Harnessing the Power of Wind

Having the right partner is as vital as having the right technology.

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GE’s Power Conversion business:
Having the right partner is as vital as having the right technology.

GE Energy Connections
Power Conversion

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Facts & Figures

INDUSTRY

2
Renewable electricity generation is the second largest generation source

400
400 GW of total global wind capacity installed by 2015

702
702 TWh of wind energy generated in 2014

-60%
Levelized Cost of Electricity (LCoE) has reduced by over 60% in the past 6 years

2.5%
2.5% of global demand is generated by wind turbines

1
1 MW of wind energy can offset approximately 2,600 tons of CO2

30
By 2030, wind energy will save 30 trillion bottles of water in U.S.A alone as wind does not use water to generate power unlike other powergen technologies.

20,000
Gansu wind farm in China is the largest proposed wind project with 20,000 MW power capacity

GE

117
$ 117 B Revenue in 2015

300+
300 k+ Employees

170+
Active in 170+ countries

120+
120+ years experience in energy

34+
34+ GW installed capacity in Renewables

45+
More than 45 GW global capacity in wind converter installed

~10
~$ 10 B provided by Energy Financial Services in cumulative global renewable energy commitments
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INDUSTRY OVERVIEW

When it comes to how we generate power, a lot has changed in the last 15 years. In 2000 renewable energy, excluding hydro, contributed to less than 2% of the global production of electricity, and by 2013 it constituted more than 6% with estimates predicting that by 2040 it will account for 18%.

Moreover, this shift over the last 15 years is even more significant since it occurred over a period during which global demand for power has grown by more than 50%.

As markets grow, and the population increases, the world will continue to need increasingly abundant, clean and flexible power.

Attention continues to grow for the use of power generation resources that also have a limited environmental impact, and nations have been developing and implementing stringent national targets to support the future development of renewable energy sources.

The installed capacity of renewables has grown by more than 100 GW per year over the past 4 years, with a record-high of 130 GW of new capacity installed in 2014.

The result is that in 2014 renewables generated more than 5,400 TWh, accounting for approximately 40% more than the total annual consumption of electricity in the United States.

As a result of continuous attention to the environment and also to the decreasing cost of technology, it is easy to predict that renewables will become a mainstream fuel in the future.

Energy Transition
Renewables as a mainstream fuel

Developments in Wind
80% of installed base in China, EU, North America

Renewables are expected to be the largest source of net additions to power capacity over the medium term, with wind as the second largest renewable source of electricity generation after hydro. Wind power has been growing at a tremendous speed; global installed capacity of wind power reached 350 GW in 2014, up from less than 60 GW in 2005. Over the medium term, this capacity is expected to grow from 341 GW in 2014 to 617 GW in 2020.

China, the European Union and North America account for more than 80% of the total wind installed capacity, with another 10% located in India. These top four wind power markets today are expected to remain dominant through 2040. China is expected to increase its installed wind power capacity by more than 300 GW to 2040, which will raise wind power’s share of total generation in China from 3% in 2013 to 10% in 2040. In China, 125 GW of new onshore wind additions alone are expected to be deployed to 2020.

The cumulative installed wind capacity in the European Union is expected to expand to 181 GW by 2020; the share of wind power in total power generation in the European Union is expected to be close to one-quarter in 2040.

India’s installed wind capacity is expected to grow to 142 GW by 2040. Latin America is expected to reach 48 GW of installed wind capacity in 2040, where growth is mainly driven by Brazil. Overall, Africa’s onshore wind potential remains mostly untapped.

Offshore wind has been gaining momentum. The European Union has been the first region in which offshore wind has been deployed at commercial scale with 8 GW of installed capacity in 2014; by 2040, offshore wind capacity in the European Union is expected to exceed 65 GW, accounting for one-fifth of its overall wind power capacity. China is the only other market with more than 0.5 GW of offshore wind capacity today, and by 2040, is expected to reach nearly 50GW.

LEADING WIND TURBINE MANUFACTURERS
(List is not exhaustive)
- Acciona (Nordex)
- AVIC Huide
- China Creative Wind Energy
- Chengfeng Hongdou
- CSIC
- DEC (Dongfang Turbine)
- Enercon
- Envision
- Gamesa
- GE
- Goldwind
- Guodian United
- Huayi Wind Energy
- Inax Wind
- Ming Yang
- Nordex
- Sany Electric
- Servisiom
- Sewind
- Shandong Swiss Electric
- Shanghai Electric Group
- Siemens
- Sinovel Wind Power
- Suzlon
- United Power
- Vestas
- Windey
- XEMC (Darwind)
Industry Achievement

Wind industry... a track record of LCoE reduction

Over the past 2 decades the wind industry has made great strides forward with respect to the cost to produce wind energy and it really has pulled all levers available to achieve this, technology, supply chain and reliability.

