GE Smart Metering Solutions for AMI – Informing the smart grid and connecting consumers

The Energy Challenge:

Energy costs are rising and consumers have few options for managing or controlling their bills. As demand continues to climb, utilities will need to build more generation – with additional economic and environmental impact.

- There are more than 140 million meters installed in the U.S. and only a handful are smart meters.
- To deliver on key smart grid solutions, like demand response, current meters will need to be replaced with smart meters.
- Smart meters must communicate effectively with consumer interfaces, home electrical devices and the grid.

The GE Smart Solution:

GE smart meters equipped with the right communications technology are among the fundamental building blocks of smart grid deployments.

With GE smart meters tracking and reporting energy usage by time of day, utilities can charge less for electricity used during off-peak hours. As a result, consumers can save on energy costs by shifting energy-intensive activities to lower-rate periods. And utilities can better manage peak demand.

As one of the only companies with generation-to-consumption experience and expertise, GE engineers meters with full smart-grid functionality in mind:
- applying input from GE transmission and distribution experts.
- Smart meter designs complementing other GE smart grid solutions, such as Delivery and Asset Optimization.
- leveraging GE Appliances’ valuable insight into smart meter interactions with smart appliances.

Our GE expertise and experience help enable many of the efficiency, productivity, and environmental benefits of a smarter grid, including:
- Empowering consumers with information to manage energy use and save money.
- Improving power reliability and customer service.
- Supporting at-home renewable generation and preparing the grid to manage plug-in-hybrid electric vehicles.
- Improving energy efficiency and power quality.

GE is the longest-standing global meter manufacturer and has been building meters for more than 120 years. Utilities investing in smart meters understand and value GE’s financial strength, staying power, and commitment to the long-term success of a smarter grid.

GE Smart Grid Value at Work:

GE meters are leading the way with technology and functionality:
- GE meters are ready to accommodate future smart grid advances, such as Volt/Var optimization, smart appliances, phase detection and more.
- Currently, the only meter platform with the latest 4G wireless technology designed specifically for broader smart grid applications.
Here’s How It Works:

With expertise on both sides of the meter, GE is positioned to create meters that work as the cornerstone of smart grid implementation.

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<tr>
<th>What GE Delivers</th>
<th>How It Improves Your Performance</th>
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| Empower Consumers                                      | Smart meters and smart home energy panels will help empower consumers with information to:  
  • Monitor, manage, and control energy usage.  
  • Optimize performance and reduce energy losses from appliances, lighting, and on-site generation.                                                                 |
| Support At-Home Renewable Generation                   | With smart-grid-enabled net metering, consumers may be able to sell excess power back to the grid during peak hours. Selling at higher peak-hour rates can offset rising power bills, while helping utilities manage peak demand. |
| Help Prepare the Grid to Manage Plug-in Cars           | Time-of-use pricing gives plug-in owners incentive to charge cars during off-peak hours (when the price per kWh is lowest), helping utilities manage peak demand. Smart meters will also enable consumers to voluntarily offer cars as “sheddable” load, receiving payments or credits for delaying car charging to off-peak hours. |
| Improve Power Reliability and Customer Service         | Like nerve cells, smart meters help utilities pinpoint and communicate the location and cause of outages – before customers call in. Meter information fed into the utilities’ grid automation solutions – such as outage management systems and distribution management systems – helps minimize and better manage power disturbances. Information from smart meters also helps utilities proactively prepare for customer calls in outage situations. |
| Improve Efficiency and Quality of Power Delivered to   | Smart meters can act as sensors for real and reactive power to help optimize power delivery (or “the power factor”) and ultimately minimize losses. Smart meters can also track and report voltage and load signals to help utilities efficiently deliver quality power. |
| the Consumer                                           |                                                                                                                                                                                                                                   |
Delivery Optimization –
Increasing grid efficiency and reliability to maximize
power-delivery potential

The Energy Challenge:

Today’s grid is inefficient, with losses occurring throughout the system — from generation, through transmission, to consumption. Reliability issues are also problematic — costing businesses money and affecting consumers’ lifestyles.

