



Motors

The design of our motors meets our customers' requirements for power, speed, torque and mechanical dimensions.

Models

- Customized AC motors
- Customized DC motors
- Encoders and monitoring

LV/MV Power Supply

Low-voltage and medium-voltage power supply – from the land-side power network to the crane.

Supply Includes

- Land-side power network analysis
- Trailing cable (with and without fiber optics)
- Cable drum (repair and upgrade)
- Medium- and low-voltage switchgear
- Medium-voltage transformers
- Compensation system

Crane Electrical Equipment Refurbishment

Upgrade of Crane DC/AC Drive Systems, Controllers and Crane Management Systems

Crane Drive Upgrade Solutions From GE

Power Conversion offers a fully customized and comprehensive approach to crane upgrade – from the power supply to the drives and sensors, to automation systems.

Our integrated crane solutions allow for a step-by-step upgrade process or for complete refurbishment – revitalizing your old crane with new parts and advanced technology.

Features And Benefits Of GE Crane Upgrade Solution

GE's controller allows for additional supporting features to assist, monitor and reduce stress for the crane operator. We can also improve the mechanical crane construction by fine-tuning drive curves. Our solution offers:

- High-quality, precision and dynamic performance from drive system for AC/DC application
- Customized AC and DC motor, encoders and monitoring for various power, speed and torque requirements.
- Consistent and cost-effective project execution from start to finish.
- Experts that fully understand your crane needs and match our features to your specific requirements
- High-performance crane comfort with manual operation features to assist the crane operator including:
 - Boom anti-collision with and without sensor
 - Automatic slowdown in the container vessel
 - Grab automation (semi-auto, automatic, load optimizer)
 - Crane management system to the landside workstation
 - Safety features for the electrical system and for the crane
 - Gantry drive regulations for curves
 - Load measurement system
 - PC upgrade
 - Crane check



DC Drive Retrofit Package

GE offers a fully integrated DC drive package that helps to extend the life cycle of your existing DC systems. This allows you to defer a move to AC drive technology until you can assess scheduling and budget constraints. At the same time, it lets you restore existing legacy drive systems – for example a DC2000/9030 PLC with a new generation drive type.

The retrofit package exchanges the Digital Front End/Power Amp Module to convert old drives to the latest technology, leaving power modules intact.

Depending on your drive configuration, you can mount the following hardware in place of existing digital control of the DC2000 drives:

- PECE controller
- PIBe power interface board
- Keypad display
- Interfacing relays
- Gate pulse power supply
- Field exciter



Power Electronics Controller (PECe)

The PECE is an industrial PC running standard P80i IETC1131 compliant function block programming language, with a deterministic Ethernet (EtherCat) connection to the drive I/O. The system consists of a Power Electronics Controller (PECe), Power Interface Board (PIBe) and, depending on the requirements, EtherCAT I/O or Ethernet I/O (GE RSTi). The PIBe features digital and analog I/O encoder nuts and amplifier boards.

Crane Automation and Management

Our expert team will help you upgrade the remote I/O and crane management system to the current version, revitalizing your old crane with new parts and advanced technology.

GE Services

Power Conversion offers a comprehensive range of services, including:

- Retrofits, refurbishments and upgrades
- Replacement parts and repair services
- Preventive maintenance (annual) and/or extended maintenance (once every five or ten years)
- Multi-year service agreements
- Training services

Metals Solutions



Challenge & GE Value

High productivity, quality and efficiency are key for energy-intensive manufacturing industries. All three factors help you to stay competitive in sectors where raw materials and energy expenses constitute a huge share of production costs. For example, a single hot strip mill can lose up to \$30 million in annual revenue due to unplanned downtime.

GE is a full-scope partner for electrification, digital and services solutions across multiple industries, helping to improve the productivity, product quality and energy efficiency of your process. We deliver leading product and systems technology based on variable-speed drives, motors and generators. This is combined with productivity solutions and system architecture enabled by control, automation and predictive analytics. Our life cycle services and digital capability help you maximize operational efficiency and productivity with connected, responsive and predictive solutions

Challenge



Failures in Steel Making or Rolling Mills May Hinder You From Optimizing Throughput, Recovery and Asset Availability

GE Value

> *To stay competitive, steelmakers always need to reduce costs and lead time, increase operational efficiencies and use greener methods to produce metals with quality and reliability*

Metals Solutions



Steel Making

Energy-intensive processes, such as electric arc furnace operations, need to balance the requirements of steel plant operations with power grid interaction. GE offers cost-effective STATCOM and SVC solutions to improve power quality and ensure a stable and steady voltage supply. Our systems provide more active power to the process installation, helping to optimize production times and reduce operational costs, such as those from reduced electrode wear-off.



Rolling Mills

GE provides solutions tailored to almost every type of rolling mill – including hot strip, plate, reversing cold rolling, tandem, PLTCM or temper variants – to facilitate the production of modern, high-quality steel grades. Our advanced product and service solutions for power distribution, drives, control and automation help boost the overall performance of your mill in terms of plant productivity, availability, reliability, process and energy efficiency.



Processing Lines

Our offering comprises a complete set of electrical and automation products, as well as services for processing lines – including continuous pickling lines, annealing plants or continuous galvanizing lines. This enables operators to expand capacity, speed up processing and enhance overall plant productivity. GE helps to produce high-performance steel while keeping a constant focus on improving plant throughput and yield, reducing energy usage and lowering the environmental footprint.



Digital Solutions – Brilliant Metals

GE helps to modernize the aluminum smelting process by enabling a new era of productivity for the industry. Digital Smelter Twin is an organized collection of physics-based methods and advanced analytics that's used to model the present state of every asset in a smelter. It provides predictive analytics and alerts on pot stability and current efficiency. GE's Digital Twin also helps to optimize processes, for example, with pot line operations for reduced energy consumption and the avoidance of unplanned stoppages.



Digital Motor and Drive Fleet APM

GE provides solutions tailored to almost every type of rolling mill – including hot strip, plate, reversing cold rolling, tandem, PLTCM or temper variants – to facilitate the production of modern, high-quality steel grades. Our advanced product and service solutions for power distribution, drives, control and automation help boost the overall performance of your mill in terms of plant productivity, availability, reliability, process and energy efficiency.

Metals Product Portfolio

Power Electronics

High power density, reliability, availability and scalability.

Models

- MV6 Series
- MV7 Series
- LV7 Series
- LV8 Series
- Large DC drives (new or upgrades)

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%
- Variable-Speed Systems for Main, Major and Auxiliary Drives
- HV/LV Power Supply



Rotating Machines

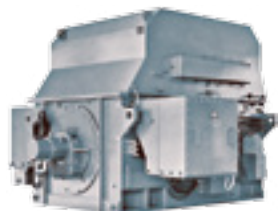
We offer reliable, efficient rotating machine technology for steel making, lamination and processing lines.

Models

- Induction Motors
- Synchronous Motors

Technical Capabilities

- Speed: 40–1,200 rpm
- Power: 1–30 MW
- Voltage: Up to 13.8 kV



Power Quality

Our Static Var Compensator (SVC) and Static Synchronous Compensator (STATCOM) belong to GE's range of power electronics-based FACTS devices. These improve the power quality of melting shops – for example those using an electric arc furnace.

Models

- STATCOM – IGBT Press-Pac
- SVC – Thyristor-Base Valve

Technical Capabilities

- STATCOM
- System Power Range Up to 300 MVar
- Step-Less Adjustable Cos Phi
- SVC
- System Capability 20 to 600 MVar
- SVC Thyristor Valves Up to 600 MVar, Voltages Up to 63 kV



Automation and Controls

Our advanced control and automation solutions designed for metal processing enable customers to optimize application capability and cost.

Functionalities

- HPCi
- Cimplicity
- Safety
- RIO
- Application SW L1, Process Framework L2
- Process Models HSM, TCM and SSCM

Technical Capabilities

- Basic Automation (Level 1)
- Process Automation (Level 2)
- HMI, Diagnostics and Safety
- Instrumentation

Motor and Drive Fleet APM

Asset Performance Management (APM) architecture for assets across the steel plant, such as blast furnaces, ladle furnaces, rolling mills, coiling machines, furnace coilers for Steckel mills, pumps and back-up rolls.

Functionalities

- Connectivity and Edge Diagnostics
- Analytics and Data Management
- Operations and Maintenance Services

Technical Capabilities

- *See What's Wrong:* Level 1 – Equipment Insights
- *Optimize Opex:* Level 2 – Maintenance Optimization
- *De-Risk Your Operation:* Level 3 – Performance Optimization
- Outcome-Based Service Agreement

Digital Smelter

Asset Performance Management (APM) architecture for assets across the smelter plant, such as potline PTA, carbon, rodding and cast house.

Functionalities

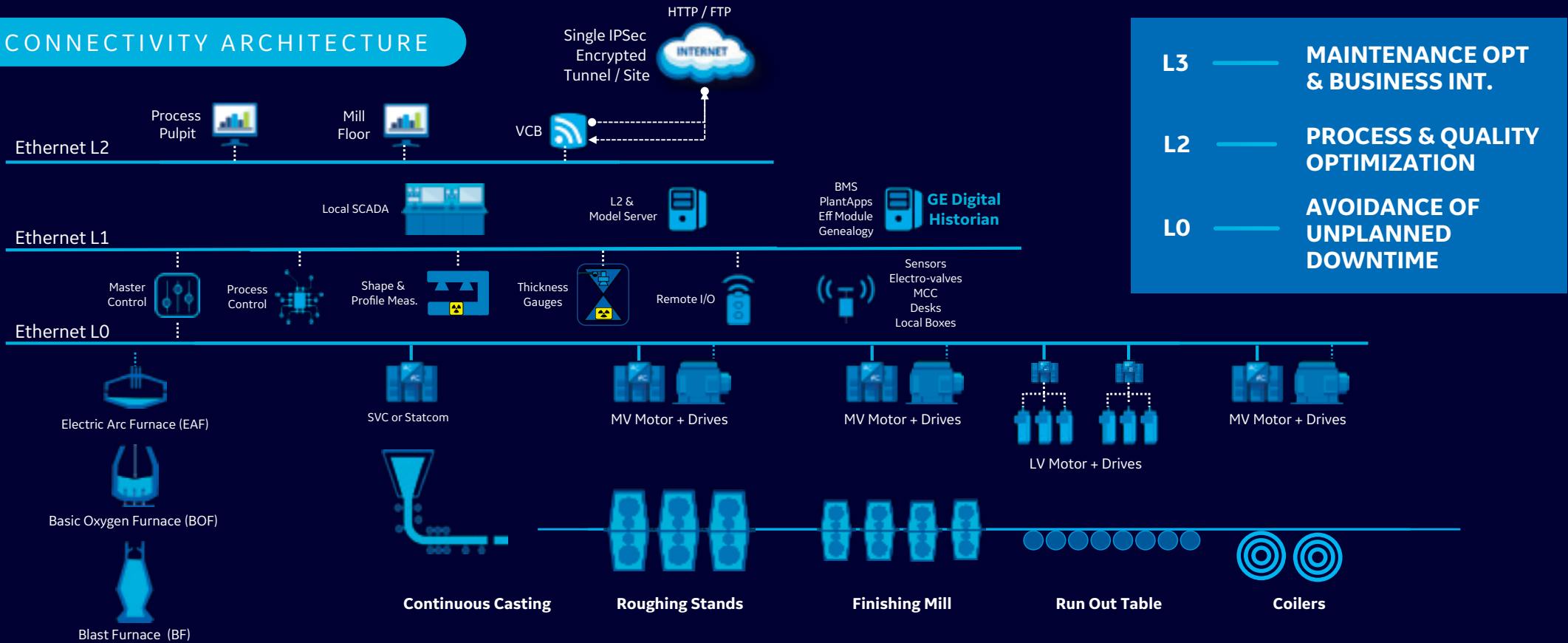
- Highly Scalable to Other PTAs and Complex Units
- Non-Intrusive Solution
- Wireless-Based Communication
- Web-Based Health Monitoring UI
- Cloud-Based Data Elasticity
- Quick and Lean Roll-out

Technical Capabilities

- Reduced Unplanned Downtime
- Asset Optimization
- Machine Learning/Pattern Recognition
- Continuous Tuning
- Condition-Based Repair
- Analytics-Based Lifting
- Per Asset Models
- As-a-Service Models
- Ecosystem Benefits

Digital Asset Performance Management

CONNECTIVITY ARCHITECTURE



From Asset Management...

