MICROGRID SOLUTIONS

Improve Grid Resiliency, Reliability and Efficiency
TODAY’S ENVIRONMENT

As power demands continue to rise, and energy availability and reliability becomes a primary concern, utilities and independent power producers need solutions to help ensure they have a reliable and economical supply of electricity.
The changing energy landscape includes the wide proliferation of Distributed Energy Resources (DERs), including renewable energy and storage being added to the grid. The increase in DERs is being driven by the following factors:

**Changes in policy and regulation**
Globally countries have set targets for the increase of green energy and reduction of greenhouse gas emissions. For example, the UK is aiming to reduce 20% of greenhouse gas emission by 2020. In the US, the state of California has set a target of 33% of retail load to be served from renewable sources by 2020.

**Security of supply**
As traditional fossil fueled generation plants are reaching end of life and retiring, developed countries need to find new sources to cover their primary energy needs, implementing and managing multiple fuel sources, including renewable generation, helps to maintain energy security and meet growing demand.

**New revenue streams**
Attractive feed-in tariffs for renewable generation have seen new investors outside the traditional energy industry investing in renewables bringing new entrants to the market. New commercial models are emerging including peer to peer energy transactions.

**Increasing availability and affordability**
As DERs are becoming more cost effective and readily available, there is a rise of the prosumer, where customers are both the producers and consumers of electricity.

**Helping enhance productivity through energy surety**
When industrial and manufacturing companies lose power, it can cost millions of dollars in down-time, waste and equipment damage. Implementing distributed energy resources enable industrial customers to continue operating even if the main grid is down.

Utilities and power producers must adapt and ensure they can find an optimal balance between supply and demand, and facilitate market changes to ensure reliable and economic operation. Integrated Microgrid Systems provide the set of solutions that are needed to manage Distributed Energy Resources efficiently and can also help the grid address the growing demand while enabling higher levels of devolved control.

In US 95GW generating capacity has or set to retire
More than 1.2B people around the globe live with power
By 2040, RENEWABLES will represent 30% of global net electricity

TRENDS DISRUPTING THE TRADITIONAL POWER SECTOR
WHAT IS A MICROGRID?

A microgrid is a contiguous section of the grid consisting of interconnected Distributed Energy Resources (DERs) and loads under common control. DERs can be distributed renewables, generators, storage devices, electric vehicles and demand response. Microgrid controls can optimize the power mix of the DERs and loads to provide reliable and economic operation to the end users.

Microgrid controls can also provide a resiliency service by operating the microgrid as an independent electrical island disconnected from the rest of the grid if required. There are different types of microgrids including:

Permanently Islanded Microgrids
These are off-grid systems where only locally generated power is consumed to meet the needs of the local demand.

Grid Connected Microgrids
These can produce and distribute power within its local distribution network as well as import power from a utility source.

Virtual Power Plants and Microgrids
A Virtual Power Plant (VPP) differs from a microgrid in that a VPP is typically associated with energy resources but not within a specifically defined grid boundary or grid sections. A VPP could be associated with, and operate within, a microgrid if the VPP resources are connected within the microgrid. Alternatively, a VPP can be a collection of microgrids.

BENEFITS OF MICROGRIDS

Microgrids can improve the electrical network through an optimized balance between supply and demand, where customers are able to dynamically utilize the most economic mix of supply and integrate variable supply resources. This is done through:

- Generation forecast and automated control
- Dispatch commitment scenarios and optimized DERs
- Integrating and managing renewables and energy storage

In addition, microgrids can help facilitate the energy trading mechanism and enable market transaction integration with utilities providing proactive management of existing energy contracts.
ANNUAL INSTALLED CAPACITY ACROSS DER MARKET IS EXPECTED TO GROW TO 335.8 GW IN 2024
GE SOLUTION

GE’s microgrid solution is a field proven, modular and comprehensive offering that integrates primary equipment, intelligent controls and communications, with advanced visualization and supervisory control software to monitor, track, and forecast load and generation resources within the microgrid network. Each solution is tailored to the application and the customers’ primary objectives.

