RESERVOIR SOLUTIONS

Flexible, modular Energy Storage Solutions unlocking value across the electricity network
UNLOCKING NEW BUSINESS VALUE WITH GE’S RESERVOIR ENERGY STORAGE SOLUTION

Improve Financial Performance
Monetize assets through new revenue streams, increased asset utilization, improved yield, and reduced operating costs.

Increase Renewables Integration
Improve integration and maximize utilization of the energy generated from photovoltaics (PV) and wind turbines.

Optimize Electrical Grid
Defer upgrades, relieve congestion, control voltage, provide reserves and ancillary services, and improve reliability with backup power and black start functionality.

Reduce Energy Costs
Commercial and industrial end users can mitigate demand charges, optimize differential (Time of Day) energy prices, and benefit from additional onsite PV generation.

Develop Microgrids
Create a new and more flexible grid by locally integrating renewable generation and smart devices with energy storage and real-time communication.
TRENDS DISRUPTING THE POWER SECTOR FROM GENERATION TO T&D

**DECARBONIZATION**
By 2040, RENEWABLES will represent 30% of global net electricity ... or more?

**IMPACT**
- Generation is becoming difficult to forecast & variable
- Grid stability, Congestion Volatility on electricity markets

**DIGITIZATION**
GROWING THE NUMBER of connected devices & smart sensors

**IMPACT**
- Allowing decision making based on dynamic and nodal prices

**DECENTRALIZATION**
GROWING PENETRATION of distributed resources (renewable, storage, efficient devices)

**IMPACT**
- End user becomes an active actor of the power system ("prosumer")
- Growing complexity of distribution grids

**ELECTRIFICATION**
GROWING PENETRATION of distributed resources (renewable, storage, efficient devices)

**IMPACT**
- Growth of Electricity demand, and an acceleration of decentralization of the power sector

**ELECTRIFICATION OF ENERGY USES**, transport (EVs) and heating

**IMPACT**
- Electrification of energy uses, transport (EVs) and heating
INCREASING RENEWABLES CREATE NEW PRESSURES ON THE GRID

1. Overgeneration from PV
2. Quick changes
3. Volatility
4. Variation in Time of Day prices

"Levelized" mindset inadequate for the future – Time of day and seasonality matter more than ever
WHY ENERGY STORAGE?

A battery energy storage solution offers new application flexibility and unlocks new business value across the energy value chain. Energy storage supports diverse applications including firming renewable production, stabilizing the electrical grid, controlling energy flow, optimizing asset operation and creating new revenue by delivering:

### Active Power Services
- Frequency regulation
- Frequency response
- Peak shaving/firming
- Remote power commands
- Ramp rate control
- Curtailment avoidance
- Scheduled dispatch/shifting
- Scheduled power commands
- State of charge management
- Islanding
- Black start

### Reactive Power Services
- Voltage control
- Voltage droop
- Power factor control
- VAR control

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ENERGY STORAGE: UNPRECEDENTED FLEXIBILITY IN GRID OPTIMIZATION

1. Baseload cause renewables to be curtailed
   Energy Storage is charged with free or negative priced energy

2. Peak Load
   Energy Storage is discharged during peak demand periods

3. Spinning Reserve
   Energy Storage discharges during dynamic events (clouds)

4. Frequency Regulation
   Energy Storage continuously charges and discharges to maintain grid stability

Energy storage provides instantaneous local capacity, and continuous ancillary services with no fuel consumption or emissions
### TYPICAL RESERVOIR APPLICATIONS

