


GE Energy

The Smart Grid

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The Smart Grid



POWERINGPOTENTIAL

GE imagination at work

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Agenda

- ✓ Smart Grid Drivers
- ✓ Smart Grid Perspective
- ✓ Highlights of Smart Grid Solutions

Think value proposition... not just technology




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The Power of Knowledge - Enabling the Smart Grid

Smart Grid Drivers



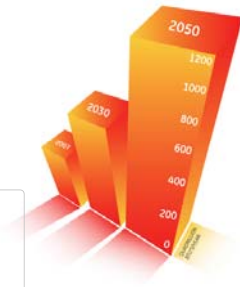
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Soaring Energy Demand

World energy consumption will triple in about 40 years



Utility Perspective

Demand optimization
Reducing demand through efficiency solutions

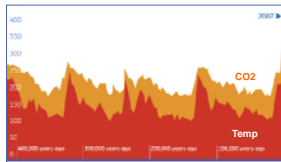


Source: U.S. Army Corps of Engineers ERDC/CERL TR-05-21

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Climate Change

Generation of electricity in US accounts for ~40% of CO2 emission



Utility Perspective

Environmental Responsibility
Reducing the carbon footprint ... critical to business sustainability and public image



Source: EPRI, "Electric Sector CO₂ Impacts, February 2007", Carbon
Climate Emissions from the Generation of Electric Power in the United States, July 2000, DOE

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Grid Reliability

Cost of power disturbances in US ~ \$100B a year



Power Outage after Hurricane Katrina

Utility Perspective

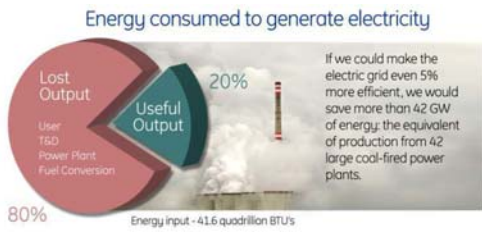
Enhanced reliability
Deploying technologies for automated system operation and outage response, as well as isolating effects of outages



Source: EPRI, Electricity Roadmap

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Grid Efficiency



Utility Perspective

Energy productivity

Enabling reduction in T&D losses, or otherwise optimizing supply resources



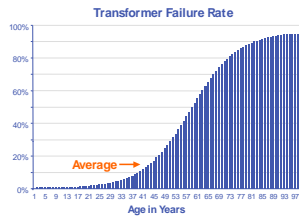
Source: Energy Information Administration & GE Estimates

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Aging Assets & Workforce

The average US transformer age is just under 40 years old

50% of US utility workers are within 7 years of retirement



Utility Perspective

Operational efficiency

Reducing O&M expense, more efficient deployment of capital & human resources, and increased productivity

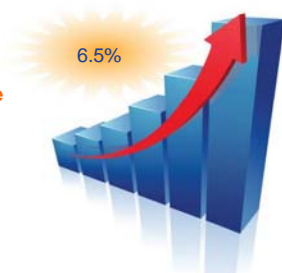


Source: William Barkley, P.E., Hartford Steam Boiler Inspection & Insurance

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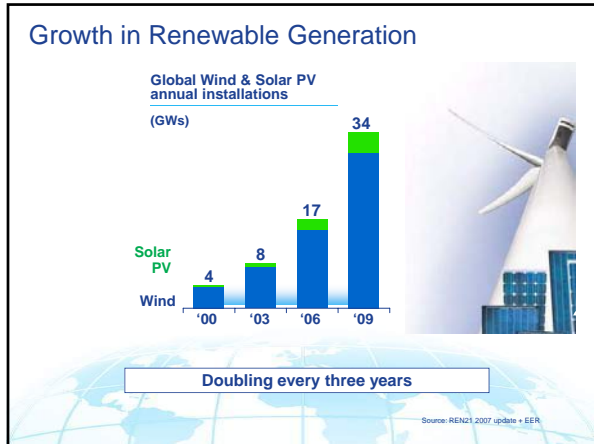
Electricity Prices on the Rise

U.S. sees 6.5% spike in '09 electric bills



Source: EIA (Energy Information Administration)

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Plug-In Hybrid Electric Vehicles (PHEVs)

The EV/PHEV is coming

EV/PHEV launches

- Nissan
- Toyota
- Ford
- Tesla 2007
- Chrysler
- Renault

Volt unveiled: GM has revealed what its new electric car will look like.