Consulting services include:
- Technical and economic feasibility studies
- Business case development
- Detailed engineering designs
- Grid interconnection studies
- Protection and controls

The system components include:
- Energy storage solutions
- Microgrid control system and Communications
- Microgrid Energy Management System
- Inverters and Balance of Plant
- Generation solutions – gas, hydro & wind
- Services (engineering, project management, installation & commission, maintenance and asset performance management services)

Typical applications include:
- Utility
- Remote communities
- Military
- Community & smart cities
- Industrial
- Campus

The solution can be delivered as:
- Supplying equipment
- Engineered packages
- Full Engineering, Procurement and Construction
GE ADVANTAGE

GE is globally recognized for designing, delivering and servicing customized microgrid solutions for diverse applications. GE is able to offer a comprehensive solution including feasibility studies and network analysis, project management and design, primary and secondary equipment, controls and advanced visualization tools. Working with GE, customers can realize the following business outcomes:

- **Improve grid reliability**
  With GE’s uniquely designed solution for grid resilience, energy and system reliability

- **Reduce Op-Ex**
  Advanced operation controls for energy bill reduction, demand response efficiencies and power mix optimization

- **Improve financial performance**
  Monetize the value of assets through new revenue streams

- **Increase operation efficiency**
  Single platform for managing grid assets, generation assets, customers (loads), markets and other counter parties

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INTEGRATED, TAILORED SOLUTIONS FROM CONSULTING SERVICES TO SYSTEM OPTIMIZATION
GE APPROACH

GE partners with customers to define the project scope and vision. This process begins with the development of the “Microgrid Energy Master Plan,” when GE consultants perform the cost-benefit analysis of different scenarios to define the multi-year roadmap of capital projects supported by operation and maintenance projects. Our approach results in a formalized business case with an investment-grade system engineering design that provides the basis of project planning and financing. GE can deliver the turnkey implementation with O&M service agreements.

GE’s System Approach

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<tr>
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<th>4</th>
<th>5</th>
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</thead>
<tbody>
<tr>
<td>Business Case</td>
<td>System Engineering</td>
<td>Project Planning &amp; Financing</td>
<td>Turnkey Project</td>
<td>Service Agreement</td>
</tr>
<tr>
<td>Cost-benefit Simulation Analysis</td>
<td>Architecture, Functions, Performance KPIs</td>
<td>Value Engineering, Plan &amp; Budgets, Financing</td>
<td>Implementation &amp; Production Roll Out</td>
<td>Training, Operation, Long Term Services</td>
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</table>

System Design Process & Optimization

Once the project scope, business objectives and services are understood, GE’s technical experts will scope the energy sources, equipment and services required. Then, utilizing an advanced optimization tool, GE delivers an a tailored solution to meet the customer’s requirements and business objectives.

GE INPUTS

- **ENERGY SOURCES**
  - Gas Turbine
  - Wind Turbine
  - Hydro Plant

- **PRODUCTS**
  - Inverters
  - Batteries
  - Microgrid Control System
  - Communications
  - PREDIX Analysis

- **SERVICES**
  - Engineering
  - Project Management
  - Maintenance & APM Services
  - Post Sales Services
  - Financing

CUSTOMER INPUTS

- **BASICS**
  - Power generation need
  - Existing equipment list

- **SPECIFICs**
  - Load profile
  - Critical loads
  - Existing equipment technical characteristics
  - Technical requirements and/or constraints