#### Standalone Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Generation</th>
<th>Transmission</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Voltage Regulation</strong>: Compensate anomalies or disturbances (e.g., voltage magnitude, harmonics, etc.) by sending reactive energy into system.</td>
<td></td>
<td></td>
<td>✅</td>
</tr>
<tr>
<td><strong>Frequency Response</strong>: Provide fast regulation of grid frequency to balance supply and demand.</td>
<td></td>
<td>✅</td>
<td></td>
</tr>
<tr>
<td><strong>Frequency Regulation</strong>: Provide regulation of grid frequency to balance supply and demand based on signals sent by the grid operator.</td>
<td>✅</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Renewable Integration</strong>: Balance the local excesses or deficits of renewable generation caused by rapid weather fluctuations.</td>
<td></td>
<td></td>
<td>✅</td>
</tr>
<tr>
<td><strong>Black Start</strong>: Energize part of the generation asset without outside assistance after a blackout.</td>
<td>✅</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Back-Up</strong>: Store energy to maintain service continuity and grid resilience in the event of an outage.</td>
<td>✅</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Peak Management</strong>: Reduce grid capacity needs during peak periods with local storage.</td>
<td>✅</td>
<td>✅</td>
<td></td>
</tr>
<tr>
<td><strong>Shifting</strong>: Buy or produce electricity at low price (off-peak) to store and sell at peak price.</td>
<td>✅</td>
<td>✅</td>
<td></td>
</tr>
<tr>
<td><strong>Capacity</strong>: Store renewable energy production for peak and base load consumption.</td>
<td>✅</td>
<td>✅</td>
<td>✅</td>
</tr>
</tbody>
</table>
## TYPICAL RESERVOIR APPLICATIONS

**Integrated Hybrid Solution Applications**

<table>
<thead>
<tr>
<th>Application</th>
<th>Solar</th>
<th>Wind</th>
<th>Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Synthetic Inertia:</strong> Compensate losses of grid inertia caused by high renewable penetration.</td>
<td>✔</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Frequency Regulation:</strong> Provide fast regulation of grid frequency to balance supply and demand.</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Firming:</strong> Prevent undesirable short-duration effects from rapid fluctuations in solar generation due to intermittency and weather conditions.</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td><strong>Improved Operations:</strong> Optimize thermal generation fleet operation and costs.</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Contingency Reserve:</strong> Provide fast ramp-rate to meet grid requirement for online dispatch within a short delay of operating reserve.</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Curtailment Avoidance:</strong> Avoid wind output curtailment at certain times, preventing loss of energy production.</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td><strong>Dispatchable:</strong> Control solar generation at request of power grid operators or according to market needs.</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>
**SERVING GLOBAL CUSTOMERS WITH LOCAL EXPERTISE**

GE is globally recognized for designing and delivering customized energy storage solutions for diverse applications. With regionally located technical experts, our teams work directly with customers during the lifetime of the project. To date GE has more than 207 MWh of energy storage in operation or in construction globally.

<table>
<thead>
<tr>
<th>CUSTOMER</th>
<th>ENERGY STORAGE DEVELOPER</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHALLENGE</td>
<td>Local grid support</td>
</tr>
<tr>
<td>APPLICATION</td>
<td>Standalone - Generation</td>
</tr>
<tr>
<td>Location</td>
<td>United Kingdom</td>
</tr>
<tr>
<td>STATUS</td>
<td>Under construction</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GE SOLUTION</th>
<th>APPLICATION</th>
<th>LOCATION</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>41MW / 41MWh BESS</td>
<td>Capacity; frequency regulation</td>
<td>United Kingdom</td>
<td>Under construction</td>
</tr>
</tbody>
</table>

This project will relieve pressure on the host country’s energy system and provide flexibility when it is most needed to deliver a more balanced, secure energy system and help reduce consumer energy cost. The focus is on building long term commercially sustainable battery storage systems that are not reliant on subsidies and incentives.
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<th>CUSTOMER</th>
<th>ENERGY STORAGE ASSET DEVELOPER</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHALLENGE</td>
<td>Balance long duration voltage and frequency irregularities</td>
</tr>
<tr>
<td>GE SOLUTION</td>
<td>7MW / 7MWh BESS</td>
</tr>
<tr>
<td>APPLICATION</td>
<td>Standalone - Transmission</td>
</tr>
<tr>
<td></td>
<td>Voltage control, reactive power support, frequency regulation, ramp rate control, peak shaving, load shifting</td>
</tr>
<tr>
<td>LOCATION</td>
<td>Ontario, Canada</td>
</tr>
<tr>
<td>STATUS</td>
<td>In operation</td>
</tr>
</tbody>
</table>

“GE worked with us to create a fully integrated energy storage solution that helps meet the growing needs of the local transmission system. The project utilizes reliable GE equipment and products ranging from enclosures through the point of utility interconnection — a strategy that is cost-efficient, simplifies system warranties and guarantees, and provides a financeable solution to our customers.”
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CUSTOMER  PUBLIC POWER UTILITY

CHALLENGE  Providing grid stability & smoothing renewable output

APPLICATION  Standalone - Transmission
Emergency power / black start capability, distribution management system integration, ramp rate control, frequency response, spinning reserve