AVERAGE ANNUAL ELECTRICITY YIELD (KW PER YEAR)

At the same time the supply developed quickly and provided huge benefits of scale. Larger demand combined with high investments in capacity in the first decade of this century and a transition from traditional suppliers in Western Europe to a global supply base enabled significant reductions in cost over the past 10 years.

Lastly the industry invested a lot to get the reliability of the equipment up to availability levels of well over 97% today. Engineering expertise developed as the industry got more mature, and a lot of money was invested in test equipment to validate turbines well ahead of deployment in a commercial wind farm, which made revenue streams for investors much more predictable. Not only does this result in higher incomes, but it also helped to reduce the risk of investments in wind farms which had the consequent benefit of reducing the cost of capital.

Because of these investments in efficiency, supply chain and reliability the wind industry has managed to drive down the cost of electricity from 15ct/kWh to below 5ct/kWh on a good wind site today. This major advancement has put wind energy at the position of lowest cost CO2 free electricity resource, and it is well on its way to reach parity with conventional electricity production.

LEVELIZED COST OF ELECTRICITY (LCOE)

The wind industry is rapidly growing and evolving. Turbines are becoming larger, and are being built in more unconventional locations across a broad range of geographies and climatic conditions. This ever changing landscape brings with it increasing technical challenges, and larger amount of turbine configurations. Keeping up with this growth, and the agility needed to adapt to more unconventional environments, is fostering portfolio diversity and accelerated product development cycles. As the industry matures, a higher level of risk management is required. Full scale life tests, increasing certification requirements and grid testing is driving development cost up.

The global deployment of turbines in unconventional and more varied sites drives the development of product variants to enable use in the site conditions at the lowest cost of energy possible. For many wind turbine OEMs this requires development of up to 3 turbine platforms with 5 different rotors to address specific climate conditions. This can include hot weather package, cold weather package, de-icing capability and features to satisfy permitting procedures to minimize environmental impact (tower height and noise). Continued growth of the industry in this environment requires higher levels of investment in technology.

In some countries, local content manufacturing can also be a key requirement to satisfy regulations and support mechanisms, which drives another level of complexity as well as investments. What this all leads to is a significant increase in complexity with respect to product management, supply chain management and technology development, resulting in a tremendous increase in required product investments.

At the same time the pace of the industry is increasing significantly. Where 15 years ago a product portfolio refresh rate of 5 years was acceptable, today 3 years is the standard. In combination with the increase in investment costs this means that there is pressure on the return on investment, and a challenge to continue to grow the industry.

SMART STANDARDIZATION AND COLLABORATION ALONG THE SUPPLY CHAIN KEY TO SUCCESS

As complexity, investment costs and product refresh rate are increasing there is a need for smart standardization in order to enable sustainable growth. Smart standardization here means standardization without giving up on flexibility. It requires well thought through designs that allow for customization, adaptations to local site conditions and adjustments to local content requirements that allow for a very high reuse rate of standard components.

Therefore further integration of the supply chain with key technology partnerships is a necessity to continue the fast advancements in technology, at an acceptable development cost.
Key Differentiators
Delivering solutions for wind power

WINNING TOGETHER THROUGH COLLABORATION, SPEED AND ADAPTATION

LOWERING LCOE

LOWER RISK & COST WITH FASTER DEVELOPMENT CYCLES

PERFORMANCE MANAGEMENT & OPTIMIZATION

LV3 - NEW GENERATION OF LV CONVERTERS

DEVELOPMENT PARTNER WITH SYSTEM EXPERTISE

CUSTOMIZED LIFE-CYCLE SERVICES

- Smartly standardized solutions for both on and offshore
- Up to 25% more power density at same footprint
- Higher reliability through lower part count

- Design and delivery of full electrical drive train and eBOP solutions
- Scalable battery storage solutions
- Test bench systems for life cycle and grid simulation

- Extended global footprint and service capabilities with customized offerings
- Local services offering at global GE quality
- Cloud based prognostics & predictive maintenance based on GE’s Predix platform

PROVEN GENERATORS AND MOTORS

STABILIZING POWER TO THE GRID

GLOBAL PARTNER

- Permanent Magnet Machines (ID, MS, SS)
- Induction Generators (DFIG, CIG)
- Pitch and yaw motors
- Low speed, medium speed and high speed generators

- 20+ years proven grid integration capability
- Meeting grid codes under harsh conditions
- Advisory Services for grid integration
- Power Quality Solutions: SVC, Statcom, PCS, Battery storage

- Worldwide manufacturing locations to meet lead time, cost, local content requirements
- Extensive network of engineers, scientists, and researchers
- Energy consulting and financing services

LEVERAGING EXPERTISE
At GE, we believe having the right development partner is as vital as having the right technology. Our energy consulting and financing services, extensive local network of engineers, scientists, and researchers help our wind partners reduce risk, and maximize return, cutting project time scales, lowering downtime and optimizing maintenance cycles.