• Making the grid just 5% more efficient would save more than 42 gigawatts of energy — that’s equivalent to the power output from 42 coal-fired power plants.¹

• Across business sectors, the U.S. economy loses $104-$164 billion a year to outages and another $15-$24 billion to power quality phenomena.²

• Smart grid technologies could reduce power disturbances by more than 75% by 2020, saving customers in excess of $50 billion in outage-related losses.³

The GE Smart Solution:

Integrate new ideas and technologies with existing assets to raise grid efficiency and reliability to new levels

GE’s Delivery Optimization portfolio will bring together a suite of distribution solutions — including three-phase power flow analysis, Integrated Volt/Var Control (IVVC) and Fault Detection Isolation and Restoration (FDIR) technologies — with substation automation, advanced control software, and communications technology. Working in conjunction with a utility’s existing energy and distribution management systems, we plan to deliver significant benefits, including:

• Efficiency savings through reduced line losses and decreased load.

• Improved power quality and reliability that helps utilities gain competitive advantage.

• Optimized performance of the full distribution network — not just individual substations — to realize a greater return on communication and control investments.

• Economic and environmental improvements that potentially help qualify for additional rate relief.

• Increased efficiencies when integrated with other smart grid solutions.
Here’s How It Works:
GE Delivery Optimization solutions could improve efficiency and performance across the grid by integrating communications, intelligence and control.

### What IVVC Can Deliver

<table>
<thead>
<tr>
<th>Visibility and Control</th>
<th>How It Improves Your Performance</th>
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<tbody>
<tr>
<td>Visibility and control of capacitor banks and voltage regulators across the entire distribution network could enable performance monitoring and prevent problems before they happen.</td>
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<tr>
<th>Look-Ahead Capability</th>
<th>How It Improves Your Performance</th>
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<tbody>
<tr>
<td>Load profile forecasting could help maximize economic benefits versus cost of operating field devices.</td>
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<tr>
<th>Peak Load Reduction</th>
<th>How It Improves Your Performance</th>
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<tbody>
<tr>
<td>Peak-period voltage control could help reduce peak load, lowering peak generation costs and deferring capital expenditures for generation and T&amp;D.</td>
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<thead>
<tr>
<th>Conservation Voltage Reduction</th>
<th>How It Improves Your Performance</th>
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<tbody>
<tr>
<td>Continuous voltage control could help reduce overall load, lowering generation operating costs and reducing base load capital expenditures.</td>
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<thead>
<tr>
<th>Loss Reduction</th>
<th>How It Improves Your Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controlling capacitor banks on distribution feeders will minimize losses, reducing base and peak generation costs and lowering T&amp;D capital outlays.</td>
<td></td>
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</table>

### What FDIR Can Deliver

<table>
<thead>
<tr>
<th>Improved System Reliability</th>
<th>How It Improves Your Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>GE Fault Detection Isolation and Restoration (FDIR) technologies under development will automatically detect and isolate faulted feeder sections, routing power to restore service within seconds and dispatching crews as needed. This will improve performance against many industry benchmarks, including CAIDI (Customer Average Interruption Duration Index), SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index).</td>
<td></td>
</tr>
</tbody>
</table>

GE Smart Grid Value at Work:
Designed to deliver a clear return on the investment:
- With up to 1-2% peak load reduction, Integrated Volt-VAR Control (IVVC) could help save up to $27 million and 29,000 tons of CO₂ per million customers each year.
- IVVC could deliver up to 34% ROI when used during peak hours.
- When combined with smart meters and Advanced Metering Infrastructure (AMI), IVVC could deliver an even greater ROI — up to 40%.

4. Dependent on load characteristics.
5. 20 year cost versus benefit — per 1 million customers.

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GEA17533 (04/09)
Asset Optimization –
Maximizing asset performance

The Energy Challenge:

Many grid assets are aging and are well beyond their design life. When you look at the transformers in use today, it’s amazing that the grid performs as well as it does. And it’s obvious that without smart intervention, reliability could be compromised:

- More than 50% of our transformers are reaching the end of their design life.¹
- Experts are retiring: On average, 50% of skilled resources are expected to retire in the next ten years, meaning transformer expertise will be lost.²
- Transformer failure rates are likely to increase: an analysis of NERC data found an average failure rate of 2.3%. This failure rate is likely to increase due to continued aging.
- An analysis of 94 transformer failures (rated 25+ MVA) that occurred between 1997-2001 showed $163M in losses from property damage. During this 5-year period, the average property damage loss was approximately $9,000 per MVA.³
- Transformers take time to replace: It may take 6 months to a year to receive a replacement transformer due to capacity constraint.

The GE Smart Solution:

Reduce capital expenditures, and reduce risk of unplanned outages by up to 80% – by predicting problems with proactive monitoring of critical assets

GE’s Asset Optimization portfolio maximizes asset performance and extends useful remaining life. It helps utilities avoid revenue loss, consumer dissatisfaction and regulatory penalties.