GE imagination at work

Empowering the Consumer

From paper payment requests

To interactive, decision-empowering tools

GE imagination at work

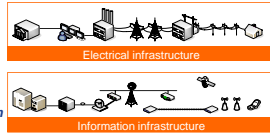
Smart Grid View

The integration of electrical and information infrastructures, and the incorporation of automation and information technologies with our existing electrical network.

Comprehensive solutions that:

- ✓ Improve the utility's power reliability, operational performance and overall productivity
- ✓ Deliver increases in energy efficiencies and decreases in carbon emissions
- ✓ Empower consumers to manage their energy usage and save money without compromising their lifestyle
- ✓ Optimize renewable energy integration and enabling broader penetration

That deliver meaningful, measurable and sustainable benefits to the utility, the consumer, the economy and the Environment.



More Focus on the Distribution System

A "Smarter" Grid



Old Grid

- You call when the power goes out. → Utility knows power is out and usually restores it automatically.
- Utility pays whatever it takes to meet peak demand. → Utility suppresses demand at peak. Lowers cost. Reduces RPEX.
- Difficult to manage high Wind and Solar penetration. → No problem with higher wind and solar penetration.
- Cannot manage distributed generation safely. → Can manage distributed generation safely.
- ~10% power loss in T&D → Power Loss reduced by 2+%. ... lowers emissions & customer bills.

Smart Grid

How is a Smart Grid Created?

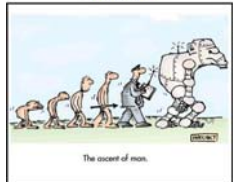
Not created all at once – will *evolve* over many years

Created through the incremental deployment and integration of *system intelligence*

Intelligent systems deployed to meet specific business and regulatory *drivers*

Each utility has

- Different starting points
- Different drivers
- Different paths
- Different deployment rates



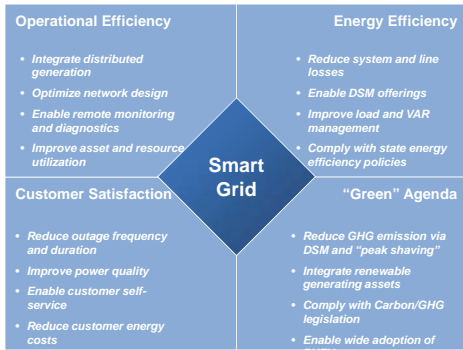
How is the Smart Grid Approach Different?

- It is a **journey, not a single destination** - not an off-the shelf product, or something you install and turn on the next day
- **It is not a one-time solution** – it is a change in how utilities look at a set of technologies that can enable both strategic and operational processes.
- It is an **integrated solution** based on **open architectures**
- **Not one specific technology enabler** - not necessarily a single vendor solution
- **Builds on the existing infrastructure**
- Provides a **greater level of integration at the enterprise level**
- Has a **long-term and wide-scale deployment focus.**
- It is the means to **leverage synergies and benefits across applications** and remove the barrier of silos of organizational thinking.
- Based on
 - a systematic approach to understand utility business & operating issues...what are the drivers for change?
 - Economic evaluation (cost/benefits analysis) of solutions that have the highest impact to address issues and implement change
 - A **roadmap** of enabling technologies



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Smart Grid Benefits



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SG Solutions Should Align with Utility Business Drivers

Business Focus

- Maintaining **low customer bills** above all else (e.g. regulators, conservative utilities)
- Secure the **green image** of the state or service territory (e.g. legislators in "progressive" states)
- Improve **reliability** performance (e.g. regulators and utilities in areas with poor reliability scores)