AUTOMOTIVE – A FUTURE MODEL FOR WIND
With its demonstrated capability in renewables power generation, grid integration and technology leadership, GE brings a broad systems expertise as your partner for wind turbine developments, to keep up with the fast growth. By leveraging best practice from the automotive industry, GE offers modular, scalable components and solutions: unified, structured, pre-engineered, to help designing the future for a range of turbine variants, while lowering system complexity and cost.

In the automotive industry, the OEM owns the brand comprising the user experience i.e. the look & feel of the car, the system integration and multi-generation product planning. The supplier is a development partner covering the technology i.e. component design, timely delivery of design & components and multi-generation technology planning.

YOUR TECHNOLOGY PARTNER FOR WIND POWER
To help you continuously reducing LCOE, our philosophy is to drive standardization of components and building blocks, allowing for highest flexibility, such as in:
- Electrical drivetrain optimization
- Electrical Balance of plant design (eBOP)
- Engineering support for product evolution

We offer close collaboration and co-creation of solutions across the supply chain which improve processes and help reduce system cost.
CONNECTING WIND TURBINES...

...TO THE GRID

SMARTLY STANDARDIZED SOLUTIONS FOR WIND TURBINES

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ON THE TURBINE

GENERATOR

CONVERTERS
(UP/DOWN TOWER)

MOTORS
(PITCH, YAW)

WIND FARM ENVIRONMENT

VOLTAGE SUPPLY
(IN/OUTSIDE TOWER)

ELECTRICAL BALANCE OF PLANT (eBOP)

BATTERY STORAGE SOLUTIONS

SUBSTATION

GRID CONNECTION
Generators....
Proven capability in harsh environments

PMG and DFIG meeting most challenging on-and offshore needs

Technical Data

PMG DIRECT DRIVE
- Power range: 3–7 MW
- Voltages: 690V, 900V, 3.3 kV
- Rated operating speed: 10–15 RPM
- Efficiency: > 94% at full load

PMG MEDIUM SPEED
- Power range: 3–8 MW
- Voltages: 690V, 3.3kV
- Rated operating speed: ~200-600 rpm
- Efficiency: ~ 98% at full load

PMG STANDARD SPEED
- Power range: 3–6 MW
- Voltages: 690V, 3.3 kV
- Rated operating speed 1000–1800 rpm
- Efficiency: ~ 98% at full load

DFIG
- Power range: up to 3.5 MW
- Voltages: up to 13.8 kV
- Network Frequency: 50 & 60 Hz
- Rated operating speed: up to 1200 rpm
- Efficiency: > 96%

CIG
- Power range: up to 6 MW
- Voltages: 690V / 3.3 kV
- Rated operating speed: up to 1800 RPM
- Efficiency: > 96%

Our Success

PMG DIRECT DRIVE
- 1st DD PMG commissioned in 2009
- Designed & built numerous units for OEMs
- Serial production for 6MW Haliade turbine commenced in 2015

PMG MEDIUM SPEED
- 1st geared hybrid PMG 5MW onshore demonstrator in service since 2004
- Other concepts developed directly with different gear box suppliers.

PMG STANDARD SPEED
- 0.5 GW installed base in onshore turbines

DFIG
- In service since 2002
- Leading supplier for Brazil market, serial production commenced in 2015
- Proven Wound Rotor Machine Design
- State-of-the-art power density

CIG
- Proven products in harsh marine and industrial environments
- Robust and simple rotor designs

Our Generator Offering

Our products can be designed to meet global standards and certifications including but not limited to IEC, NEMA, CSA, UL. GE manufacturing facilities are ISO 9001 certified.

Reducing LCOE with High Efficiency

Our generators are designed and manufactured to operate efficiently and reliably in challenging applications and severe environments. We help to reduce LCOE with:

- High electrical efficiency across the full generating power range
- Optimized systems solutions incorporating our range of full and partial power converters
- Using components proven in diverse industries
- Ease of maintenance enabling lower O&M cost
- Noise levels as low as 77dBA* can be met to help reduce the cost for the overall system whilst reducing environmental impact. [*such as achievable in closed type machines with operating speeds up to 1200 rpm]

Wind Turbine Applications

Our wind generators are designed and built with state of the art manufacturing equipment employing VPI (vacuum pressure impregnated) insulation systems giving reliable, robust and optimized designs proven in industrial applications worldwide.