GE delivers a broad selection of transformer Asset Optimization tools — from monitoring and diagnostics to advanced prognostics and maintenance services. Using advanced technology — and proven modeling — we capture and analyze critical transformer data to provide:

- Fleet condition assessment
- Remote monitoring and alarm notification
- Advanced Maintenance Services
Here’s How It Works:
The GE Asset Optimization portfolio takes transformer data and turns it into knowledge and action.

<table>
<thead>
<tr>
<th>What GE Delivers</th>
<th>How It Improves Your Performance and Results</th>
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<tbody>
<tr>
<td>Fleet Condition Assessment</td>
<td>Provides the current health condition and risk assessment of the fleet, and recommends actions for maintenance, repair or replacement.</td>
</tr>
<tr>
<td>Remote Monitoring and Alarm Notification</td>
<td>Provides near-real-time information on transformer health and prognosis of changing behavior that may indicate future problems.</td>
</tr>
<tr>
<td>Advanced Maintenance Services</td>
<td>This end-to-end transformer life management helps maintain and prolong the life of critical assets.</td>
</tr>
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</table>


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GEA17537 (04/09)
Integrating Renewable Generation—Helping utilities bring on more clean energy

The Energy Challenge:

As power systems around the world dramatically grow their wind generation portfolios, today’s infrastructure will need a facelift to maximize the benefits of renewable resources.

- Today, wind and solar resources are connected to the grid according to a conventional, centralized generation paradigm. Unfortunately, this approach does not fully account for some of the fundamental differences in wind (and solar) power.

- At high penetration levels, renewable energy variability can present unique system operational challenges. Additionally, grid congestion itself can act as a further obstacle to integrating renewable energy.

- Many energy experts agree that high penetrations of renewable sources like wind and solar—beyond 20-30%—are achievable. But managing a grid with these variable power sources will become more challenging at these higher levels, particularly in the future.

The GE Smart Solution:

Advanced generation and transmission technologies for renewable integration

GE smart grid technologies exist today and we are actively collaborating with utilities to develop technologies for the future. Together, we are enabling the optimization and use of high percentages of renewable power. Technologies include improved wind turbines and solar cells, advanced wind and solar power plant controls and grid-control technologies that help alleviate congestion.

GE is one of the only companies that provides solutions on both sides of the wind turbine—from advanced power controls on the turbine itself, to the EMS that helps economically and efficiently dispatch generation from multiple sources:

- GE is the leading supplier of wind turbines in the US.
- GE has 12,000 wind turbines installed worldwide, representing 18 GW of installed base.
- GE has developed several industry firsts, including windfree reactive power, low-voltage ride-through and zero-voltage ride-through. We are currently developing high-voltage ride-through.

A critical and central element of our efforts is GE’s XA/21 Energy Management System (EMS). This mission critical system for a smarter grid helps effectively and efficiently aggregate, manage, and dispatch power.
Here's How It Works:
GE has technologies on both sides of the turbine, helping make renewables a vital contributor to our energy solutions.

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<tr>
<th>What GE Delivers Today</th>
<th>How It Improves Your Performance</th>
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</table>
| “Grid Friendly” Wind Power Plants | • WindCONTROL®: Like a conventional power plant, the system supplies reactive power to the grid when needed, regulating system voltage and stabilizing weak grids.  
• WindRIDE-THRU®: Delivers uninterrupted turbine operation through grid disturbances – even at zero voltage.  
• WindFREE™ Reactive Power: Provides VArs to prop up and stabilize the grid, even if the wind’s not blowing.  
• WindINERTIA™: Proprietary to GE, this inertial response at wind plants helps improve grid resilience to disruptions, like generator tripping. |
| Congestion Relief | • Grid efficiency technologies – like voltage and VAr control and series capacitors – help reduce reactive losses and improve voltages to alleviate congestion.  
• Variable frequency transformers help reroute power and isolate congestion.  
• Security Constrained Dispatch built into GE’s XA/21 Energy Management System helps manage real-time grid congestion.  
• Wide-Area Monitoring Systems (WAMS) will help detect and counteract the first signs of grid instability, relieving congestion.  
• Dynamic line-rating technologies help provide real-time readings of power lines to maximize flow through those lines. |