- Remote support
- Guaranteed response time
- Time-based maintenance
- Parts and strategic stock

GE is a pioneer in industrial digital twins, having developed more than 300 models.

...to Performance Management

- Connectivity and visualization
- Predictive analytics
- Maintenance optimization
- Power management optimization
- Performance commitments

Driving transformation in metals with the world's first digital smelter in China.

Cyclo-Converter Retrofits

Extend the life cycle of your legacy cyclo-converters by retrofitting with GE's proven drive control.

Minimize the Risk of Unplanned Outages

Any unplanned outage comes with significant costs. Ensuring plant availability is a key priority but it can be a challenge, especially when you're running obsolete and legacy cyclo-converter drives for metal rolling mills, SAG mills, ball mills, cement plants or similar.

If you currently rely on legacy drive controls, obsolescence is a risk you can't ignore as it can lead to extended unanticipated downtime in the event of a failure. To help you tackle obsolescence and save the time and expense of a complete system replacement, GE offers reliable and cost-effective retrofits for your cyclo-converter drive controls.

This engineered retrofit will modernize your controls and data interfaces, substantially improving control capabilities, enhancing performance and extending the life of your existing cyclo-converter. Remote monitoring, powerful diagnostics and self-test capability can make your system easy to maintain, in turn reducing costs.

The GE Advantage

We have designed all of our drive application equipment with reliability in mind. As a full-scale OEM with deep engineering expertise and fleet knowledge, we're your partner of choice for carrying out retrofits of legacy drive controls nearing the end of their life cycle. We're there wherever and whenever you need us providing:

- A local presence, globally
- 24/7 technical support
- Installation and commissioning services
- Field engineering services
- Preventive maintenance services
- Replacement parts and repair services
- Training services

Cyclo-Converter Drive Control Retrofits

GE's exceptional drive services can help you achieve the most value possible from your drive controls. The external control interface, GE's P80i control system toolbox, is widely considered one of the best systems for configuring, troubleshooting and maintaining legacy drives and controls.

Features and Benefits

- Experts who fully understand your industry will match our drive features to your specific requirements
- Consistent and cost-effective project execution from start to finish
- Phased upgrades and updates that fit your operating budget
- Improved process control resulting in lower operating expenses

More Reasons to Upgrade

- Extend the life cycle of your existing drive systems and defer moving to the latest drive technology until the time is right
- Improve reliability through industrial PC-based control
- Enhance control flexibility and drive performance
- Modern touchscreen controls, HMIs and multiple networks to simplify operations and integration with plant level controls
- 24/7 remote technical support via Visor to resolve issues in the shortest time possible – helping to ensure minimum downtime

Power Electronics Controller (PECe)

- Standard industrial PC
- Intel-based chipset VXWorks
- Operating system IEC1131
- Compliant function block
- Deterministic Ethernet
- Five 10/100 Ethernet ports
- 1.2 to 2.5 GHz
- 60°C Ambient
- Fanless operation
- Two or four PCI slots allows Profibus, Profinet, Reflective Memory, CANbus, Modbus, EGD, etc.

Power Interface Board (PIBe)

- 24 copper or 32 fiber optic outputs to power devices
- 8 digital inputs
- 4 digital outputs
- 8 analog inputs
- 4 analog outputs
- 2 current transformer inputs
- Capable of 60 V, 10 amp outputs to power devices
- One encoder input



Field I/O

- Modular construction
- Digital inputs/outputs ... 24 VDC
- Analog inputs/outputs ... +/-10 VDC
- Fast deterministic EtherCat interface from PECe

Touchscreen for Operator Control and Maintenance

Replacing antiquated meters and push-buttons with modern touchscreen controls will improve your ability to operate and maintain your drive controls.

P80i Toolbox – Drive Commissioning and Maintenance

High Speed Trending

- Unlimited signals per trending
- Up to 3,000 samples per signal
- Limited only by PECe memory capacity

Tool Capabilities

- Configure trend (trigger, period, variables to be recorded)
- Set trend to be downloaded to a compact flash drive
- Upload records from the drive
- Display records in a trend
- Display "live" or "logged" data

MiniSemi Control Upgrade

Minimize the Risk of Unplanned Outages

With reliance on legacy drive controls, obsolescence is a risk you can't ignore. It can lead to extended and unanticipated downtime in the event of a failure. To help you tackle obsolescence and save the time and expense of a complete system replacement, GE offers a fully integrated upgrade package for your drive controls. A MiniSemi engineered upgrade will modernize your controls and data interfaces, substantially improving control capabilities, enhancing performance and extending the life of your existing drive systems.

The GE Advantage

GE supports you from start to finish with project management, application engineering, hardware and software engineering, system testing, technical direction of installation, commissioning and spare parts. The breadth of our experience spans pulp and paper, mining, metals, plastics, rubber and material handling. From hot strip mills, cold mills, winders and paper machines to hoists, cranes and more, our experts know your application and understand your challenges. It means they can help you get the best performance possible from your drive systems.

We're there wherever and whenever you need us providing:

- A local presence, globally
- 24/7 technical support
- Installation and commissioning services
- Field engineering services
- Preventive maintenance services
- Replacement parts and repair services
- Training services

Proven Designs Supporting Your Objectives

Used by GE Power in demanding industrial applications, our GE drives employ proven hardware. Its structured design improves engineering efficiency, reduces downtime, increases system reliability, improves process control and reduces total installed project costs.

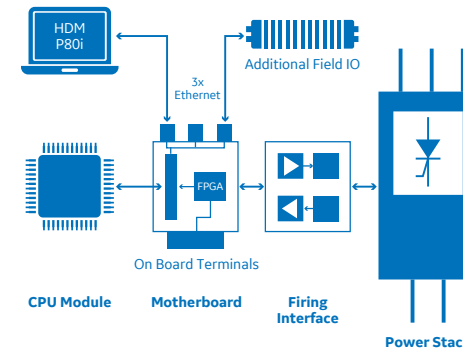
Features and Benefits

- Experts who fully understand your industry will match our drive features to your specific requirements
- Consistent and cost-effective project execution from start to finish
- Phased upgrades and updates that fit your operating budget
- Improved process control resulting in lower operating expenses

More Reasons to Upgrade

- Extend the life cycle of your existing drive systems
- Improve reliability through industrial PC-based control
- Enhance control flexibility and drive performance
- Digital capabilities that can provide insights into your equipment and help you predict failures before they occur
- Modern touchscreen controls, HMIs and multiple networks to simplify operations and integration with plant level controls
- 24/7 remote technical support via Visor to resolve issues in the shortest time possible – helping to ensure minimum downtime

PECe-Lite Drive Controller



Key Benefits

- **Simplifies understanding, commissioning and maintenance** by using a suite of system software tools and an application environment common to PECe drives, process control and automation
- **Supports easy drive upgrades** through a wide range of power stack and I/O interfaces
- **Delivers a powerful, small-sized and cost-effective solution** for the majority of drive control applications
- **Minimizes spares through modular hardware and control design** enabling application across a large range of GE drives

PECe-Lite Drive Controller

GE's PECe-Lite complements the PECe as the standard performance drive controller for Power Conversion equipment. This highly modular unit combines the power, performance and flexibility of the HPCi controller with specialized high-performance interfaces to the drive's power electronics and power stack.

Power stack interfaces are made using up to two plug-in interface modules for connection to the complete range of power stack technologies, over both copper and fiber-optics. PECe-Lite supports existing power stack interface modules used in the PIBe3.

PECe-Lite provides a significant number of built-in I/O. Additional I/O is accommodated using an EtherCAT-based I/O system.

The HPCi controller is programmed using the P80i system software tool, and commissioned and maintained using the P80-HPCi Data Manager (HDM) software tool.

Power Generation Solutions



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

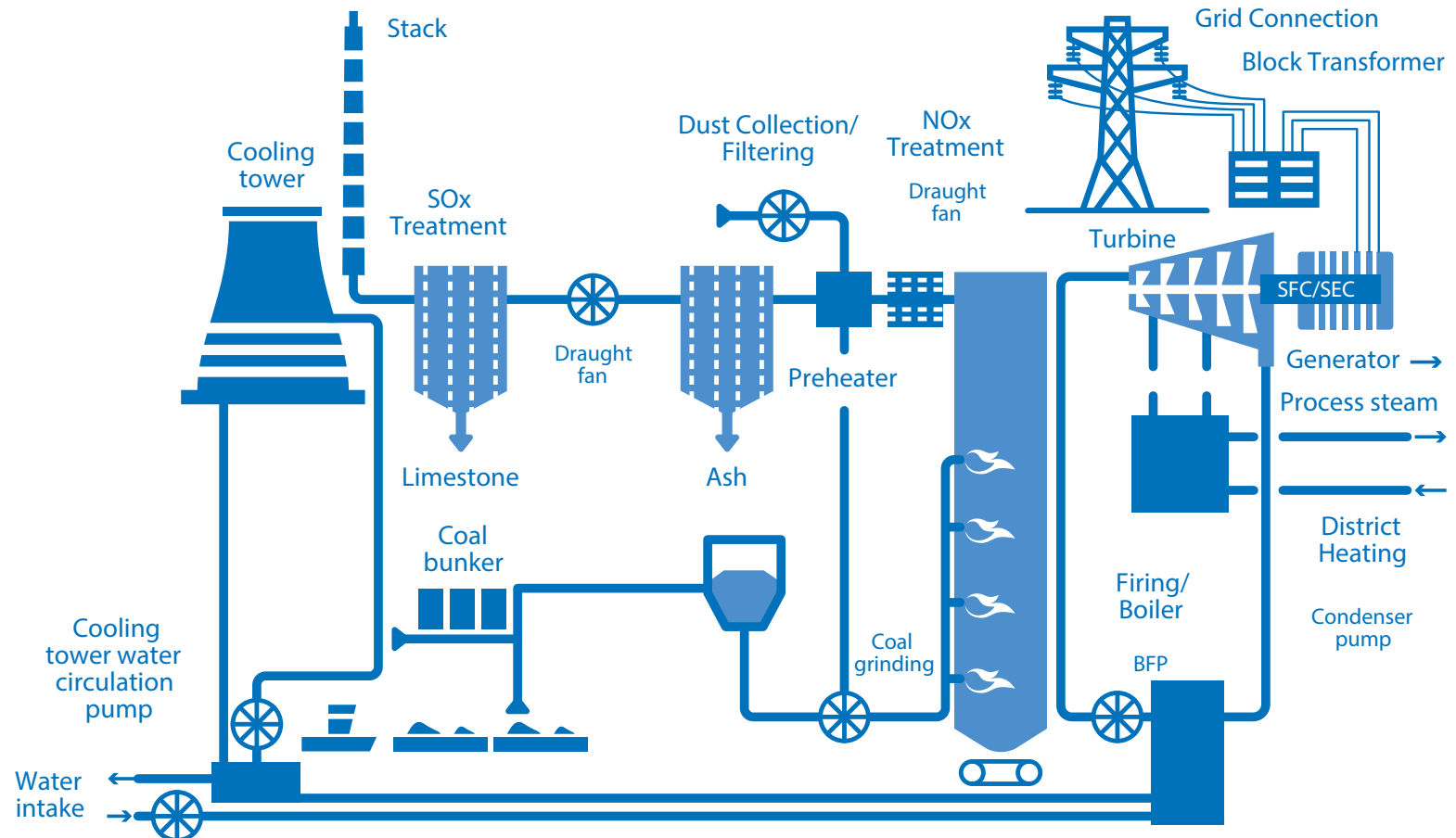
- Up to 70 MW
- For gas turbine, diesel or small hydro plants