Dimensions and Weight dependent on product configuration and integration to nacelle.
Pitch & Yaw Motors
Compact. Reliable. Low maintenance.

SETTING THE STANDARD IN MOTOR MANUFACTURING FOR 125+ YEARS
GE manufactured motors for some of the first commercial and industrial electrical applications. We continue to deliver innovative mechanical power solutions to the world.

Our range of products has demonstrated capability in a variety of applications, such as fans, pumps, compressors, grinding mills, metal rolling, mine hoists, refining, or propulsion. Our motors work across the industry segments i.e. Oil & Gas, Mining, Power & Energy, Cement, Metals, Marine, Pulp & Paper, Water & Wastewater.

STANDARDS & CERTIFICATIONS
We work with all global standards such as ABS, API, ATEX, CSA, GOST, IEC, IEEE, and NEMA. GE machines are available for use in Division I or II and Zone 1, 2, or 22. GE manufacturing facilities are ISO 9001 certified.

TESTING
Every machine is tested in our global state-of-the-art facilities to your exacting requirements. GE has one of the largest capacities for full load testing.

PITCH MOTORS FOR WIND TURBINES
We continue to innovate with product quality. Our motors are designed and manufactured to operate efficiently and reliably in challenging applications and severe environments where reliability and ease of maintenance is critical.

IMPROVING OPERATIONAL EFFICIENCY
• Compact design for small footprint enabling more space in the system
• Higher reliability based on improved bearings technology to help minimize maintenance
• High availability levels and ease of maintenance, supported by a global service structure
• Higher efficiency through reduced power consumption on external fan.
• Incl. shaft grounding system
• Improved temperature sensor based on thin film technology

40,000+ PITCH MOTORS INSTALLED
• Proven track record in pitch motors for wind turbines since 2007

Technical Data
WP 20NM
• Applicable for 20Nm power of the pitch system
• Power: 4.1 kW
• Voltage: 80 VDC
• Network Frequency: 60 Hz
• Variable speed: 1930 rpm
• Efficiency: min. 83.8 %
• Weight: max. 79 kg

WP 30NM
• Applicable for 30Nm power of the pitch system
• Power: 6.6 / 6.2 kW
• Voltage: 100 VDC
• Network Frequency: 60 Hz
• Variable speed: 2100 / 3100 rpm
• Efficiency: min. 83.8 %
• Weight: max. 120 kg

Technical Data
LV3 POWER MODULE
• 690V nominal ± 10%
• 1250A RMS @ 50/60Hz
• 25% overload for 60s in 600xØ2.5kHz PWM
• 50°C inlet, up to 60°C wideband
• 20 year life @ wind turbine duty
• Three phase assembly ~95 kg
• Single phase module ~20 kg

Technical Data
LV3 POWER CUBICLE
• 600 x 600 x 2000 mm
• Gen & line side power electronics
• Integrated dynamic break module
• Generator side reactor
• IP-54 design incl. an liquid heat-ex
• ~1300 MW building block @ 0.9pf

PV1 Wind Converters
Smartly standardized products based on LV3 power module & cubicle

EXTENSIVE EXPERTISE IN RENEWABLES
Having more than 20 years of experience in wind, onshore and offshore, GE as converters installed in over 42GW of wind turbine capacity worldwide.

Our next generation low-voltage power modules build on proven designs and extensive on- & off-shore wind expertise. They are designed to meet marine standards under harshest environmental conditions. State of the art manufacturing as well as continuous reliability testing and improvement enable highest product performance.

LV3 POWER MODULE - UP TO 25% HIGHER CURRENT DENSITY
• LV3 Power Module having up to 25% increased current density vs. previous GEPC designs
• Modular power module design for multiple low-voltage segments
• Flexible service model full/part replacement

STRUCTURED PRODUCTS
GE’s LV3 doubly-fed (DF) and fully-fed (FF) wind converter portfolio is based on a smartly standardized modular system of building blocks comprising the LV3 Power Module & Power Cubicle. Our structured products can help to reduce opex and downtime cost as they benefit from a standard product core, helping to streamline application and requisition engineering, allowing for advanced manufacturing, thus higher flexibility for the customer.