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<tr>
<th>What GE Is Developing</th>
<th>How It Improves Your Performance</th>
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<tr>
<td>Wind Forecasting</td>
<td>Integration of wind-forecasting technologies with GE’s XA/21 EMS will help utilities economically and efficiently manage generation, responsive loads and more – anticipating changes in wind speed and solar insolation.</td>
</tr>
<tr>
<td>Demand Response</td>
<td>Smart grid technologies enabling consumer-load reduction could help utilities manage renewable variability.</td>
</tr>
<tr>
<td>Energy Storage</td>
<td>Battery systems will rapidly charge and discharge energy to provide frequency support via smart grid automation technologies (such as GE’s XA/21 EMS), addressing the second-to-second mismatch between supply and demand.</td>
</tr>
</tbody>
</table>

GE Smart Grid Success in the Field:
GE is working with the Maui Electric Company (MECO), the DOE, and other partners to help integrate additional wind power into Maui’s grid. Approximately 10% of the island’s electricity is generated from wind power. In the future, the state of Hawaii aims to produce 40% of its electricity from renewables.

Maui’s challenge: Managing the variability of substantial renewable energy sources.
GE’s Solution: Coordinated and automated demand response and dispatchable energy storage and distributed generation. This smarter grid will more rapidly respond to production drops with more intelligent and automated controls. It will aggregate distributed resources, such as diesel engines, renewable generation, batteries, and even smart appliances to help re-balance generation and load. This can give MECO new strategies to address sustained changes in wind or solar power production.

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GEA17534 (04/09)
Digitized Substations –
A standardized approach to hasten improved grid performance

The Energy Challenge:

Realizing the promises and benefits of a smarter grid – from improved reliability and increased efficiency, to the integration of more renewable power – requires smarter tools. Advanced computing power and two-way communications are key to a grid that can operate at the speed of our 21st Century digital society.

• Only 10% of the 48,000 U.S. distribution substations are digitized.
• Lack of digitization limits both the proactive and reactive responsiveness of substations for improving efficiency, reducing waste and controlling peak load requirements.
• Upgrading these substations to meet today’s energy challenges requires time, resources and money.

The GE Smart Solution:

GE is delivering a smart, cost-effective, short-cycle solution for digitized substations – essentially, a digitized substation “in a box,” which is scalable to meet the varying needs of utilities across the globe.

Pre-assembled and highly integrated, GE’s modular enclosures can be shipped as complete units for new substations or retrofits. Our substations are custom-engineered for each utility through GE’s digital design process and then standardized across the utility’s distribution network. This modular approach helps reduce project costs and cycle times.

These new substations help make utilities smarter by digitizing and automating data collection, analysis, and dispatching. By turning data into useful information and knowledge, utilities can improve reliability, efficiency, power quality and safety, while reducing operating and maintenance costs.

GE Smart Grid Success in the Field:
GE delivers technology and coordination with our broad suite of products for a smarter, digitized substation. Solutions include relays and protection, substation controls and gateways, communication, telemetry and security applications — integrated quickly, safely and cost-effectively.

The numbers back it up:
• GE has delivered over 350 digitized substations.
• One utility saved over $5 million in 4 years.
• One customer cut cycle time by as much as 4 months.
• Buildings can be completed in five months and entire substations in nine months using GE’s automated and digitized engineering tool – down from 12 months without it.
**Here’s How It Works:**

GE Digitized Substations deliver consistent, predictable operations across a utility’s assets. The modular format installs faster and provides for uniform training, support and maintenance that helps reduce costs and improve employee productivity.

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<tr>
<th>What GE Delivers</th>
<th>How It Improves Your Performance</th>
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<tr>
<td>Improved Efficiency and Power Quality</td>
<td>Software applications for voltage and VAr control integrate with digital substations to improve power quality and efficiency.</td>
</tr>
<tr>
<td>Improved Customer Service and Reliability</td>
<td>Access to timely fault and disturbance data, to analyze and restore system failures, improves power reliability and service. Integration with monitoring and diagnostics technology helps predict maintenance needs and reduce unexpected transformer failures.</td>
</tr>
<tr>
<td>Lowered Operating and Maintenance Costs</td>
<td>Digitized approach reduces engineering costs, improves quality, and compresses cycle times.</td>
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<td></td>
<td>Digital equipment condition monitoring extends life of capital equipment, helps defer or prioritize replacement expenses and helps reduce on-site maintenance and inspection.</td>
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<td>Advanced and digitized relay functionality helps eliminate the need for certain devices, such as RTUs, while digital, high-speed LANs cut masses of control wiring and switches.</td>
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<td>Intelligent, modular design reduces field wiring installation time and costs.</td>
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<td>Design reduces the number of relay panels and zones by more than 50%, the quantity of equipment and panel space by more than 75% and redundant wiring by more than 50%.</td>
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<tr>
<td>Efficient and Cost-Effective Implementation</td>
<td>GE’s digitized engineering applications lower cost, improve quality, and reduce cycle time of design and installation.</td>
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<td></td>
<td>GE’s modular approach reduces substation cost and ensures speedy delivery.</td>
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<tr>
<td>Improved Safety</td>
<td>Standardizing substations across the utility’s distribution network contributes to the safety of substation personnel.</td>
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GEA17536 (04/09)
Smart Appliances – Appliances that communicate with the grid, empowering consumers to save