GE SOLUTION  33MW / 20MWh BESS

LOCATION  Southern California (US)

STATUS  In operation

Located in California, which has some of the most aggressive renewable portfolio requirements in the US, this 33MW / 20MWh battery system complements the integration of renewable resources, such as solar and wind, by adding stability and improving power quality.
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**CUSTOMER**  INVESTOR-OWNED ENERGY COMPANY

<table>
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<th>APPLICATION</th>
<th>LOCATION</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting resource adequacy requirement</td>
<td>Hybrid - Solar</td>
<td>Southern California (US)</td>
<td>In operation</td>
</tr>
<tr>
<td>Solar integration</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GE SOLUTION  2MW / 8MWH BESS

“We have a history of working with GE in thermal and wind, and we are pleased to continue our long-standing collaboration into the evolving world of energy storage. GE brings a strong technical solution, along with performance guarantees.”
GE is globally recognized for designing and delivering customized energy storage solutions for diverse applications. With regionally located technical experts, our teams work directly with customers during the lifetime of the project. To date GE has more than 207 MWh of energy storage in operation or in construction globally.

### CUSTOMER  PUBLIC POWER UTILITY

<table>
<thead>
<tr>
<th>CHALLENGE</th>
<th>APPLICATION</th>
<th>LOCATION</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Addressing local grid reliability concerns</td>
<td>Hybrid - Thermal (EGT) Spinning reserve</td>
<td>Southern California (US)</td>
<td>In operation</td>
</tr>
</tbody>
</table>

This project consists of two 10 MW of battery energy storage systems, each paired with GE’s proven 50 MW LM6000 aeroderivative gas turbines, capable of providing instantaneous response during a spinning reserve event.

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GE SOLUTION

GE’s Reservoir is a flexible, compact energy storage solution for AC or DC coupled systems. The Reservoir solution combines GE’s advanced technologies and expertise in plant controls, power electronics, battery management systems and electrical balance of plant – all backed by GE’s performance guarantees.
GE’S RESERVOIR STORAGE UNIT . . . Up to 4MWh Capacity

Enhanced to reduce installation cost and shorten project schedule

- Up to 15% extended battery life utilizing proprietary blade protection units
- Up to 50% reduced construction time with factory built & tested solution
- Improve safety by reducing fault current by up to 5x
- Enable up to 50% more solar energy sales with enhanced PV to inverter loading ratio
Renewable Reservoir – “Solar + storage” as system approach

A) AC Coupled – PV and ES “Separate” Systems

- High dc/ac ratios as only dc side needs to be rated for peak PV
- Less material cost for transformer, dc/ac inverter, cables
  ➔ Less CAPEX: ~15%

B) DC Coupled – PV and ES “Hybrid” System

- Less energy losses due to reduced conversion stages
- Higher efficiency with SiC technology
RESERVOIR SOFTWARE SUITE

The reservoir software suite includes edge to cloud infrastructure that's scalable, adaptable and easy to use. The software suite includes:

- **FLEET MANAGEMENT**: Fleet aggregation software designed for asset monitoring, alerts, trends and forecasting.
- **COMPONENT LIFE ANALYTICS**: Manages battery life based on history and expected future use profiles to minimize downtime and unplanned outages.
- **DISPATCH OPTIMIZATION**: Charges and discharges batteries based on equipment status and market conditions to maximize customer outcomes.

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**RESERVOIR SERVICES**

GE’s service agreements are customized based on the customers’ requirements and can lower operating costs and reduce operational and financial risks:

<table>
<thead>
<tr>
<th>PLANNED MAINTENANCE</th>
<th>UNPLANNED MAINTENANCE</th>
<th>PARTS PLANS</th>
<th>REMOTE OPERATIONS CENTER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routinely service equipment and keep the energy storage system online, resulting in superior fleet performance.</td>
<td>Monitor, troubleshoot and inspect equipment, boosting uptime and lifecycle production.</td>
<td>Provide full range of offerings to support preferred levels of service.</td>
<td>Provides continuous monitoring and diagnostics services 24-hours a day, 365 days a year.</td>
</tr>
</tbody>
</table>
PERFORMANCE GUARANTEE

The specific performance criteria and duration of the performance guarantee will vary depending on your application, economic incentives, and requirements. Performance guarantees are only available to customers who maintain a contractual services agreement with GE.