COMPACT POWER CUBICLE - ENABLES REDUCED CONVERTER FOOTPRINT
• Standard building block for doubly-fed & fully-fed converters
• Compact cubic integration for reduced converter footprint
• Standard building block for doubly/fully-fed converters
• Modular options

Technical Data
LV3 POWER CUBICLE
• 600 x 600 x 2000 mm
• Gen & line side power electronics
• Integrated dynamic break module
• Generator side reactor
• IP-54 design incl. an liquid heat-ex
• ~1300 MW building block @ 0.9pf
LV3 Series Converter Doubly-Fed
Compact: up to 25% higher power density

LV3 Series Converter Fully-Fed
Reduced footprint, fewer parts and increased reliability

Technical Data
LV3 DOUBLY FED
• 1.5MW to 3.6MW
• 690V AC nominal ± 10%
• 50/60 Hz
• Compliant to all major grid codes
• Up to 1250A Grid Side Current
• Up to 1150A Rotor Side Current
• Cooling up to 50°C w/o derate

DIMENSIONS
• Width: 2,600 mm
• Height: 2,100 mm
• Depth: 600 mm
• Weight: ~3,000 kg

FEATURES
• Integrated dynamic brake
• IP-21 & IP-54 designs available
• C3 or C4 capable enclosure
• Multiple field-bus protocols
• CE, UL, CSA, DNV/GL
• Latest GEPC control platform & Industrial Internet options

LV3 FULLY FED
• 1.5MW to 5.0MW
• 690V AC nominal ± 10%
• 50/60 Hz
• Compliant to all major grid codes
• Up to 4800A Grid Side Current
• Generators up to 5MW w/ 0.9PF
• Generator voltage up to 750V

DIMENSIONS
• Width: 2,700 mm
• Height: 2,100 mm
• Depth: 1,200 mm
• Weight: ~4000 kg

FEATURES
• Full dynamic-brake rating capable
• Filter-less, IP-54 design
• C3 or C4 capable enclosure
• Cooling up to 50°C w/o derate
• Multiple field-bus protocols
• CE, UL, CSA, DNV/GL
• Latest GEPC control platform & Industrial Internet options

Typical Configurations

ENCLOSURE
IP54
NEW GENERATION
LV3 POWER MODULE
COMPACT FOOTPRINT

LINE CONTACTOR OPTIONS CUBICLE POWER ELECTRONICS CONTROL CUBICLE FILTER

LINE CONTACTOR OPTIONS CUBICLE POWER ELECTRONICS CONTROL CUBICLE FILTER

GRID INCOMER CUBICLE

GRID INCOMER CUBICLE

LINE CONTACTOR OPTIONS CUBICLE POWER ELECTRONICS CONTROL CUBICLE FILTER

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LINE CONTACTOR OPTIONS CUBICLE POWER ELECTRONICS CONTROL CUBICLE FILTER

GRID INCOMER CUBICLE

GRID INCOMER CUBICLE

GRID INCOMER CUBICLE
Moving to Medium Voltage
Future technology for higher efficiency & system optimization

ON THE TURBINE
As wind turbines get bigger transportation becomes more challenging and currently a point has been reached where logistics cost start to grow exponentially. To continue downwards on the LCOE curve more power dense solutions are required. In addition larger units have to deal with higher heat losses, which requires larger cooling systems to ensure reliable operation. Solutions with higher efficiency are required to address this challenge.

To manage the logistics and thermal challenges GEPC has developed a medium voltage solution that it has in operation in wind turbines for more than a decade.

WIND FARM POWER COLLECTION SYSTEMS
To collect power from multiple turbines in a wind farm and establish a reliable and efficient connection to the grid, GE’s new MV7 Series Uwave technology, ranging from 3-13.7 kV and 40 MW single thread, enables significantly smaller drive system footprint, helping to reduce construction costs and allow more room for critical operations.

HELPS TO REDUCE SYSTEM COST
- Building block concept allows for scalable power
- Reduced cabling costs vs. LV solutions
- Higher power density and smaller footprint of new MV7 Series Uwave technology
- Smaller filter size due to higher switching frequency

PROVEN MEDIUM VOLTAGE DRIVE TECHNOLOGY
Cutting-edge power electronics technology and decades of process expertise come together in the MV7 Series—a world-class water-cooled medium voltage drive portfolio. It is suitable for a wide range of power conversion applications with proven track record of 30+ GW across industries. Our MV7 Series has demonstrated capability in demanding applications such as Marine thrusters (250+ drives) and power generation applications (200+ drives).

LOWER OPERATING EXPENSES
- Better power quality and stability of operation
- Easy to install and maintain
- High reliability and availability for higher uptime and lower operation & maintenance costs
- Reduced amount of electrical components helps to increase system reliability
- High availability supported by a comprehensive services offering

Winning Together
COLLABORATION.
SPEED.
ADAPTATION.