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)

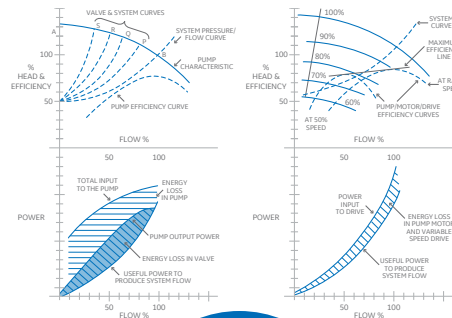
Thermal power plants typically consume a percentage of the power they produce, driven by the operation of auxiliary systems such as boiler feed pumps, circulation pumps, cooling water pumps, condensate pumps, exhaust and draught fans, conveyors, and coal mills. In the past, fixed-speed or hydrocoupling 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



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

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

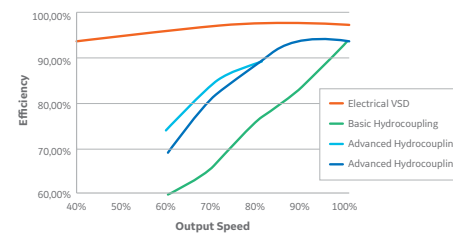
Key Benefits

- 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 made 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

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

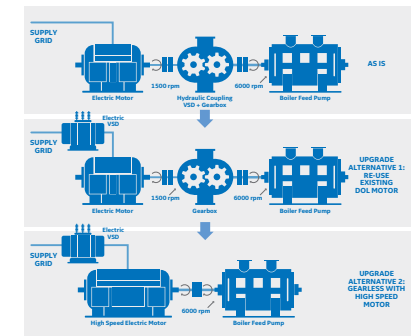
- up to 11% of the BFP energy consumption
- i.e. 28k MWh out of 255k MWh = savings of up to 2.9M\$/year†

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

Up to **11%** energy savings†

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
- 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



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

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 (gear-less)
- 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.

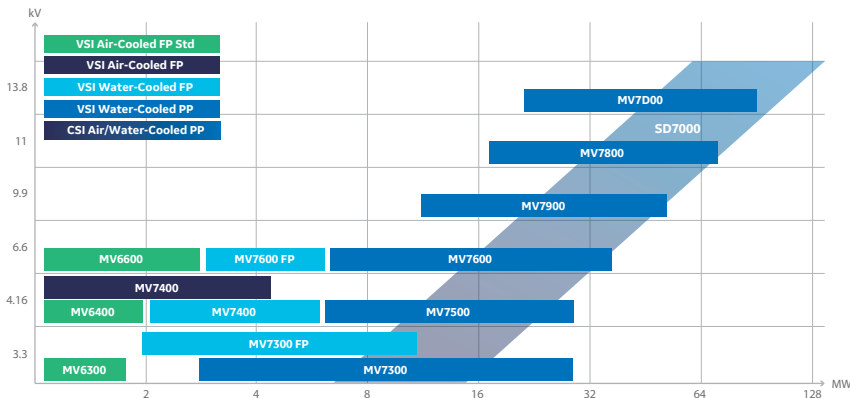
Output power	Up to 81 MW
Output voltage	Up to 10 kV
Output frequency	15-90 Hz, 0 to 15 Hz on request
Input voltage	3 to 10 kV ±10%
Input frequency	50 or 60 Hz ±5%
VFD system efficiency	Up to 99%
Power factor	>0.96 (DFE) / 1 (AFE)
Input harmonics	IEEE 519 compliant

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/m³
- 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

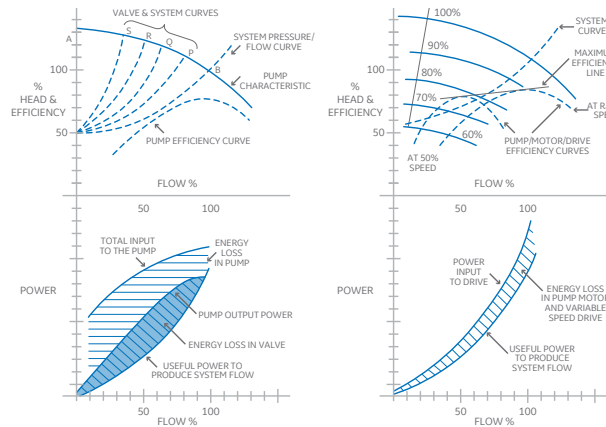
Benefits

- 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



- 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

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:

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 eVSD for 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 Convertteam generators
- Addition of eVSD for 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



Power Quality & Supply Solutions



Challenge & GE Value

The Grid Stability Challenge

How do you maintain grid stability and voltage control in both steady-state and transient conditions? The evolving world of power generation is becoming ever more challenging for transmission system operators. A larger share of renewables, the retirement of base-load plants, increased environmental regulation and greater cross-border trading are all making grid stability more complex.

To maintain the reliability and quality of power supply in these conditions, you need efficient solutions to provide dynamic voltage support and reactive power compensation.

GE's power quality solutions comprise FACTS devices. We've designed our power electronics-based Static Var Compensator (SVC) and Static Synchronous Compensator (STATCOM) solutions to ensure dynamic voltage control, as well as increased power transfer capabilities.

Our SVC is built around our proven high-power thyristor valves which are widely used for industrial and transmission applications. GE's STATCOM is based on our tried and tested range of Voltage Source Converters (VSC) with a demonstrated capability in energy and industrial applications. These include wind, power, mining, melting shops and other industries using IGBT technology.

To Improve Productivity and Grid Stability, GE's Power Quality Solutions Provide Dynamic Voltage Control and Fast Reactive Power Compensation

Power Quality & Supply Solutions

Energy efficiency is key to ensuring safe, affordable and sustainable energy systems for the future. Our variable-speed drive systems (VSIDS) and power quality and supply solutions help to increase the flexibility, efficiency, stability and reliability of power and grid operations.

Full System Solutions

GE offers full SVC or STATCOM substation system solutions, including power analysis, engineering, electronics, controls and dielectrics. Our solutions for power supply and stability also include rotating stabilizers, and MVDC technology.

- 20-plus years' industry experience
- 100 SVCs and STATCOMs installed
- 6,000+ MVar installed



Benefits

- Proven technology – for reliable operations
- Local grid strengthening and Var support – enabling higher productivity and power quality
- Easy integration into new and existing grid infrastructure
- Helps reduce network extension investment costs
- Meets grid code compliance requirements
- Modular hardware – for maximum flexibility and optimized footprint
- Low noise emissions – both audible and electrical

Power Quality & Supply Product Portfolio

Static Var Compensator (SVC)

GE's SVCs are built around our proven high-power thyristor valves, which are widely used for industrial and transmission applications.

System Capability

- Thyristor-based technology
- From 20 MVAR to 600 MVAR
- Controls based on industry-standard components
- Remote monitoring and diagnostics
- Solutions for industrial and grid applications
- Containerized options

SVC Thyristor Valves

- Range up to 600 MVAR
- Voltages up to 63 kV
- Power circuit consisting of two or three stacks
- Snubbers and divider resistors for thyristor protection
- Water-cooled
- Easy to maintain



Static Synchronous Compensator (STATCOM)

GE's STATCOMs are based on our proven range of Voltage Source Converters (VSC) with demonstrated capability in energy and industrial applications. This includes wind power, mining, melting shops and other industries using IGBT technology.

A STATCOM offers better dynamic performance than an SVC. In particular, it provides a faster response time, as well as the ability to generate or absorb reactive power when the grid voltage drops. It therefore helps increase reliability and availability of the grid operation.

System Capability

- Valve based on IGBT press-pack technology
- Power range up to 300 MVAR
- Step-less adjustable cos phi
- Transformer to connect to high-voltage grid
- Air- or water-cooled
- Air-conditioned option
- Remote monitoring and diagnostics
- Controls based on industry-standard components
- Containerized options



Rotating Stabilizers

GE's rotating stabilizers are high-inertia rotating machines that can support the grid network in delivering efficient and reliable synchronous inertia and can help stabilize frequency deviations by generating and absorbing reactive power.

System Capability

- The rotating stabiliser can provide several services including
- Synchronous Inertia Response (SIR)
 - Steady/Dynamic Reactive Power, (SSRP/DRP)
 - Option for Fast Frequency Response (FFR) with larger converters

Value

- Range up to 200 MVAR
- Similar grid support capabilities as a CCGT power station
- No grid disturbance with variable speed drive start
- Stability at point of non-synchronous generation
- Voltage support to enable more active power
- Easy to maintain



MVDC

GE has extensive experience in energy transmission technology and a proven track record including electrifying the central European railways. GE Power Conversion's Medium Voltage Direct Current (MVDC) technology can transform the grid to reach higher capacity without the need to overhaul existing infrastructure or install new power distribution assets.

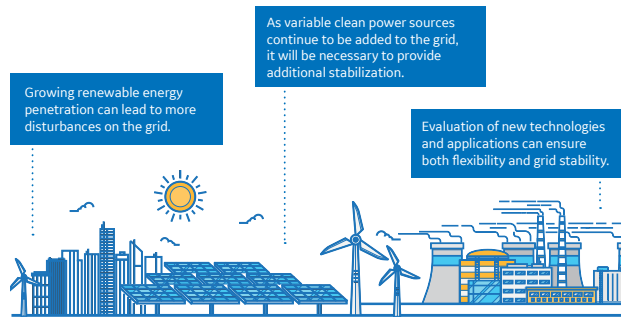
System Benefits

- Enabling more efficient power transmission to and from remote areas – both onshore and offshore.
- Control of active and reactive power
- Voltage optimization
- Higher power flow over same cables
- No increase to fault levels



Rotating Stabilizers

CO₂ free, high-inertia machines to help stabilize weak grids and enable higher penetration of renewable energy.