The Energy Challenge:

- The days of simply bolting additional generation onto the grid to meet increased demand and peak loads are over. The environmental cost of climate change, the business cost of construction and the challenges of siting make unchecked generation additions too costly for everyone.
- Other than one-dimensional fixes, such as fluorescent lights and programmable thermostats, consumers have few ways to reduce energy use.
- Consumers have no compelling incentive or, in many cases, means to actively or passively reduce energy use during peak times, necessitating peak-generation assets.
- Residential electricity prices are on the rise for a variety of reasons:
  - The cost of coal, burned for 50% of U.S. electricity, increased 40% from 1995 to 2007 and will continue rising.
  - The cost of building power plants is rising dramatically.
  - Anticipated federal legislation will likely force coal-fired generators to pay carbon taxes, adding yet more cost.

The GE Smart Solution:

Efficient appliances communicate with utilities and shift peak consumption to off-peak times

GE smart appliances will react to time-of-use pricing signals from a smart meter and delay certain high-energy-consuming tasks until lower-rate, off-peak hours. This smart appliance flexibility helps consumers manage energy usage and save money – without compromising their lifestyles. Shifting to off-peak times also helps utilities manage peak demand. At the end of the day, consumers with smart appliances can lower their electric bills and utilities can defer building additional expensive peaking power plants – which will further reduce consumer costs.

GE is your only resource for both smart appliances and smart meters. Our end-to-end innovation – from generation to consumption – means there is no weak link in your energy supply chain.

Plus, GE smart appliances are lifestyle-sensitive. Rather than simply shutting down during peak demand, they can shift to an operating mode that consumes less electricity. This empowers consumers to reduce their energy usage and carbon output.
Here’s How It Works:

Smart appliances communicate with smart meters and utility applications. They shift routine functions – such as freezer defrost cycles – to off-peak times of day. Smart appliances can also be called upon to reduce consumption during high demand periods or emergency situations, such as heat waves or generation outages.

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<tr>
<th>What GE Delivers</th>
<th>How It Improves Your Performance</th>
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<tr>
<td>Respond to price signals from utility to control high-consuming cycles on appliances</td>
<td>Help consumers save, without compromising lifestyles</td>
</tr>
<tr>
<td>GE’s energy-management-enabled appliances (smart appliances) will receive utility pricing signals via smart meters and react based on the appliance’s internal programming. It requires no customer interaction. For example, the automatic defrost feature in a freezer uses more energy than any other refrigerator cycle. GE smart refrigerators can delay the defrost cycle from occurring during peak-energy-use hours, so consumers save money and utilities reduce peak demand, both without impacting consumers’ daily routines.</td>
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GE Smart Grid Value at Work

A pilot program with Louisville Gas and Electric Company (LG&E) is placing smart appliances in a select number of homes. The appliances automatically respond to pricing signals transmitted from LG&E. Here’s what LG&E consumers in the pilot are saying:

- “It appears I saved $10-20 last month.”
- “I like the fact they interact with the LG&E meter to automatically make adjustments based upon the current rate period. That provides energy savings for me that I would have a difficult time duplicating otherwise.”

According to the Brattle Report, time-of-use pricing reduces consumer energy use by 5%. However, when combined with enabling technologies, such as smart appliances, smart thermostats and home energy displays, savings jump to an average of 25%.


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GEA17539 (04/09)
Demand Optimization -
Helping manage load, costs and consumption

The Energy Challenge:

Demand Optimization solutions help utilities better manage peak loads by suppressing or shifting these loads to other times of day, while empowering consumers to make simple, painless choices to control their costs and lessen their environmental footprint.

- GE estimates that more than 10% of the supply-side infrastructure in the U.S. is built to meet peaks in demand that occur less than 1% of the time.
- Peak load continues to grow faster than base load, adding generation costs to the utility and reducing reserve margins.
- Building new generation to support peak load is costly and unsustainable.
- Load will continue to grow, as world energy consumption is forecasted to triple by 2050.¹
- U.S. electricity prices are on the rise, and consumers today have little to no control over electricity costs or consumption. They lack information to make smart energy choices that can reduce their carbon footprints and lower their energy bills.