Technical Data
MV7 SERIES
- Voltage: 3.3 kV
- Power range: From 3 to 10 MW
- IEC compliance / UL available on request

Typical Configuration - 8MW
4400(L) x 2000(W) x 2560(H) mm
Electrical Balance of Plant (eBOP)

For renewables applications.

Applications is modular and scalable, meeting the specific requirements of both developers and utilities. The system includes the collector system, grid interconnection substations and the transmission line connection to the utilities electrical network.

**Major Components of the Solution Include**

- Modular control building with protection, control, metering and communications panels
- Medium and High Voltage switchgear
- Capacitor banks
- GSU Power Transformer (generator step-up)
- Integrated SCADA system
- Optional monitoring and diagnostic systems for transformers and breakers

**Key Benefits**

- Minimizes inefficiencies, due to system planning and design
- Optimizes configuration of the substation consistent with customer requirements resulting from rigorous and accurate scoping
- Reduces costs, increases flexibility and provides standardization by utilizing industry leading design tools for ease-of-integration in design, procurement and installation
- Reduces testing, commissioning and maintenance actions, due to modular system design

MODULAR AND SCALABLE

Providing a broad range of products and services to meet customer’s specific project requirements, GE’s solutions range from high voltage switchyard equipment to systems hardware and design and engineering services. GE’s engineering services capabilities include system studies, civil, electrical, protection and control engineering, control building and panel assembly and on-site installation and testing. GE utilizes proprietary engineering tools to optimize the design and configuration of the collector circuits and provides turnkey SCADA solutions required for the integration of the power plant into the grid, including the HMI screens for providing status and controls with the option of remote control and diagnostics.

GE’s Electrical Balance of Plant offering for wind

Grid Integration & Power Quality

Grid integration analysis and power systems operation & planning

For over a century, the electrical grid has served its purpose, delivering power when and where it is needed. In recent years, several factors have converged that have heightened attention on the reliability and functionality of electric grids.

Utilizing the power of software, power systems, machine learning, and other advanced analytics and next-generation design and visualization techniques, GE is using its extensive knowledge of the grid to develop new solutions that will help utilities predict and prevent potential failures before they happen. GE’s portfolio of power-grid-based technologies enables the use of real-time information to improve the operation of the grid.

GE intermittency management and renewables integration technology also allow the grid to handle more renewable power without increasing wear and tear on utility equipment, while also enabling the efficient transfer of renewable power over long distances, helping to move power from sunny, windy areas to the places where people live and work.

Our dedicated expert group of engineers and business experts is specialized in complete power system analysis and simulation. Cross-business teams work to analyze and ensure the compliance of wind, solar and thermal power plant integration to the grid, keeping GE and its customers ahead of grid interconnection challenges.
Battery Energy Storage Solutions
Manage intermittent energies and improve plant profitability

Higher System Flexibility
By its nature, renewable energies can sometimes produce too much, or too little energy. This unpredictability can be managed through battery storage, allowing excess power generated to be stored for use at a time when power demand is higher.

Enhanced Prospects for Diverse Applications
When managing intermittent energies in renewable and/or decentralized power plants, requirements such as continuous energy supply during black-outs, cold start support or power demand control to avoid high peak tariffs are important to enable cost-effective plant operation.

Improving Operational Efficiency in Cyclic Power Applications
GE’s standardized, modular and scalable solutions help you to flexibly manage plant energy conditioning. Our customized storage offerings allow plant operators to play in the balancing power market, and/or to buffer the energy output of renewable or decentralized power plants.

GE’s Battery Storage Offering
Designed to meet specific site needs for power management and grid connection, GE’s solutions include:
- Energy Management: peak demand reduction, back-up, wind turbine self-consumption, power quality
- Transmission and Distribution: capacity management, asset deferral, frequency regulation, harmonic suppression, voltage support, and power quality.
- Micro-Grid Applications: grid management, PV integration, and grid enhancement.
- Thermal and Renewable Power Generation: virtual spin (no emissions), ramp rate control, frequency regulation, time shifting, voltage support, curtailment avoidance.

NEW VALUE FOR INDUSTRIAL CUSTOMERS
At the heart of GE’s software portfolio is the Predix platform. Predix leapfrogs traditional enterprise IT solutions with a native cloud architecture that augments industrial operational technologies (OT) for both GE and non-GE assets.

In essence, the Predix sweet spot is where IT and OT converge. To provide a simple yet concrete example that highlights the capabilities of the Predix platform: we will look at a wind turbine. The Predix Machine device gateway connects such assets to the Predix Cloud, regardless of vendor or vintage, enabling operational and historical data to be collected and analyzed, thereby improving operational models and potentially unlocking transformative business value.