Ensuring Grid Stability

Fossil fuel-based power generation has been around for decades, and traditionally, the continuous rotating mass of synchronous gas- or coal-powered generators inherently stabilize grid frequency. The advantage of coal, oil or gas power generation is that while it cannot be turned on or off easily as demand dictates, the rotating turbines and generators have a lot of built-in inertia. This means a long lead time to ramp up and down, even under fault conditions. The result is a more robust grid that makes managing trips or blackouts easier.

However, the increasing use of non-synchronous wind and solar energy is reducing the amount of synchronous generation on the grid and is changing the rules of

dispatchable power. This possible instability could lead to grid operators constraining renewable generation to ensure grid stability or having to run costly coal or gas power plants in reserve.

As the power generation landscape is being reinvented around renewable energy, so are national grid codes that define performance – especially in countries with weaker grid infrastructures – are changing in response to this new power generation mix. These grid codes specify the power quality of electricity that plant and grid technologies must deliver – both in normal operation and under fault conditions – and are now giving rise to a range of creative solutions such as GE's rotating stabiliser.

The global energy mix is changing, with more clean renewable energy sources being added to the grid. The intermittency of renewable energy sources has raised clear challenges to grid integration and its stability.

Leveraging our vast experience in rotating machine technology, GE's rotating stabiliser solution provides a CO₂ free and cost-effective solution to replicate the synchronous inertia response provided by traditional thermal power generation.



Rotating Stabilizers

GE's rotating stabilizers are high-inertia rotating machines that can support the grid network in delivering efficient and reliable synchronous inertia and can help stabilize frequency deviations by generating and absorbing reactive power.

Rotating stabilizers can help reduce emissions and maintain grid performance by providing the same synchronous inertia as coal or gas power plants without the associated CO₂ emissions and high running costs. This flexible technology can be deployed as/when required by the system operator.

GE's rotating stabilizers have three operating modes:

- Synchronous inertia support to the grid with instantaneous response to change in grid frequency
- Power factor correction to provide continuous leading or lagging Vars
- High-power pulse generation enabling a high-power pulse from a weak power source

Extended Power Quality Offering

Our wide range of electrification solutions include motors, generators and power electronics-based turbine starting static frequency converters (SFC) and static excitation equipment (SEE), variable-speed drive systems for power plant auxiliary systems, MVDC, power quality systems and automation and controls.

Typical Ratings

	Power (MVA/r)	Energy (MW-s)	Inertia (kg-m ²)	Speed (rpm)	Volts (kV)	Rotor mass (tonnes)	No load losses (kW)
Horizontal Axis Machine	65	486	355000	500	15	200	840
Vertical Axis Machine	200	2115	1416000	522	22.9	400	1670
Example Synchronous Condenser	50	75	4965	1500	11	28	355

Key Features and Benefits Extended System Services

The rotating stabiliser can provide several services including Synchronous Inertia Response (SIR), Steady/Dynamic Reactive Power, (SSRP/DRP) and an option for Fast Frequency Response (FFR) with larger converters.

- Supports the network grid when increasing non-synchronous penetration, and with wide-scale distributed generation
- Similar grid support capabilities as a CCGT power station
- No grid disturbance with variable-speed drive start

Proven Technology

Based upon mature hydro-power generator technology to deliver high reliability and low maintenance

- Co-located Distributed Generation
- Optimize grid connection agreement and reduce overall costs
- Stability at point of non-synchronous generation
- Voltage support to enable more active power

Worldwide Services Support

Our focus on service keeps us actively engaged, both when things are going right, and when they are going wrong. With a comprehensive global network of experts, GE is uniquely positioned to provide the knowledge, experience and skills for your full range of industrial service requirements – protecting your assets and maximizing productivity.

MVDC Power Transmission

As demand for electricity increases power grids will be required to transmit more power, more efficiently. Today's grid is structured around transmitting electricity from large, centralized power plants running on coal, oil, gas and nuclear. While these will continue to dominate the energy mix for years to come, renewable energy is expected to supply a third of global power by 2040, creating new challenges for the power distribution network operators.

Better efficiency, greater control

GE Power Conversion's Medium Voltage Direct Current (MVDC) technology can transform the grid to reach higher capacity without the need to overhaul existing infrastructure or install new power distribution assets. Traditional grids transmit power from large thermal power stations over High Voltage AC lines and then step down to lower voltages for distribution to consumers.

GE's MVDC technology helps to stabilize the process and maximize productivity by managing dynamic voltage support and fast acting reactive power compensation. MVDC systems have several advantages over traditional AC distribution:

- Control of active and reactive power
- Voltage optimization
- Higher power flow over same cables
- No increase to fault levels

At GE's Power Conversion business, we're developing the use of DC to enable more efficient power transmission to and from remote areas—both onshore and offshore. MVDC systems can connect remote systems to the central grid where it is not economical to use High Voltage DC links (eg. island communities). This will reduce the use of diesel generation and cut CO₂ emissions.

Reliable technology

Critical systems demand efficient and reliable technology. At the centre of GE Power Conversion's MVDC power transmission technology is the MV7000 variable frequency converter. Cutting-edge power electronics coupled with decades of process expertise come together in the MV7000 — a world-class water-cooled medium voltage converter suitable for a wide range of power conversion applications, which help to improve efficiency, control accuracy and operational flexibility.

Proven Experience

Rail Electrification

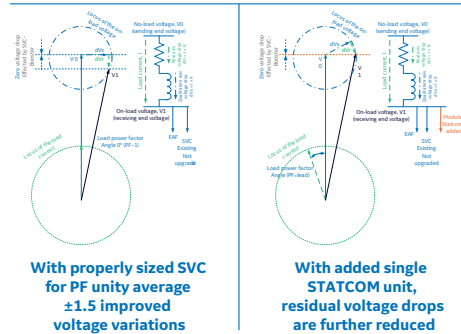
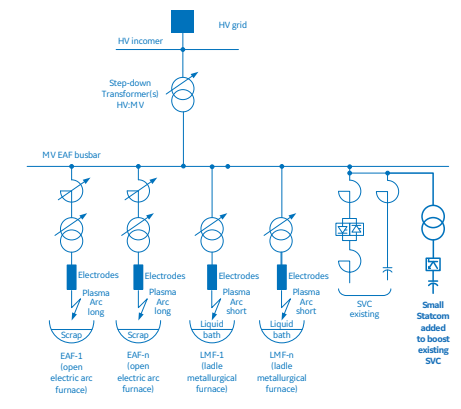
GE has a proven track record in the supply of power conversion stations for electric rail networks by using MVDC systems to convert between AC grids operating at different frequencies. 800+ MVAR installed in rail substations.

Key Benefits

- Help to avoid unbalanced utility grid loads and the resulting costs.
- Reduce complexity by bringing down the number of feeder stations
- Eliminate the 'dead zone' in overhead lines.
- Provide flexibility to connect rail grid to power grids at different locations or from different providers.
- Help optimize rail system operation, thus reduce failure time and maintenance cost.

SVC Booster with STATCOM for Electric Arc Furnaces (EAF)

Typical SVC Booster Connection



How STATCOM Helps Boost Productivity

Electric Arc Furnaces (EAF) are high-power industrial loads which cause power-quality problems at all voltage levels due to their unbalanced and non-linear characteristics. The rapid swings in real and reactive power they require cause voltage drops, rapid voltage variation and distortion across the AC supply network. This not only has a negative impact on power system quality and other loads, but also on arc furnace operation. This can include reduced power output, increased electrode consumption and poorer efficiency, which in turn lead to higher operational costs.

As a result, some sort of dynamic reactive compensation is required to limit the voltage disturbances injected by the arc furnace. This is normally achieved through an SVC with TCR. Despite sizing the SVC for PF unity, residual voltage drops remain due to active power.

Therefore, instead of increasing or revamping the SVC with TCR to further increase the EAF output, our idea is to add a small STATCOM to further increase productivity. The power quality performance remains that of the existing SVC, enabling the STATCOM to increase EAF production.

Key Benefits

- Boosted productivity
- Quick return on investment
- Easy fitting
- Off-the-shelf design
- Better use of existing system

Preventive Maintenance for SFC/SEE Drives

Reduce Maintenance Cost and Risk of Unplanned Outages While Extending the Lifetime of Your System

Any unplanned outage of your asset will significantly impact plant operations. Fixing it can then be costly and time consuming.

Building on our years of design and manufacturing experience in critical electrical equipment, GE has structured a preventive maintenance program to suit the operational requirements of your plant's SFC and SEEs.

Both these programs are tailored to ensure maximum availability of your asset. As well as maintaining records of all functional parameters and spares requirements, we identify any obsolete parts and advise on suitable replacements.

Preventive Maintenance Programs

Regular maintenance ensures efficient drive operation and reduces failure risk. We offer structured inspections and planned maintenance programs through our specialized technical team. These are geared to the drives' operating environment, ensuring that the cost of maintenance and failure risk are reduced.

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, effectively, when it's convenient for you. We'll also work with you to understand historic maintenance, environmental conditions, budget and operational constraints and business imperatives. Any lessons learned can be applied to your system to enhance drive performance.

During the preventive maintenance service, we:

- Perform and record preventive actions – according to a prescribed schedule of appropriate checks and tests
- Identify safety-critical issues – bringing them to your attention immediately and proposing resolutions
- Prioritize the dispatch of parts needed to resolve any such issues – if necessary, the field service engineer will remain or return to site to supervise
- 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