The GE Smart Solution:

GE’s Demand Optimization portfolio helps utilities manage demand, while empowering consumers to manage energy usage and save money - without compromising their lifestyle:

- Demand Optimization technologies will react to actual, rather than estimated, demand portfolios - helping utilities “shed” just the right amount of load for just the right amount of time to ensure a reliable supply of power to customers.
- By offering programs to alter non-critical loads at consumers’ homes (e.g. refrigerator defrost cycles and temperature control), utilities could better manage peak demand, while maintaining levels of function and comfort for electricity customers.
- Management of peak demand could help utilities lower their need for more expensive peaking power plants.

Here's How It Works:

Demand Optimization solutions empower utilities and consumers to make better energy decisions.

<table>
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<tr>
<th>GE Is Delivering the Future</th>
<th>How It Improves Your Performance</th>
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<tbody>
<tr>
<td>Automating demand response through utility management applications</td>
<td>Advanced decision support and visualization tools determine required demand reduction – how much load to shed, and for how long. Automating once-manual demand response processes in real-time helps maximize the economic benefit and improve power reliability for customers.</td>
</tr>
<tr>
<td>Predicting demand reduction potential with advanced network management systems</td>
<td>Intelligent, advanced network management applications will calculate real-time load demands and use customer behavior models to forecast demand-reduction for each demand response activity.</td>
</tr>
<tr>
<td>Empowering consumers with Home Energy Management (HEM) applications</td>
<td>Advanced home energy management applications, home-area-network-enabled appliances and smart energy panels will help consumers make informed decisions to manage energy consumption based on cost, comfort or both.</td>
</tr>
</tbody>
</table>

GE Smart Grid Value at Work

Consumers, utilities and the environment could all benefit from Demand Optimization results:

- Utilities should experience approximately 1.6% peak load reduction for a savings of $15 million a year in peak generating costs. ²,³
- Reductions in inefficiency and waste could contribute to environmental improvements by cutting annual CO₂ emissions by up to 58 thousand tons.
- A yearlong DOE study showed that smart grid consumers were able to save 10% on power bills and cut power usage 15% during peak hours with access to time-of-use pricing information - a critical component of demand-response applications. ⁴

² 20-year cost versus benefit per 1 million customers
³ O&M, avoided capital, revenue enhancement, includes loss of revenue
⁴ DOE Pacific Northwest Laboratory, GridWise project, January 9, 2008

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DMS/OMS – Distribution Management System/Outage Management System
Optimizing renewable integration and asset performance to increase productivity, uptime and cost-control

The Energy Challenge:

Distributed generation, demand response, microgrids and plug-in vehicles are adding complexity to our electrical network. Today's passive, top-down power distribution system needs to be replaced by active networks to accommodate multi-directional power flow and two-way communications.

• Utilities need new, radically different technology to view continuously changing distribution systems that are 1,000 times more complex and more dynamic than traditional real-time systems.

• This thousand-fold increase in datapoints and asset information could make asset management and decision making seemingly impossible.

• An increasingly complex grid with multi-directional power flow will need real-time communications and precise grid-wide control from a central location.

The GE Smart Solution:

Create a two-way, digital smart grid backbone that delivers understanding, decision support and control

DMS/OMS are smart grid automation technologies that provide real-time information about the distribution network and allow utilities to remotely control switches in the grid. Utilities can rely on DMS/OMS to:

• Manage outages and expedite restorations, delivering improved power reliability to customers.

• Improve operational efficiency by digitizing manual processes, integrating formerly discrete systems and empowering field crews with real-time information.

• Effectively integrate distributed generation — including renewables — by providing a real-time network view to better manage two-way power flow.

• Help automatically detect and isolate outages, restoring customers without operator intervention.
Here’s How It Works:
Distribution Management Systems/Outage Management Systems are the foundation for smart grid performance and benefits. Their system-wide intelligence, integration and functionality provide a single view and centralized management, maximizing performance across a smarter grid.