For example, with respect to predictive maintenance, Predix allows customers to leverage all of the components of the Predix platform to predict potential problems, conduct preventative maintenance, and reduce unplanned downtimes.

The Predix Machine component can monitor data collected from sensors and, using physics-based analytics, detect potential error conditions based on the asset model, and then gracefully shut down the asset. In addition to these edge applications, Predix Machine can also pass the sensor data to the Predix Cloud, where the operational data for all similar machines under management can be stored and analyzed. Over time, data scientists can discover new patterns and create new and improved physics-based analytical models. The new analytic can then be pushed back to all of the assets, effectively improving the performance of all assets simultaneously.
Hybrid Power Plant Solutions
Innovative systems beyond just power generation

The challenge – Integrating Renewable and Conventional Energy Generation

Due to the increasing environmental consciousness around the globe, the amount of renewable energy generation is steadily increasing. Not only industry and utilities in the Western world aim at reducing their carbon footprint and their dependence on fossil resources, but also developing countries seek to include renewable energy generation into their portfolio to lower the costs of electrifying remote and off-grid regions. Thus, the smart integration of existing conventional and novel renewable power generation is a global challenge in energy systems.

The generation of conventional and renewable power – ideally – becomes integrated and is generated in spatial proximity to the customer.

Conventional energy is required to cover base-load demands and to compensate for fluctuations in renewable generation. Renewables are used to off-set diesel fuel consumption. Storage devices gain increasing interest in generating conventional and renewable power – from individual components to a holistic solution for hybrid power generation, our flexible offering ranges from pre-feasibility studies to the commissioning of the final plant, including GE technology and service agreements.

As such, manufacturers can reduce their dependence on transmission grids and have more control over their energy costs, utilities can electrify remote areas without the need of installing new transmission lines while keeping the costs of fuel and fuel transportation low, and island (both energetic and physical) can reduce their reliance on fossil fuel which allows them to generate energy more cost-efficient. Especially in face of rising fossil fuel prices, these benefits are achievable at very short payback periods.

Our value

From individual components to a holistic solution for hybrid power generation, our flexible offering ranges from pre-feasibility studies to the commissioning of the final plant, including GE technology and service agreements.

Our commitment is a solution that is tailored to the customer’s needs by a deep understanding of the on-site setup. To be fast and flexible in implementation, GE divides hybrid energy solutions into modular building blocks to easily scale the projects while keeping overheads from individual layout efforts to a minimum.

Test Systems
Reducing risk through full scale testing

Helping to lower development cost

The substantial cost of installations means that industry cannot wait for turbines, substructures and components to prove themselves in service – turbines and other technology must be fully tested and validated prior to deployment.

Enables life-cycle and grid simulation

Electrical malfunctions and turbine protection systems have historically led to unforeseen excessive loadings of mechanical components and thereby reduced expected, calculated life-time. Therefore a simulation of worst case conditions is essential for design of a reliable product. The way that a given wind turbine responds to any foreseen or unforeseen event can be revealed at a test rig.

Maximum flexibility of test scenarios

Mechanical stress realized by a wind load unit, enabling bending forces in different angle of degrees. By testing control and protection systems, or single components under external conditions, the influences on load carrying components like main bearings, yawing systems, gearboxes etc. can be measured. The provision of Fault Right Through capabilities (Grid Simulator) ensures that the wind turbine is working under weakest grid conditions.

Expertise in turnkey installations of test benches

Our references does include test benches for turbine components like gearbox, generator and inverter and as well as for complete Nacelles.

Our offering

Beyond the supply of power electronics like switch gear, transformer, inverter and motor, we are in position to perform the test bench visualization, control, cabling and installation. Even the design and execution of specimen foundation, mechanical adapter’s i.e. tower- and hub-adapter, safeset coupling, wind load unit, heat exchangers and other infrastructural components is part of our business - everything from a single source.
PHASES OF PROJECT MANAGEMENT

GE's offers cover at each step of your project, namely conceptual design, engineering, manufacturing, equipment transportation and commissioning of the plant. We will accompany you from the initial talks and sales pitches to the handover of the commissioned plant. GE can look back on a rich experience in wind that allows a straightforward design and construction of your plant. From our perspective, experienced project managers are key to success – they coordinate the individual contractors, immediately perceive uprising challenges and manage them in a structured and well-organized manner.

GE offers training sessions for your employees, either on-site or at its manufacturing facility. They are held by experts to comprehensively convey the service and maintenance concepts. GE is passionate about customer satisfaction in each and every product and service offered. Long term relationships are built with our customers by jointly contributing to their success.