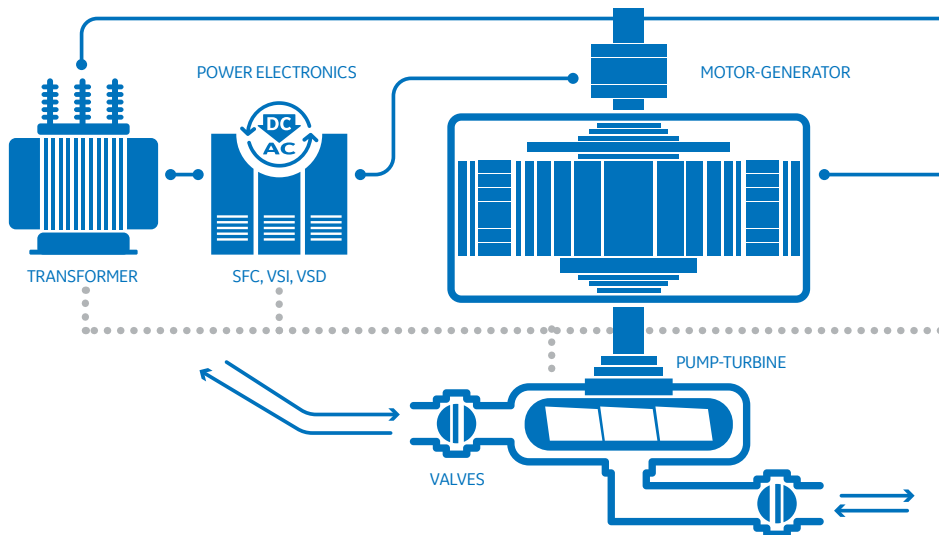
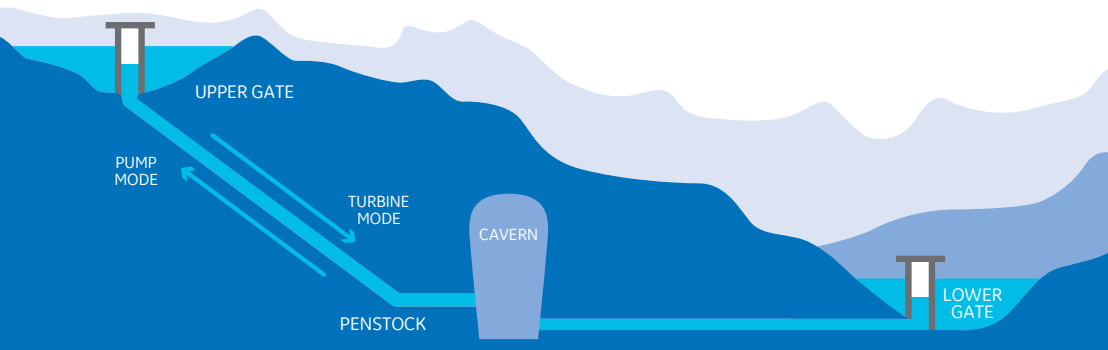
After the preventive maintenance service, we issue a maintenance report, document the status of the drive value (used to compare with thyristor health in future maintenance schedules) and recommend:

- **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

Pump Storage Solutions



Pump Storage Solutions



Each Pump Storage Project is Unique

With our full range of water to wire solutions, we help you to:

- Optimize grid performance
- Reduce system and operating cost
- Enhance energy output and lower overall project risk by benefiting from our enterprise synergies

Water to Wire Solutions

- Leading technology based on standardized components as building blocks for power generation, conversion and grid connection
- Extension to your design institutes and engineering teams
- GE's enterprise synergies for your benefit

25+ GW of PSP power are started each day with GE's power electronics

45+ PSP plants operate with GE's power electronics

Multiple Reasons for Investing in Pumped Storage Power

When investing in a Pumped Storage Power (PSP) plant, the decision-makers identify and define the main requirements the plant has to fulfill.

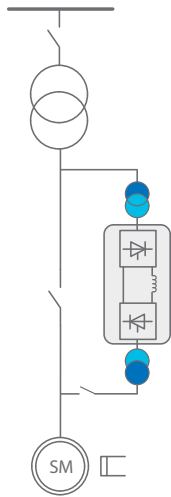
Reasons may vary, for example with the main drivers being to produce power from water as a renewable energy source, to balance the grid or to build a large-scale energy storage system to help manage the national power grid and security of supply. Investors and decision-makers need to identify the best technology suitable to meet the project's specific purpose.

Ge Technology Helps Optimize by Cost, Output and/or Grid Support

GE offers integrated solutions for conventional fixed-speed, as well as variable-speed doubly or fully fed systems. These help to minimize cost, maximize energy output and provide optimal grid support.

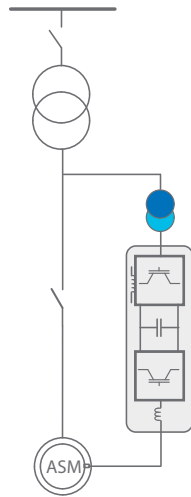
SOFT STARTER

Conventional fixed-speed systems, SFC



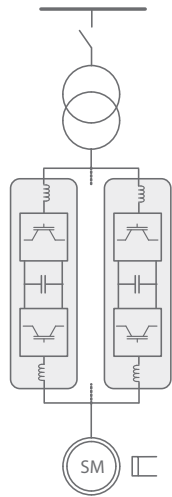
AC EXCITATION

Variable-speed driven systems, doubly fed VSI



CONVERTER

Variable-speed driven systems, fully fed VSI



Blue: Converter transformer
Grey: Power electronic modules
SM: Synchronous Machine

ASM: Asynchronous Machine
SFC: Start-up frequency converter
VSI: Voltage Source Inverter



Static Frequency Converter (SFC)

System Capability

- The SFC is used to start the unit in pump mode, operating the generator as a motor under variable frequency and rated voltage
- Power up to 40 MW
- Voltage up to 21 kV

Power Electronics

System Capability

- Voltage Source Inverter (VSI) for variable speed by means of doubly fed asynchronous generator
- Variable speed for motor and generator in fully fed electrical mode
- Static Frequency Converter (SFC) enabling soft start in pump mode



Servicing Over the Life Cycle of PSP Plants

100+ YEARS EXPERIENCE OF SERVICING AND MODERNIZING POWER PLANTS PREVENTIVE MAINTENANCE PROGRAMS

Services for Power Electronic Systems

Enhancing Energy Harvest Across the Project Life cycle

GE's services support continuous plant operation, enabling higher energy yields and a high return on investment across the life cycle. Our broad range of services is pivotal for helping utilities and power plant operators to protect assets and keep critical processes running. We can also help to decrease risk and enhance productivity while the owner/operator concentrates on their core business.

Fleet Data Analytics and Predictive Maintenance

We deliver expert on-site and remote 24/7 support and emergency interventions through advanced digital platforms. And all customized to meet unique customer requirements.

From 'Help Me Fast' To 'Partnership'

We offer both on-demand services and long-term service contracts. A range of options, from 'Help Me Fast' to 'Partnership', creates a fully inclusive contract offering. Key elements of our customizable services for power electronic systems in PSP plants include:

- Remote monitoring and diagnostics
- Maintenance
- Spare parts and obsolescence management
- Factory repairs and overhauls
- Warranty extensions
- Response time guarantees
- Modernization and upgrades
- Operation and maintenance training



Higher
Output



Reduce
Downtime



Lower
Losses



Extend
Lifetime

Research & Test System Solutions

FOR GROUND
TEST ONLY



Challenge & Value

**Reliable
Technology
Validation**

Customized and Turnkey Solutions

Maximum Test Scenario Flexibility

Mechanical stress – for example that realized by a wind load unit – can produce bending forces at different angles and to varying degrees. By testing control and protection systems, or single components under external conditions, we can measure the influences on load-carrying parts such as main bearings, yawing systems and gearboxes.

We provide adaptable, robust and dynamic test systems for efficient and reliable equipment operations based on:

- Reliable and proven product motors and drives, combined with automation and controls
- System solutions that may include mechanical structure and additional electrical balance of plant products
- Equipment installation services

**Shorter
R&D cycles**

Engineering and Consulting Expertise

Life cycle and Grid Simulation

Electrical malfunctions and equipment protection systems have historically led to unforeseen excessive loading of mechanical components, reducing their expected and calculated life cycle. It's therefore essential to simulate worst-case conditions to design a reliable product.

GE is your partner for customized test system solutions including:

- Feasibility and design studies
- Consulting, planning and contracting
- System engineering to meet customer specifications

**Optimized
Testing
Economics**

Project Life Cycle Services

Helping to Lower Development Cost

The substantial cost of installations means that customers can't wait for critical equipment, substructures and components to prove themselves in service. Cars, turbines, compressors and other technology must be fully tested and validated before they are deployed.

To manage the timing, execution and performance of services for critical assets, we provide customized support, upgrades and life extensions. This includes:

- Project management services and maintenance programs – from component level up to the broader electrical system
- Standard packages and customized solutions
- Remote diagnostics
- Technical support and training maintenance
- Upgrade or replacement of GE Power Conversion's legacy and other OEM equipment

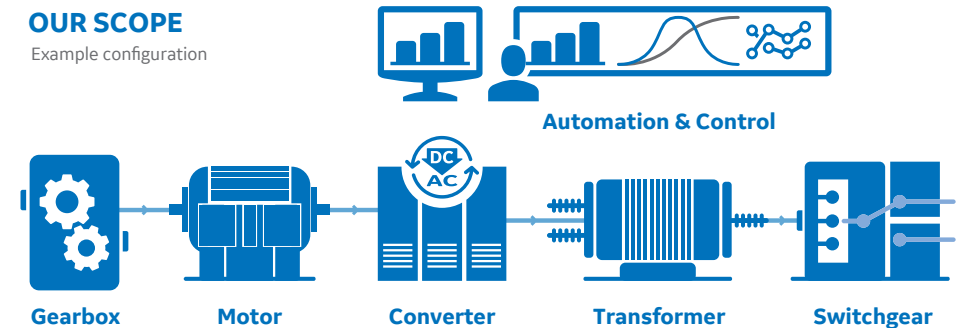
Research, Development and Test Systems Solutions

Robust product testing of critical equipment is the foundation for quality and reliability. It means manufacturers of critical equipment and research centers for industries such as renewables, power generation, oil and gas, automotive, marine or aerospace need to stay ahead of the game. For example, simulating years of wear and exposure in months can lead to shorter development times.

GE provides adaptable, robust and dynamic test systems for efficient and reliable equipment operations across these industries. Our customized and turnkey solutions, combined with engineering and consulting expertise and project life cycle services, help to improve the performance of your products.

OUR SCOPE

Example configuration



Adaptable, Robust and Dynamic Testing

- Easy-to-adjust test set-up
- Modular test bench software
- Standard interfaces
- Robust and durable mechanical and electrical set-up
- Allows for highly dynamic processes testing including quick load charges and fast response times

Typical Test Conditions

- Load simulation
- Grid emulation
- FRT – LV/HV
- Environment simulation
- Fatigue testing
- Customized testing

Technical Range

- Speed: 5 to 50,000 rpm
- Power: 150 kW to 100 MW
- Torque: 100 Nm to 18 MNm
- Control and measurement cycle time: <2 ms
- Hardware in the loop (HIL)

Critical Equipment Testing Solutions



Automotive Test Systems

The automotive testing industry requires high performance, with highly innovative software features as a key to success. GE provides automotive testing solutions for combustion, drive line, electric & hybrid vehicles. The automotive industry is changing rapidly and forcing us to constantly deal with new challenges. The demand for electric vehicles is increasing worldwide while at the same time new testing capabilities are needed and customers are asking for cars with more custom design options – while for the coming years conventional drive trains will be in demand.

Advances in battery storage technology are constant. However, battery testing is inconsistent across all markets. Manufacturers are using different chemistries, formats, and processes. System integrators are developing systems that may be useful for one application, but inefficient for another. Flexible test benches are necessary to accommodate high testing accuracy of prototypes, pre-series and constantly changing products or partial systems to ensure long-term investment protection.

Based on our experience and know-how, and given the hardware and software available, we have developed systems, which can be easily combined with GE drives to provide high performance testing in the automotive industry for electric or hybrid vehicles and battery emulation. GE provides innovative software modules, e.g. the patented 300 Hz ETPS engine torque pulsation simulation system which is an embedded feature of the drive software specifically for this industry segment.



Wind Tunnel Testing Solutions

Wind tunnel testing plays a major role in the development of high-speed vehicles – not just around their aerodynamic form but also to ensure cooling air is effectively directed into the vehicle. GE's services cover all electrical equipment including drives, automation and visualization solutions. We have supplied systems to a variety of institutes and universities, as well as the National Aeronautics and Space Administration (NASA).