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<tr>
<th>What GE Delivers</th>
<th>How It Improves Your Performance</th>
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<tbody>
<tr>
<td>Outage Management</td>
<td>Outage Management Systems improve power reliability and customer service, reduce operating costs,</td>
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<td>prevent regulatory penalties and automate responses to incidents, such storm damage. Up-to-date</td>
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<tr>
<td></td>
<td>outage assessments and realistic restoration times also improve customer service.</td>
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<tr>
<td>Improved Reliability</td>
<td>DMS integrates with load-flow and fault-level analysis solutions in the control room to help</td>
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<td>prevent major unplanned outages, protect assets against failure and re-route power around</td>
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<td>outages. This also helps eliminate damaging media coverage associated with network problems.</td>
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<tr>
<td>Distributed Generation</td>
<td>Traditionally, electricity has flowed one way, from a power station to a customer. As more</td>
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<td>distributed generation comes online, power will be entering the network from multiple locations and</td>
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<td>traveling in multiple directions. DMS will provide live network information to help manage</td>
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<td>renewable energy distribution. It will also help utilities understand the actual energy flow from</td>
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<td>real-time generation, ensure local-generation voltage quality and minimize losses.</td>
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<td>Smart Crews/Field-Force Automation</td>
<td>Real-time communication between field staff and DMS makes crews more efficient, improves</td>
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<tr>
<td>Possibilities</td>
<td>customer service, reduces SAIDI, lowers phone costs and improves safety.</td>
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<tr>
<td>Automatic Fault Restoration</td>
<td>Integrating with automated network switching devices, the centralized system’s world view of</td>
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<td>distribution can automatically identify and restore faults, providing lower maintenance costs and</td>
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<td>higher return than traditional embedded automation.</td>
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GE Smart Grid Success in the Field:
GE’s DMS/OMS are installed at 69 utilities in 16 countries all over the world.

Our customers report outstanding results, realizing performance gains that make huge impacts on their business, including:
- Productivity increasing by up to 50%*
- Operating expenditures reduced by up to 40%*
- Improve performance by up to 25%*
- Typical payback within 12 months of purchase*

*Based on data from customers, consultants and legacy consolidation model.
Network Engineering and Mobile Workforce Management –
Designing, managing and maintaining the smart grid

The Energy Challenge:

Smart Grid technology has the potential to impact many, if not most, of a utility’s business processes. Its far-reaching effects include customer relationships and billing, power reliability and quality, grid security and critical infrastructure protection. Our 100-year-old network may be physically inadequate for the job.

- The public’s desire to increase renewable energy use and reduce fossil fuel consumption requires redesigning our power network to support this fundamental shift in generation sources. We need a retrofitted grid that supports distributed generation, as well as distributed storage.
- Increasing demand (expected to triple globally by 2050),
  rising fuel costs, mounting environmental concerns and restricted T&D expansion capacity will drive next-generation technology for more efficient network planning, design and asset management.
- The need to more efficiently maintain and extend the life of critical assets, coupled with increasing pressure to minimize environmental impact, necessitates a highly efficient mobile workforce. Equipping and optimizing this new type of field crew will significantly reduce fuel consumption and CO2 emissions.

The GE Smart Solution:

Geospatial applications will play significant roles in the smart grid – from system design and engineering, to managing the two-way communications network that enables grid advances

GE’s geospatial network engineering and mobile workforce management solutions are foundational elements of the smart grid. They address the smart grid’s emerging advanced network modeling requirements, including the growth of distributed generation, increased use of renewables and a tightly integrated, two-way communication infrastructure. GE’s geospatial solutions will enable utilities to cost-effectively enhance, refurbish and optimize the existing distribution network for the unique demands of the smart grid, supporting energy needs for the next 100 years.

GE’s mobile workforce management solutions put the right information at the fingertips of field crews, while offering utilities a 360-degree view of their mobile workforce effectiveness. A highly optimized crew scheduling system and tightly integrated applications suite enable mobile workers to address problems quickly and efficiently, with minimal back office support:

Smallworld Electric Office and Network Inventory – geospatial-based solutions for efficient design and management of complex electric networks and smart-grid communications infrastructure support.

MapFrame Mobile Solutions – mobile computing platform for automating field-based processes and enabling smart grid mobile applications.

Field Force Automation – scheduling and dispatching services for field-crew management and efficient work-order delivery.

Here’s How It Works:

Geospatial technology, coupled with mobile workforce management, will enable decision makers to see the “big picture” by presenting an accurate, detailed representation of the smart grid while efficiently directing mobile workforce operations.