GE OPTIMIZATION TOOL

OPTIMIZED MICROGRID SOLUTION
### Application Examples

<table>
<thead>
<tr>
<th>Application</th>
<th>Project</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Military</td>
<td>Navy Shipyard</td>
<td>Philadelphia</td>
</tr>
<tr>
<td><strong>Challenge</strong></td>
<td>Meet the existing and future electricity capacity needs and integrate on-site generation and storage capabilities to reduce and flatten the overall load curve of the campus. Ensure greater energy efficiency and power system availability.</td>
<td></td>
</tr>
<tr>
<td><strong>Solution</strong></td>
<td>A suite of power system modernization solutions and a grid connected microgrid system for resilient, reliable power including:</td>
<td></td>
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<tr>
<td>- Microgrid Energy Management System</td>
<td>- DS Agile – DAPserver grid automation controller</td>
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<tr>
<td>- e-terra software platform (Microgrid-SCADA &amp; Microgrid-DMS)</td>
<td>- Reason Ethernet switches</td>
<td></td>
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<tr>
<td>- Digital Substation - Agile protection and control relays</td>
<td>- Nanogrid controllers</td>
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<table>
<thead>
<tr>
<th>Industrial</th>
<th>Aluminium Production Facility</th>
<th>United Arab Emirates</th>
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<tbody>
<tr>
<td><strong>Challenge</strong></td>
<td>Ensure maximum uptime for continued and safe plant operations in the event of utility power loss.</td>
<td></td>
</tr>
<tr>
<td><strong>Solution</strong></td>
<td>Microgrid system with fast loadshed capabilities to enable:</td>
<td></td>
</tr>
<tr>
<td>- Optimal integration and management of renewable generation including solar and back-up for maximum process uptime</td>
<td>- Seamless transition of power from utility source to on-site generation</td>
<td></td>
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<tr>
<td>- Fast loadshed of non-critical loads if load exceeds available generation</td>
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<tr>
<th>Campus</th>
<th>University of Ontario Institute of Tech.</th>
<th>Canada</th>
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</thead>
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<tr>
<td><strong>Challenge</strong></td>
<td>Reduce electricity costs on campus while maximizing renewable sources, and provide a seamless transition between grid connection and on-site generation for critical loads during grid failures.</td>
<td></td>
</tr>
<tr>
<td><strong>Solution</strong></td>
<td>Campus-based microgrid system with monitoring and control capabilities delivering:</td>
<td></td>
</tr>
<tr>
<td>- Active system to optimally control Battery Energy Storage System (BESS) and other energy storage sources based on different forecasting engines, providing a seamless transition in case of grid failure</td>
<td>- Simulation tool to evaluate the performance of the control system when faced with different load and electricity prices</td>
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<tr>
<td></td>
<td>- Monitoring system to provide status, event, and alarm management with remote data access</td>
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<td>APPLICATION</td>
<td>PROJECT</td>
<td>LOCATION</td>
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</tr>
<tr>
<td>SMART CITY MICROGRID</td>
<td>NICE GRID</td>
<td>NICE, FRANCE</td>
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**Challenge**
Enable the prosumer to efficiently take advantage of significant photovoltaic distributed generation and energy storage, by enabling islanding for secure supply and provide demand response solutions for flexible consumption.

**Solution**
Grid modernization solutions delivering a community based microgrid including:

- e-terra Platform Distributed Energy Resource Management Solution (DERMS)
- Microgrid Energy Management System
- DS Agile microgrid controller
- DAPserver substation SCADA SA-DA platform
- Agile protection and control relays
- Reason Ethernet switches

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<tr>
<td>UTILITY</td>
<td>ISSY GRID</td>
<td>ISSY-LES-MOULINEAUX, FRANCE</td>
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**Challenge**
Reduce consumption peaks and ensure grid balance while reducing the carbon footprint of the district.

**Solution**
District level microgrid system to optimize energy efficiency for a variety of loads including: commercial, residential, street lighting, EV charging and public buildings. GE’s microgrid solution provides monitoring and control of:

- Renewable generation integration
- Energy storage
- Smart street lighting
- EV charging

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<td>COMMUNITY RESILIENCY</td>
<td>POTSDAM NY MICROGRID</td>
<td>POTSDAM, NY USA</td>
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</table>

**Challenge**
This town in northern New York, near the Canadian border, had experienced significant winter ice storms that wiped out power to much of the town and its critical and emergency response infrastructure for an extended period of time, putting the community and its residents at risk.

**Solution**
GE’s Energy Consulting business partnered with National Grid, Clarkson University and Nova Energy specialists to engineer the technical and economic designs for a resilient microgrid for the community. This project is part of the state’s larger "Reforming the Energy Vision" initiative, also known as NY REV. GE’s scope of the solution includes:

- Business case development
- Economic dispatch modelling
- Interconnection and stability studies
- Distribution infrastructure, communications and controls design and engineering
KEY COMPONENTS

Microgrid Services
GE provides a full range of services from microgrid design and simulation to optimizing microgrids for resiliency, reliability, up-time and performance. GE’s service agreements are customized based on the customers’ requirements. Microgrid owners can lower their operating costs and mitigate operational and financial risks. GE’s services include:

- **Microgrid Advisory Services:**
  - Concept plan
  - Load analysis and DER dimensioning
  - Cost-benefit analysis and energy master plan

- **Microgrid System Design Services:**
  - Stability study and analysis
  - Electric grid system design

Microgrid Operation & Maintenance Services
- Multi-year service agreement
- Performance and availability based contract
- Preventive and condition based maintenance
- Asset Performance Management (APM)
- Grid modernization and upgrade

Microgrid Energy Management System
GE’s Microgrid Energy Management System (MEMS) is a single, unified platform for microgrid planning and operation optimization. Operators are able to monitor, optimize and control the system to reduce the overall energy cost and improve system reliability and resiliency. The MEMS is a multi-layer control system with the following components:

- **Microgrid Supervisory Control Room**
  Using GE’s e-terraMicrogrids, this advanced grid control room software solution powers more than 70% of utility grid control centres enabling activities from “operation planning” to “after the fact” scenarios.

- **Microgrid Middleware Communication Platform**
  GE’s e-terraMBus provides field proven, unified communications middleware supporting both real-time (e.g. microgrid SCADA) and non-real-time (e.g. OpenADR) messaging.

- **Nanogrid Automation Controls for Distributed Energy Resources at Building Level**
  GE’s e-terraMEdge delivers distributed intelligence and control automation at the building level to forecast and optimize DER assets and loads.
Microgrid Controller & Generation Optimizer
GE’s Multilin DMC490 is a powerful multi-function server and automation controller that has been specifically designed for the optimization and control of microgrids. The DMC490 optimizes the cost of operation and energy of renewable and non-renewable generator sources.

The microgrid control system supports applications such as interlocking, on-demand triggers, and automatic feeder transfers which can be realized through an embedded IEC 61131-3 compliant user-based configurations.

Energy Storage Solution
GE’s Reservoir solution is a flexible and modular energy storage solution for AC or DC coupled systems. This innovative and standardized architecture is designed for energy, power and renewable applications.

The Reservoir solution is an integrated turnkey offering that combines GE’s advanced technologies and expertise in controls, power electronics, battery and operational management systems, and electrical balance of plant – all backed by GE’s performance guarantees.

FROM OPERATIONAL SOFTWARE AND INTELLIGENT CONTROLS TO ENERGY STORAGE AND SERVICES, GE DELIVERS COMPREHENSIVE MICROGRID SOLUTIONS
Jenbacher Gas Engines
GE’s offers a wide variety of combined heat and power (CHP) systems using Jenbacher gas engines up to 10 MW. The compact, modular designs of the engines lend themselves to small footprints which can be scaled to meet unique customer requirements and help pass regulations.

The Jenbacher gas engine is designed with fuel flexibility to run on natural gas or a variety of other gases, such as:

- Biogas
- Flare gas
- Landfill gas
- Propane
- Sewage gas
- Special gases (e.g. wood gas, pyrolysis gas, coke gas, coal mine gas)
- Steal gas
- Flare gas

With more than 16,000 Jenbacher gas engines in operation, GE can furnish onsite power, heat and cooling for a variety of commercial, industrial and municipal applications.

Wind Turbines
GE provides a full suite of turbines created for a variety of wind environments. The portfolio of turbines feature rated capacities from 1.7 MW to 4.8 MW (Onshore) and 6MW (Offshore). GE can provide tailored solutions ranging from a single component to full turnkey power plants.

+16,000 Jenbacher gas engines in operation
+50 GW of installed on-shore wind capacity
+25% of total hydro installed capacity worldwide
Hydro Power Solutions
GE’s hydro turbines and generators represent more than 25% of the total installed capacity worldwide. GE provides a broad range of hydro power solutions and services, the portfolio includes:

Large hydro
A full range of hydroelectric turbines up to 900 MW and hydro generators that are customized for each project to ensure optimized performance.

Small hydro
A complete range of solutions for small hydro applications up to 30 MW, with options for turnkey plants or individual components.

Hydro services
To ensure plant operators, owners and investors can achieve and maintain optimum performance, GE’s PlantLife program is a comprehensive asset management program, which offers both customized and off-the-shelf solutions.
For more information about GE’s Microgrid Solutions visit
GEGridSolutions.com/microgrid