AVAILABILITY GUARANTEE

This guarantees that the battery energy storage solution will be available to charge or discharge electric energy at the nameplate power output and at the agreed-upon percentage of time.

CAPACITY GUARANTEE

The amount of energy that the battery is able to extract from and discharge to the grid can be guaranteed.

CUSTOM METRIC GUARANTEE

Some owners have unique measurements or metrics. In such cases, GE works with you to assess the risks involved and define a guarantee structure that aligns the interests of both parties throughout the life of the asset.
**LIFECYCLE MANAGEMENT**

*Capacity Based Performance Guarantees*

### Beginning of Life (BOL) Sizing
- **System Capacity (kWh)**
  - Years of Operation:
  - 0, 5, 10, 15, 20
  - Capacity Variations:
    - 50%, 70%, 90%, 110%, 130%

### End of Life (EOL) Sizing
- **System Capacity (kWh)**
  - Years of Operation:
  - 0, 5, 10, 15, 20
  - Capacity Variations:
    - 50%, 70%, 90%, 110%, 130%

### Capacity Additions
- **System Capacity (kWh)**
  - Years of Operation:
  - 0, 5, 10, 15, 20
  - Capacity Variations:
    - 50%, 70%, 90%, 110%, 130%

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**Lowest capex**
- Stays above capacity req. without future upgrades
- Lower degradation

**Does not meet fixed capacity requirement**
- High capex
- Most expensive solution

**Power applications**
- Remote locations
- Tax credits

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**BEST FOR**
- EGT

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**Lower capex than EOL**
- Takes advantage of falling battery prices

**Higher system complexity**
- Must leave additional space

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**Most energy projects**
- Long project life needed
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**Services**
- 52+ service and repair centers
- 17 technical institutes

**GLOBAL EXPERTISE**

- **126 MWh** in North America
- **53 MWh** in Europe
- **21 MWh** in Asia
- **7 MWh** in Africa

**INDUSTRY EXCELLENCE**
- 10 years of storage experience
- 20 year performance guarantee

**PIONEERING**
- 1st Hybrid EGT storage + gas turbine peaker in operation
- Black Start first proven emergency start of CCGT

**LOCAL EXPERTISE**
- 40+ Countries providing comprehensive consulting & services

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## GE Reservoir Storage Unit

**Enhanced to reduce installation cost and shorten project schedule**

### Electrical Integration
- DC disconnect, service rated
- Auxiliary power equipment
- Optional combiner Package for DC coupled PV
- Bottom and front entry cable option

### Custom Enclosure
- High density 4 MWh design
- All weather design
- Outdoor rated
- High efficiency cooling
- Long service life

### Blade Protection Unit
- Active string regulation extends life up to 15%
- Reduce fault currents by up to 5X to improve safety
- Intelligent DC bus enables direct PV integration
- Enables safe replacement of individual battery modules
- Reduces NFPA PPE levels from HRC4 to HRC2

### Battery Blade Unit
- Integrated protection unit
- Serviceable with integrated lockable disconnect device
- Digital twin technology for lifecycle management
- 1500V Class with less cable, fuses and switches
- Tier 1 Li-Ion cells for highest cycle life

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Reservoir Storage Unit, Large Energy Application (1.2 MW / 4 MWh)

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SYSTEM DESIGN PROCESS

Once the project scope, business objectives and services are established, GE’s technical experts will define the energy sources, equipment and services required. Using advanced system planning and optimization tools, GE will deliver a tailored solution to meet the desired objectives.

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**GE APPROACH**

GE's broad portfolio of Reservoir Solutions can be tailored to the operational needs enabling efficient and cost-effective storage distribution and utilization of energy where and when it's needed most.

Our approach results in an investment grade business case that provides the basis of project planning and financing.
Enabling Renewable Dispatchable Generation

Energy storage coupled with a Solar Farm can transform variable generation into predictable and reliable solar generation in compliance with local grid code and enable new revenue streams.
**Frequency Response**

Energy Storage can raise the frequency of the grid by discharging to push real power or to lower the frequency by charging. State of Charge (SOC) of the batteries is controlled through advanced algorithms which manage continuous frequency regulation. This enhances a power system’s responsiveness to frequency changes.

- **Service Class:** Power
- **Value Type:** Revenue
- **$/MWh**
- **Periodicity:** Frequent
- **Duration:** Short