Renewables Testing Solutions

Wind turbines and solar farms are increasingly contributing to meeting the world's energy demand. Such systems work often under extreme conditions and in remote places. Yet they're expected to provide maximum reliability and minimum lifetime costs without compromising performance – sustainably delivering power to the grid under varying environmental influences. Product life cycle testing and grid emulation are key for testing renewable power generation systems. GE offers consulting expertise, test systems and services that meet these requirements using a range of drives, electrical machines, test and simulation software.



Test Benches for Compressors, Turbines, Generators and Gearboxes

GE delivers turnkey solutions, on-demand adaptable drive technology and energy-efficient solutions with high accuracy and speed. To help ensure the highest reliability, we develop and test units under worst-case conditions. Our offering covers the complete drive system from medium voltage down to the motor shaft. Our mechanical construction expertise, combined with design and engineering, results in the manufacture of powerful testing solutions, from turbines and combustion engines to power trains and vibration simulation.

Research, Development and Test Systems Product Portfolio

Power Electronics

Offering high power density, reliability, availability and scalability.

Models

- LV8 Series
- ProTX Series
- MV6 Series
- MV7 Series

Technical Capabilities

- Output power: 0.25 to 120 MW
- Output voltage: Up to 13.8 kV
- Output frequency: Up to 1,200 Hz
- Input frequency: 50 or 60 Hz +/-5%
- Variable-speed systems for main, major and auxiliary drives
- HV/LV power supply



Electric Motors

Reliable and efficient rotating machine technology.

Models

- Induction motors
- Synchronous motors
- High-speed motors
- PM motors

Technical Capabilities

- Speed: 40 to 30,000 rpm
- Power: 1 to 30 MW
- Voltage: Up to 13.8 kV



Generators

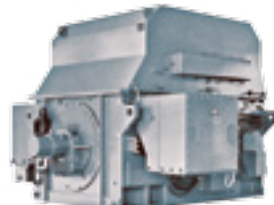
Operate effectively and reliably in challenging applications.

Models

- 2-Pole turbo generators (gearless)
- 4-Pole synchronous gas and steam turbine (alpha) – laminated or solid rotors

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



Extended Systems

Test and simulation software, as well as services including electrical and mechanical infrastructure.

Systems

Systems scope may comprise:

- Automation and control
- Test and simulation software
- Electrical plant balance
- Mechanical structure
- Power supply

Energy Systems

- Battery testing
- Battery simulation
- Power electronic and inverter testing

Technical Capabilities

- Load simulation
- Grid emulation
- FRT – LV/HV
- Environment simulation
- Fatigue testing
- Customized testing

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 test 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

E-Charging Challenge

The World is Changing

The reduction of CO₂ emissions is a main global objective. The world watches out for carbon dioxide (CO₂) emissions and faster solutions provided by the industry to create respective infrastructures.

While the European Automobile Manufacturers Association is “concerned about the extremely aggressive CO₂ reduction targets and the imposition of sales quotas for battery electric vehicles”, we need to prepare for a faster, reliable and sustainable change of standards.

Consumers as well as enterprises (as fleet owners) cannot be forced to buy electric vehicles, without the necessary infrastructure or incentives in place.

Industry Challenges

Today’s electric vehicle (EV) market is highly subsidized and requires government support to compete in the automotive industry. EVs are however, becoming more viable and competitive due to the increasing pressure from society on cutting emissions and advancing sustainable solutions, lowering costs and the growing availability of charging infrastructure, especially in cities. It is expected that within the next

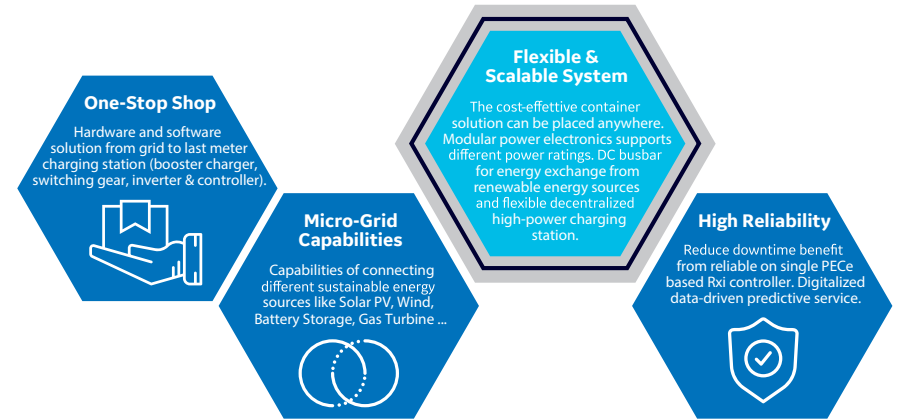
10 years long range battery electric vehicles can reach cost parity with internal combustion engine vehicles and thereby become the rational end-user choice. In order to achieve the EU target of zero emission vehicles by 2050, it is expected that all new car sales by 2035 need to come from these sources.

Energy providers are expected to cope with the higher power demand emerging from these new technologies. A key challenge is the optimization and balancing of the grid through the electric vehicle charging infrastructure, which includes collecting and processing real-time data.

To transfer this mega-trend to corporate fleets such as the heavy good or load-carrying vehicle industry and its players, we need to provide not only high power density, but also a flexible and smart charging solution.

GE can play a key role in establishing a solid interface in the triangle of automotive industry, energy industries and the growing demand of corporate fleets by providing a turnkey solution for the end-user.

E-Charging Today and Tomorrow



The GE Value – Solution Overview

GE’s flexibility across the complete portfolio allows our customers to select products and systems that meet their specific requirements, while maintaining the key benefits of standardization and pre-engineering processes.

Our core offering is a containerized converter solution, or an installation directly in the customer’s electrical switch room, that enables a centralized connection of multiple charging stations for electric vehicles. Potential end-user cases could be, but are not limited to company workplaces, vehicle fleets, real estate owners and public entities to help increase attractiveness by providing customers with fleet management solutions and innovative services that fulfill their aspiration for a sustainable development.

The Solution – From Standardized Solutions to a Flexible and Reactive Approach

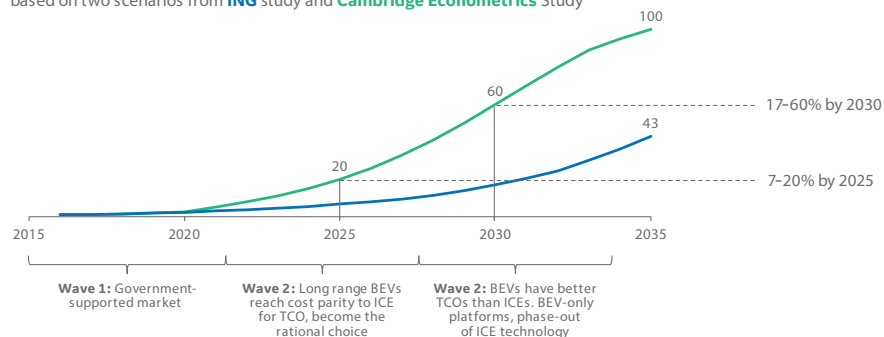
GE has a proven track record, expertise and resources to meet specific customer needs with a portfolio of technology, products and services across the commonly used power supply methods and grid operations. Cost-effective system design, highest energy output, efficient connection to the grid and long-term reliable operation are key to our customers’ success.

At the same time this solution can be utilized as an energy management system that integrates a large variety of local sustainable energy sources such as batteries, Solar PV, Wind or even gas turbines.

At last this solution enables a smart grid interaction by collecting and processing real-time data and in turn providing insights to optimize and balance the grid through the electric vehicle charging infrastructure.

BEV (and Other ZEV) Will Fully Replace ICEs by 2035–2050

The graph shows the assumed ZEV share of new vehicle sales until 2050 in Europe – based on two scenarios from **ING** study and **Cambridge Econometrics** Study



BEV = Battery Electric Vehicle, ZEV = Zero Emission Vehicle, thus including BEV but also fuel cell electric vehicles, ICE = Internal Combustion Engine Vehicle, TCO = Total Cost of Ownership – Source: Study ‘Fuelling Europe’s Future’ – by Cambridge Econometrics & Element Energy; ING Economics Department • July 2017

E-Charging Solution

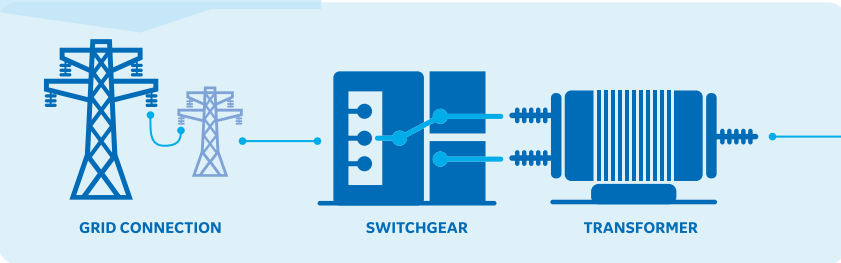
Connecting Fleets to Wire

Charging station management and fleet management solutions provide facility owners real-time monitoring and control on all levels of their assets. From grid load, energy storage usage to electric vehicles' data are all visualized, available to facility owners or operators even remotely.

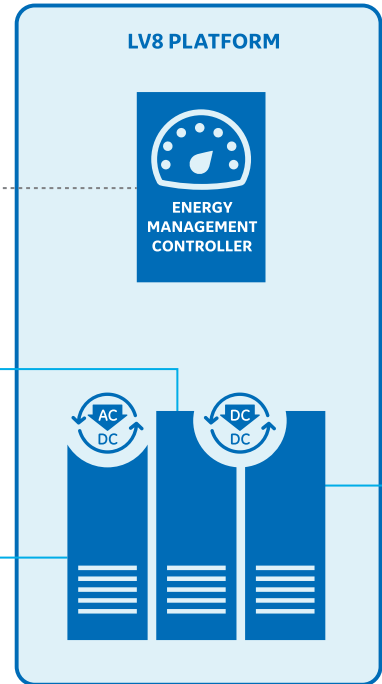
Thanks to the optional built-in and smartly controlled alternative energy sources, such as solar, wind, bio gas buffered with battery, GE's ultra-fast charging solutions could provide end customer charging solution in the most economical way.



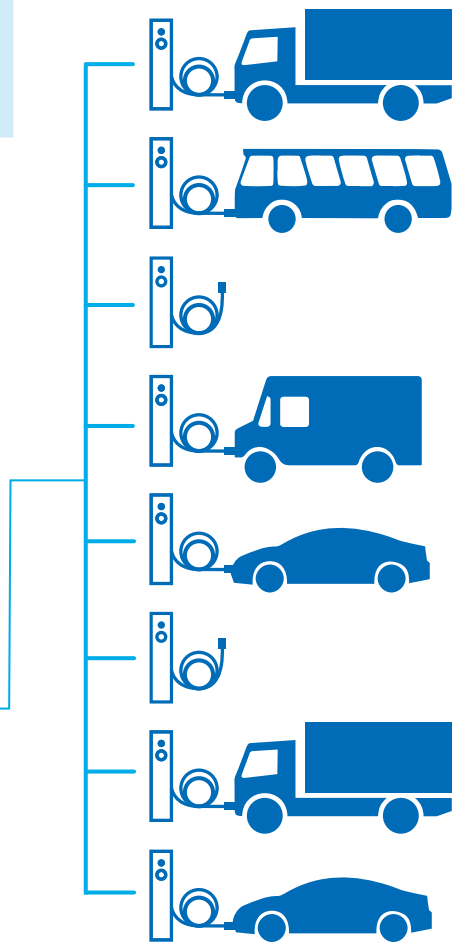
Grid load overview with the balancing capability is provided in the software solution.