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<th>What GE Delivers</th>
<th>How It Improves Your Performance</th>
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<td><strong>Smart Grid Network Management</strong></td>
<td>Engineering and design applications specially tailored to the unique requirements of the smart grid allow for optimized network configuration, advanced modeling of network assets and efficient enhancement of the existing network. Support for both the power delivery network and the two-way communication infrastructure enables utilities to accurately manage, optimally configure and efficiently support smart grid requirements around distributed generation, renewables and reduced environmental impact.</td>
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<td><strong>Mobile Applications</strong></td>
<td>Comprehensive, up-to-date information increases the efficiency and accuracy of field-based work, including inspections, audits, design, vegetation management and storm damage assessment. “Smart crews” will leverage enterprise data at their fingertips through secure communication to the back office. With tightly integrated applications, they will work closer to the customer and ensure the reliable and efficient operation of the network.</td>
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<td><strong>Workforce Management</strong></td>
<td>A highly efficient mobile workforce not only increases the reliability of the Smart Grid but will reduce the impact of the workforce on the environment. Accurate forecasting and optimized planning allows complex work to be completed more efficiently by ensuring the right people are assigned the right tasks and have the right tools.</td>
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GE Smart Grid Success in the Field:
Across the globe, more than 1,000 utility and telecommunications companies have deployed GE’s geospatial solutions to improve operational efficiency. More than 35,000 field workers are empowered with MapFrame Mobile Solutions in the United States, alone.

Here’s an example of GE GIS in action:

**Challenge:** After a devastating hurricane season, one of the largest US utilities faced a major challenge. Network data, which was the basis for many mission-critical operational systems, was incomplete due to major reconstruction.

**Solution:** To correct data inconsistencies, the utility implemented a Feeder Audit Inspection project with Smallworld™ as the data management solution and MapFrame as the mobile computing platform.

**Result:** The inspection audit was two-to-three times faster and more efficient than previous projects using a manual process.
Energy Management Systems (EMS) – Mission control for a smarter transmission grid

The Energy Challenge:

The power grid was designed and built to move electricity from static generation sources with predictable performance out to businesses and neighborhoods for delivery and consumption.

• While the level of automation in today’s transmission grid is quite extensive, the penetration level of renewable energy sources is still quite small.

• As the addition of renewable and distributed generation accelerates, transmission control and management will need to address a whole new set of operational issues.

The GE Smart Solution:

By rethinking the way we control and operate the grid, GE’s Energy Management System is helping reduce losses and relieve congestion in transmission systems.

GE’s Energy Management System (EMS) acts as the central nervous system for the transmission grid, giving users the ability to aggregate, manage, and dispatch power at the transmission level. It helps utilities:

• Choose the ideal, most affordable generation mix (known as economic dispatch), keeping costs lower for utilities and consumers.

• Reduce losses and waste in power delivery - driving a more efficient system.

• Maintain power reliability.

To effectively manage smart grid communications in the future, the next generation EMS will forecast renewable energy assets’ availability, while monitoring, controlling and optimizing their use in real-time. Unlocking the true value of these assets, while maintaining reliability of supply, will require significant innovations in modeling, forecasting and control.
GE Smart Grid Success in the Field:
Over 100 utilities serving 1.3 billion consumers currently rely on GE for EMS solutions:

- Installed on six continents, GE’s EMS controls some of the most densely populated locations on earth.
- With over five million online hours of operation in some of the world's most demanding environments, GE’s EMS provides exceptional reliability.

Here’s How It Works:
GE’s EMS systems will enable the smart grid to capitalize on the growth of renewable generation resources by leveraging experience in transmission intelligence.

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<tr>
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<tr>
<td>Renewable Energy Forecasting</td>
<td>GE is developing renewable energy forecasting technology that is commensurate with the accuracy of demand forecasting packages. This will help utilities cost effectively meet demand while maintaining adequate reserve margins.</td>
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<tr>
<td>Real-Time Data Aggregation, Monitoring &amp; Control</td>
<td>Large wind farms may consist of hundreds of individual turbines, and larger renewable owner/operators may operate many farms. Viewing and controlling these assets will require an EMS that can support high numbers of datapoints at high rates of speed. GE’s EMS is positioned to meet scalability challenges presented by renewable generation, with the proven ability to scale in excess of two million datapoints.</td>
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<tr>
<td>Advanced Modeling and Optimization</td>
<td>As new devices - such as energy-storage technologies - are added to the grid, GE’s EMS will help utilities dispatch and control them, while also assessing their impact on grid operation and stability. GE is working on advances in economic dispatch, automatic-generation control, power flow, contingency analysis and state estimation to accurately model new technologies.</td>
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<tr>
<td>Enhanced Simulation &amp; Training</td>
<td>GE’s Dispatcher Training Simulator is undergoing extensive enhancement to faithfully simulate renewable energy sources and associated energy storage devices. This enables trainees to understand their impact on the security and economic operation of the grid.</td>
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