**GLOBAL FOOTPRINT TO OPTIMIZE LOGISTICS AND SERVICES COST**

With the growing size of wind turbines, logistic costs also become a larger piece of total cost. Therefore preferably wind turbines are manufactured close to the installation site. GE also offers long-term and local service support to operate the equipment reliably and efficiently.

**SCALABLE MANUFACTURING CAPACITY AND LOCAL CONTENT**

Certain countries require local content manufacturing to satisfy regulations and support mechanisms. To support the strong growth of the wind industry as well as local content requirements, GE has global manufacturing footprint, and has capacity to meet the increasing need for power generating equipment in large quantities. For example, GE’s factories in Brazil produce DFIG generators, DF and FF converters, machine heads and hubs, as well as top boxes. GE’s S.15MW DFIG has obtained BNDES accreditation for Brazilian market, making GE as the only supplier of generators at a power rating, compliant with FINAME requirements, the special credit line for the purchase of components produced locally.

**KEY DIFFERENTIATOR | SERVICES ACROSS THE PROJECT LIFE-CYCLE**

- Project Management
- Global Partner. Local Footprint.
- Scalable manufacturing capacity and local content
- Global footprint to optimize logistics and services cost
- Customer planning office
- Project management
- Application engineering
- Mechanical/electrical support
- Subsupplier
- Plant construction contractor
- 500+ service engineers

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Project managers are key to a successful project by coordinating the individual stakeholders.
Our Services Offering

to support your business

ENHANCING ENERGY HARVEST ACROSS PROJECT LIFE-CYCLE
GE’s services support continuous plant operation, giving higher energy yield and therefore high return on investment across life-cycle. GE Services provide a broad range of activities that are necessary for utilities and farm operators to protect assets, keep critical processes running, to help decreasing risk and enhancing productivity while letting the owner/operator concentrate on their core business.

LONG TERM & LOCAL SUPPORT
We offer both on demand services and long term service contracts with a range of options from “Help Me Fast” to “Partnership” which creates a fully inclusive contract offering. With over 1,000 field service engineers, and operating in more than 170 countries GE has the organization to support customers wherever they may be.

FLEET DATA ANALYTICS AND PREDICTIVE MAINTENANCE
Through advanced digital platforms, we deliver expert onsite and remote 24/7 support, emergency interventions and all customized to meet unique customer requirements.

MEETING THE NEEDS OF YOUR OPERATIONAL MODEL
GE offers customized services to meet the needs of customers’ individual support requirements (from commissioning training to revamping) comprising:
- Remote monitoring & diagnostics
- Maintenance
- Spare parts & obsolescence management
- Factory repairs and overhauls
- Warranty extensions
- Response time guarantees
- Modernization and Upgrades
- Operation and Maintenance Trainings

MODERNISATION PACKAGES
Our modernization packages reduce risk, increase productivity and secure compliance with changing grid requirements. Especially our converter field exchange program for 1.5, 2, 2.5 MW turbines brings up to date technology and higher yield to older turbines.

Our Wind Service Center is capable to remotely support our customer’s local teams 24/7 working hand in hand. To respect the individual levels of capabilities of our customer, our service offerings can be tailored.

### KEY DIFFERENTIATOR | SERVICES ACROSS THE PROJECT LIFE-CYCLE

#### Our Services Offering

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<thead>
<tr>
<th>Term in Years: Up to 20</th>
<th>“Help Me Fast”</th>
<th>“Partnership”</th>
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<tr>
<td>Contract Management</td>
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<td>Onsite Customer Support during Interventions</td>
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- Included in fixed fee
- Supplied as an extra fee
- Customer to supply as Prerequisite
Our goal is to offer our customers a complete commercial solution covering GE’s products, services and financing. More than 100 commercial finance experts in more than 25 countries provide you with financial advisory services through all stages of your project (acquisition, pre-bid, bidding, execution and negotiations) and support in structuring and arranging financial solutions using a variety of financial products, such as deferred payment, leasing, project- and export financing, contracting, equity and mezzanine funding.

The team works closely with and has access to local, global and alternative debt and equity sources, such as export credit agencies, commercial banks, multilaterals, policy banks, leasing companies, private equity and institutional investors. In addition, GE might consider investing in or providing financial support for strategic projects acting as a catalyst for third party debt and equity.
Our Success

45+ GW of converters installed globally on and offshore

20+ YEARS EXPERTISE IN RENEWABLES
300+ WIND FARMS
35+ COUNTRIES

Contact Us

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The GE Store

DRIVING COMPETITIVE ADVANTAGE ACROSS OUR BUSINESSES

We drive enterprise advantages that benefit the entire company, through what we call the “GE Store”. It means that every business in GE can share and access the same technology, markets, structure and intellect. No other company has the ability to transfer intellect and technology as we can through the GE Store.