GE's ultra-fast charging offering is a containerized converter solution or an installation directly in the customer's electrical switch room.



The charging points are compatible with a variety of charger standards and available for a large amount of level 3 DC fast charging solutions. Both AC and DC transmission solutions enable either centralized or decentralized approaches.



Water Solutions

Challenge & GE Value

With a global population growing by around 75 million every year, water is essential for sustaining life. A rise in food needs, rapid industrialization and climate change all add up to ever-increasing pressure on global water resources. Emphasis is needed on conservation, quality and more efficient ways to make water readily available.

Transforming salt water into fresh water through desalination, providing access to distant freshwater resources via upgraded water transportation and treating low-quality wastewater to turn it into drinking water are all viable solutions. However, they have one thing in common: they require energy.

Optimizing these processes and seeking out the most efficient solutions are among the key challenges.

Cost-Effective and Flexible Operation for Water

Equipment Supply

Energy Efficient

Our leading technology motors plus MV and LV drives combined with automation and controls provide:

- Reliable and proven products and components
- System engineering to meet customer specifications
- System solutions that include additional electrical balance of plant products
- Possible equipment installation services

Outage Excellence

Electrical System Optimization for Planned Outages

To manage timing, execution and performance of service for critical pumping assets, we provide customized support, upgrades and life extensions for water pumping systems:

- Focusing on component level up to the broader electrical system
- Increasing performance of pump systems and overall plant efficiency
- Providing maintenance, upgrade or replacement of GE and other OEM equipment

Asset Performance Management

Productivity Solutions that Minimize Unplanned Downtime

For our motors and drives we offer digital solutions enabling:

- Equipment insights to 'see' failures before they occur
- Correct information at the right time to enable optimization of maintenance costs
- Process-based analytics at plant level, optimizing asset performance
- Outcome-based service agreements

Key References

Victorian Desalination Project, Victoria, Australia

Australia's largest seawater desalination plant with reverse osmosis technology capable of 450,000 m³/d.

Scope of Supply

- Variable-Speed Drive Systems (VSIDS) using Diode Front End (DFE) technology architecture for:
 - 27 first-pass high-pressure pumps
 - Six transfer pumps
 - Three booster pumps
 - Low-voltage high-power converters
 - Low-voltage harmonic passive filters

Benefits

- 30% CAPEX savings
- +1.5% energy efficiency
- Improved reliability (reduced number of active components)



Strategic Tunnel Enhancement Programme (Step), Abu Dhabi, UAE

World's largest wastewater treatment plant with 45 km of underground pipelines capable of 1,300,000 m³/day.

Scope of Supply

- Eight 6.38 MW pump drive trains (motors, VSD and transformers) running at 500 rpm plus pump process automation
- Very strong collaboration with the EPC and the pump OEM to define the optimum solution, applying state-of-the-art hydro technology
- Full simulation of electrical architecture to ensure a perfect fit with power grid requirements

Benefits

- Increased energy efficiency
- Reduced maintenance
- Controlled plant water flow



Water Security Mega Reservoirs Project, Qatar

Five potable water mega reservoir sites (including reservoirs and pumping stations) with initial storage capacity of about 2,300 million gallons of water with 480 km of buried ductile iron pipelines with a diameter up to 1.6 m.

Scope of Supply

- Variable-Speed Drive Systems (VSIDS) for booster pumps:
 - Four 0.35 MW low-voltage VSIDS
 - Nine 2.3 MW medium-voltage VSIDS

Benefits

- Increased energy efficiency
- Reduced maintenance
- Controlled plant water flow



Water Solutions

Fully Integrated Electric Solutions to Help Improve Efficiency

A growing global population, rising food needs, rapid industrialization and climate change are applying pressure to global water resources. Collectively, we need to focus on conservation, quality and new ways of making water more available.

Water desalination, used water treatment and more efficient transportation are all technologies that decrease production costs, in particular by optimizing energy consumption, improving operational efficiency and limiting maintenance needs.

GE offers the water industry complete electrification packages for pumping systems. The value lies in our ability to meet the exact requirements of industrial users through power system studies. These can determine expected levels of voltage flicker, power factor, harmonic distortion and bus-bar voltage stability.

With over 1,000 field service engineers and a presence in more than 170 countries, GE operates as a global and local partner for motors, drives and electrification systems. This allows us to operate wherever and whenever you need us.

An Offering Tailored To Your Needs

Desalination

The most energy-efficient way of producing fresh water is to desalinate sea and brackish water using the reverse osmosis process.

GE's customized solutions are designed to improve the efficiency of your processes, increasing their reliability and availability.

We offer a wide range of solutions including products and systems.

GE's expertise in the power conversion field allows us to provide advanced technology to solve electrical and automation issues.

Water transportation

Water transportation encompasses pipelines carrying water over hundreds and even thousands of kilometers. Medium- and high-power systems are essential to transport large quantities over such long distances.

GE has many years of expertise in MV drive trains, providing customers with solutions that address key needs such as:

- Water process control, leakage detection and pipe integrity
- Improving the pipeline's lifetime
- Preventing the 'water hammer' pressure surge effect, allowing a reduction in the sizing of mechanical parts
- Increasing availability in case of grid fault
- Raising efficiency across the transport velocity range

GE's wide range of solutions and technical expertise allows us to help customers choose the best technical solution. This combines reliability, availability and efficiency, and meets grid quality requirements.

Wastewater and sludge treatment, drinking water treatment and distribution

Wastewater, sludge and drinking water treatment – and its distribution – require a wide variety of drive train systems and automation solutions. GE addresses these market needs with a full range of converters and motors (both low-voltage and medium-voltage), and by designing solutions for the supervision, automation and control of the water processes.

GE supports its water customers with solutions that provide high efficiency in any flow range – as well as improving availability in case of grid fault.

Water Product Portfolio

Variable-Frequency Drives

Delivering high power density, reliability, availability and scalability.

Models

- MV6 Series
- MV7 Series
- LV drives

Technical Capabilities

- Output power: 0.5 to 18 MW
- Output voltage: Up to 13.8 kV
- Output frequency: Up to 300 Hz
- Input frequency: 50 or 60 Hz +/-5%
- Variable-speed systems for main, major and auxiliary drives
- HV/LV power supply
- Air- or liquid-cooled



Motors

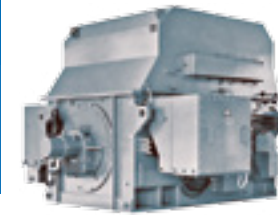
Reliable and efficient motor technology for water processes.

Models

- Induction motors
- Synchronous motors

Technical Capabilities

- Power: 0.5 to 40 MW
- Voltage: Up to 13.8 kV



Automation and Control

The controls across our automation and drive systems platform are built using a suite of reliable and secure automation components. We then assemble them into modular, flexible and scalable automation solutions.

Models

- Controllers, I/O, Motion
- HMI/SCADA
- Leakage detection and pipe integrity
- Process and production management and optimization



Wind Service Solutions



Services Support for the Wind Industry

Given the drive to reduce operations and maintenance spends and achieve an improved levelized cost of energy (LCOE) in the energy market, it's crucial to operate wind assets efficiently. GE offers life-cycle services which ensure reduced downtime and improved energy production across your wind farm.

Our local footprint, global presence and responsiveness mean we can offer comprehensive service packages for your electrical systems. These include installation and commissioning, spare parts management, technical support, onsite and classroom training, preventive maintenance, retrofit and refurbishment.

Tailored Service Contracts to Suit Your Requirements

Whether you're a turbine manufacturer, service provider or farm operator, GE can offer modular and customizable service packages throughout the life cycle. These can include individual elements or a services mix including:

- Spare parts
- Preventive or corrective maintenance
- Modernization and upgrades
- Remote or on-field technical support
- Technical training
- Support to enable digital transition

GE's robust service agreements are focused on increasing the availability of your wind assets and increasing operational efficiency, while reducing capital expenditure and downtime.

Repairs and Modernization

Our replacement parts and repair services for all electrical components can increase your turbine and overall system performance. For example, power stacks can be overhauled and upgraded in specialized workshops – including full-load testing to meet any applicable quality standards.

Our Rotating Machines Services team is specialized in Doubly Fed Induction Generator (DFIG) up-tower repairs and factory overhauls, independent from the OEM. For specific fleet issues, we also offer root-cause analysis and concept redesigns to improve reliability and life expectancy.

Critical Spare Part Stock

Holding the right spares in stock is vital for keeping your operations running, as well as avoiding long lead times and the unavailability of critical parts. We therefore offer a capital spares strategy, advising on which ones you should keep in stock to minimize downtime risk.

We then keep you informed about obsolete parts and upgrade packages, allowing you to order replacements and ensure your operations run smoothly.



Support and Training for the Wind Industry

Engineering Support

To address all technical issues, GE's team of engineers will work closely with you from project conception to ensure the right technical specification, grid codes and designs are in place. Throughout the project, our team of experts will also support you with retrofit and upgrades – including Fault Ride Through (FRT) retrofits – and work with you to develop life extension concepts.

Local Service Support

Improving the reliability and production of your wind farm is our priority. That's why we've established regional service hubs that provide repairs, refurbishments and retrofit services in the fastest way possible.

Remote Support

We provide remote support to minimize risk and maximize the availability of your critical plant assets. Our remote support solutions ensure a fast response, connecting experts at the Center of Excellence (CoE) with the field service teams on site working with the equipment. This provides 'over-the-shoulder' support to identify and fix your issues remotely.

Our remote access platform enables real-time data capture and generates periodic health reports. These help to monitor scheduled maintenance services, plant operations and perform remote diagnostics. It's all powered by our 24/7 hotline and rapid response team to ensure both global and local level mitigation of unplanned downtime.

Training Courses

We provide training courses delivered by the experts who design, install and commission our equipment.

These are tailored towards industry experts who are building their product-specific maintenance and troubleshooting expertise. We can tailor each course to meet the precise needs of your operating environment, industry or regulatory requirements. Plus, if required, we can even deliver it at a location of your choice.

GE's training courses provide hands-on experience of maintaining crucial plant components such as LV (Low-Voltage) breakers, controllers, converters and switchgear. They ensure your engineers are up to date with the latest equipment, product development and industrial challenges. And they help your team to build the right expertise and skills to efficiently use GE products and systems, as well as significantly reduce downtime and increase performance.



Asset Performance Management Solutions



Asset Performance Management for Electrical Rotating Machines and Power Electronics

A new way to work. Optimize maintenance schedules and reduce unplanned downtime with revolutionary monitoring of electrical rotating machines and power electronics.

Data Driven

Everyone wants to go straight to the end game: extracting valuable insights from your data. However, 85% of the effort is gathering, structuring, and normalizing the vast amount of data available from many different sources. As a result, many organizations can only analyze a limited data set after an issue has occurred, and not make holistic use of all the data available to obtain real-time indicators that could drive business efficiencies.

In addition many large organizations are the product of mergers and acquisitions, and as a result data capture, analysis and storage is carried out in entirely different systems and with different approaches across the organization. Extracting value and making comparisons using this data is a real challenge.

Reduce Downtime

Most industrial companies are used to employing planned maintenance techniques as a way of reducing failures and maintaining high availability. However, it has been demonstrated that the benefits of planned maintenance quickly reach a plateau, and so many organizations continue to explore alternatives.

While some equipment failure modes become more likely as equipment ages, most failures actually occur randomly and are independent of both time and planned maintenance. Our customers' reliability teams know this fact. They constantly strive to eliminate random failure, but struggle because of the lack of appropriate tools to mitigate the randomness. They're often forced to rely on metrics like MTBF (mean-time-between-failures) which is a historical aggregate rather than a forward-looking indicator providing insights on a particular piece of equipment.

Optimize Cost

Without the ability to connect silos of information and analyze aggregated data across an organization many opportunities to identify pockets of inefficiency are lost.

Most operators lack the tools needed to evaluate the data and make balanced decisions. Organizations need to be able to evaluate the risk impact of changes to their maintenance spend and to track which asset strategies are operating optimally. Ultimately organizations need to know they're making the best preventative maintenance choices for a given spend level.

Minimal Hardware, Maximum Results

Around the world over 40 million new motors are installed each year, driving everything from LNG plants to steel mills. Electrical machines are at the heart of the modern industrial world. The impact of unplanned downtime is estimated to be more than \$30 billion every year. At the same time the drive for energy efficiency is constantly increasing the number of variable frequency drives connected to rotating machines. For most GE customers this has become the standard solution in place of the direct on-line architecture.

We use our expertise in variable frequency drives and more than 100 years of engineering experience with motors, generators and control equipment, to bring together advanced High Frequency Sampling, Physics Based Analytics and Advanced Pattern Recognition with our domain and equipment experts. This depth of knowledge and capability means that the Power Conversion business not only helps identify future issues, but supports our customers to avoid or resolve these issues.

The use of Physics Based Analytics means that fragile vibration monitors are not required and a wider range of potential failures can be detected.

Edge analytics leverages the spare processing capacity in customer drives to pre-process data before sending manageable amounts of data to the cloud. All of GE Power Conversion's HPCI drives can become seamlessly part of a capable analytical network.

Cloud based decision tools provide dashboards and insights at enterprise level and in detail, leveraging the data from hundreds of similar machines of the same type, in a secured environment. Basing analytics in the cloud ensures that only the very latest algorithms are deployed for faster, better, more accurate results.

Minimal hardware needs (one Visor Connect Box can monitor hundreds of motors) means deployment to every item of equipment is cost effective for the first time.



SOFTWARE
BASED
SENSING



PHYSICS
BASED
ANALYTICS



EDGE
ANALYTICS
FOR SPEED

Rotating Machines Fault Mode Detection

		DETECTION METHOD			MOTOR / GENERATOR MV/LV	
		PBA	TEMP	VIB	IND	SM
BEARING	Outer Race Defect	•			•	•
	Inner Race Defect	•			•	•
	Ball Defect	•			•	•
INSULATION	Shorted Turns	•			•	•
ROTOR BAR	Broken Rotor Bar	•			•	•
MECHANICAL	Mixed Eccentricity	•			•	•
	Vibration Discrete Tone Identifier			•	•	•
	Vibration RMS			•	•	•
	Bent Rotor Shaft	•			•	•
ELECTRICAL	Voltage THD	•			•	•
	Current THD	•			•	•
	>0 & <0 Sequence Voltage	•			•	•
	0> & <0 Sequence Current	•			•	•
	Current Harmonics	•			•	•
	Energy Usage (Trend)	•			•	•
	Efficiency Estimation (Trend)	•			•	•
TEMPERATURE	Bearing Temperature	•	•		•	•
	Stator Temperature	•	•		•	•

PBA = PHYSICS-BASED ANALYTICS
 TEMP = TEMPERATURE
 VIB = VIBRATION
 IND = INDUCTION MACHINE
 SM = SYNCHRONOUS MACHINE

Electrical Signature Detection provides a wider range of failure mode detection than conventional temperature and vibration monitoring

The GE Difference

At GE we have the unique ability to access high frequency data through our data acquisition devices (either drives or the RMDM box in the absence of a drive). Leveraging these devices allows us to look at a richer set of dynamic modes versus the SCADA/cloud data only. Using the same signals we use for drive control, our expertise enables us to cut through high frequency data noise using advanced signal processing techniques, allowing the extraction of the clean signals needed for fault analysis. GE's unique experience and know-how of rotating machines engineering, manufacturing and servicing provides a deeper understanding of the physics behind the data.

The Confusion Matrix

	Positive Condition	Negative Condition
Test Outcome Positive	True Positive (TP)	False Positive (FP)
Test Outcome Negative	False Negative (FN)	True Negative (TN)

Simplifying the process: two key metrics

True Positive Rate (TPR)
Out of all faulty assets, how many were caught? = $\frac{TP}{TP + FN}$

Positive Predicted Value (PPV)
Out of all alarms, how many indicate faulty assets? = $\frac{FP}{TP + FP}$

The starting point to determine whether an algorithm is performing well or not is defining the possible outcomes of that algorithm. To that purpose, the confusion matrix determines four possible outcomes for a binary test, plus a series of metrics associated to those outcomes.

Finding the True Positives

Monitoring systems can give one of four possible outcomes:

- **False Positive:** An alarm is raised when there is no impending failure
- **False Negative:** An asset fails, but no alarm was raised
- **True Negative:** No alarm is raised and no failure occurs
- **True Positive:** An alarm is raised and after a predetermined period of time a failure occurs or signs of impending failure are present

The Power Conversion approach is a system of constant learning with both analytical tools and engineering support to tune the algorithm to the unique circumstances of every customer. Every alarm is analyzed, coded and investigated and the learnings incorporated into the algorithm.

Two metrics associated outcome for eliminating downtime and cost are:

- **True Positive Rate (TPR):** Proportion of detected future failures versus the total number of failures
- **Positive Predicted Value (PPV):** Proportion of alarms given when there was a future failure condition versus all alarms given

Avoided Cost of Downtime

The True Positive Rate (TPR) is related to the avoided cost of downtime. Every asset that fails causes the customer to incur unplanned downtime

to repair or replace that item, and to incur cost, both directly for replacement parts and labor and indirectly in terms of lost operating revenues.

Cost of Replacement

The Positive Predicted Value (PPV) measures the impact of replacing or repairing equipment as a result of an alarm when that equipment wasn't at risk of failure. The higher the PPR, the more accurately the analysis is identifying future failure.

Balancing Risk

Every customer will have a view on their own level of acceptable risk versus the cost of asset replacement or inspection. Using the TPR and the PPR we define this optimal point for every customer and tune the analytics to deliver the optimum acceptable risk.

Equipment Health Index

Once the system is set up and the optimal risk selected the various algorithms associated with the different failure modes will generate an Equipment Health Index (EHI). The task becomes connecting the real world experience to the algorithms to minimize false alarms and therefore

help to minimize the maintenance cost for a given risk tolerance.

Expert Review

Subject matter experts in our managed services team monitor the data from the system to adjust the algorithms and alarm thresholds based on post event analysis of the equipment. The objective is to capture 100% of the instances where the algorithm didn't behave as expected. This leads to continuous improvement of the response, specific to each customer's process.

The Real Difference

- Risk thresholds tailored to each customer's situation
- Expert review of all alarms, driving continuous improvement
- Delivering expert decision making support that enables reliable, condition based maintenance

Four Levels of Service Support

Detect

Equipment Insight to increase uptime and reduce opex through prognostics. We provide a mix of on-site and cloud based systems to monitor the health of your equipment and provide you with an Equipment Health Dashboard and managed services. With improved situational awareness customers get visibility of real-time equipment health and detailed insights from the engineering team on the alarms raised with recommendations for action.

Protect

In addition to the benefits of Detect you gain support not just for failure modes, but our experts will help identify and address performance deviations. This means that not only can we help increase availability and operational uptime, we'll also be supporting you to increase productivity and / or quality by looking for those hard to find deviations from the norm that drive production losses. In addition we will help you to avoid or reduce unnecessary maintenance costs, lowering opex by optimizing inventory levels, collecting all the equipment information needed to undertake risk based maintenance operations.

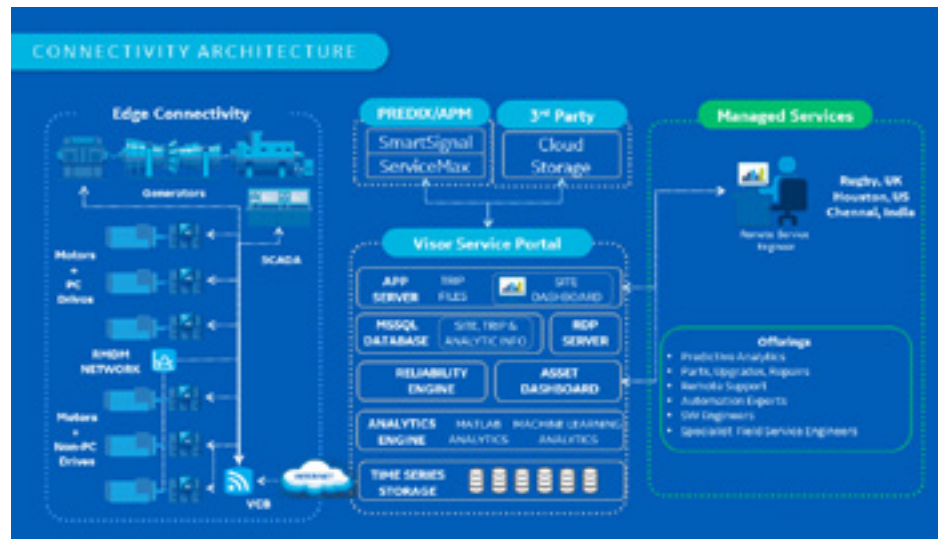
Focus

Focus brings you all the benefits of the first two tiers and is designed to impact root causes of productivity, quality and reliability issues. So, with Focus you get enhanced technical support and on-call field service experts to help resolve issues on the ground. GE will undertake all routine maintenance of the equipment covered by the

agreement. You decide the objectives, we provide the expertise and support to help you achieve them. Focus also alleviates the challenges of obsolescence. We will complete the studies and plan the strategy to cost effectively extend or manage equipment life. Cyber security is another problem area for most companies, one which potentially increases as the amount of data increases, so with Focus comes regular cyber security assessments.

Fix

The most complete service possible. You set the parameters. We agree a performance guarantee for the equipment and take care of everything related to the achievement of the performance. It's that simple. All the maintenance, repairs, obsolescence issues, and inventory complexities that distract you from your core business... gone.





Power Conversion Products and Solutions Portfolio

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