Smart Grid Solutions

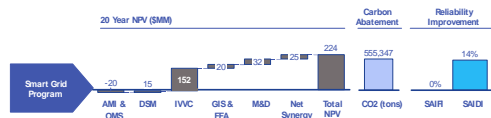
- **Reduced O&M** through lower meter related and outage costs
- **Reduced cost of energy** through DSM and IVVC
- **Reduced capex** through Asset management, DSM and IVVC
- **Lower carbon emissions** through reduced energy consumption and field force drive time, via DSM, IVVC, AMI and FDIR
- **Renewables integration** facilitated by DSM and DER to help with intermittency
- **Solar PV and plug in hybrids** facilitated by AMI and feeder automation
- **Significant SAIFI and SAIDI improvement** through AMI, FDIR, integrated OMS and FFA
- **Improved power quality** facilitating increasingly digital economy
- Ongoing **Asset Management** will further improve reliability
- **Improved customer service** through billing accuracy and reduced outages



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The Need for a Business Case

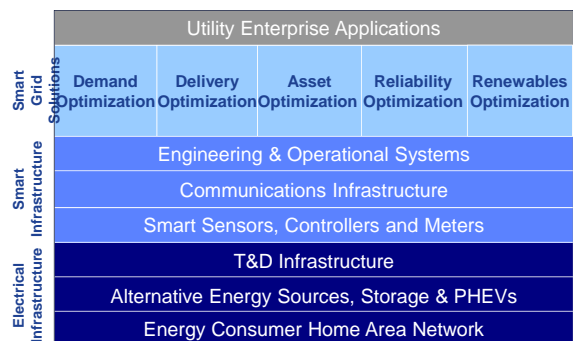
- Business case support for stimulus funding proposals and rate filings
- Tool to identify the best scenario aligned with your business objectives & priorities
- Identify shovel-ready solutions for immediate SG deployment
- Tied with integrated SG program and roadmap for successful, long-term deployment

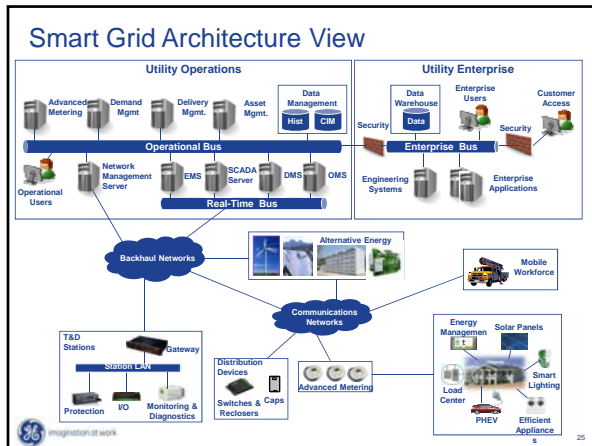


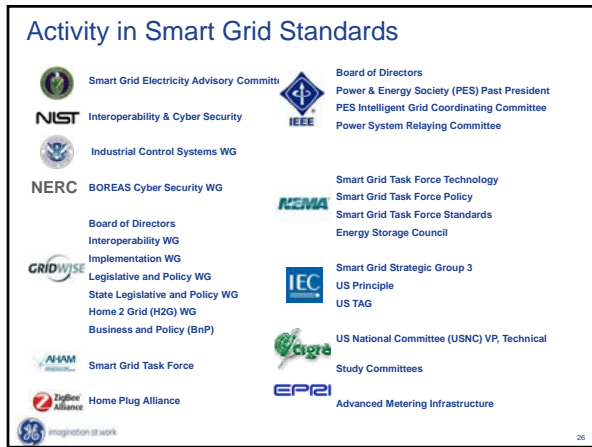
Hurdles to Smart Grid Widespread Adoption

- ✓ Lack of comprehensive, long-term and integrated Smart Grid strategies and roadmaps tied to quantifiable benefits
- ✓ Substantial capital investment required up front
- ✓ Regulatory structures that do not fully recognize the benefits of smart grid technologies (e.g., decoupled rates)
- ✓ Utility business models that minimize risk and ties returns to electricity revenue
- ✓ Interoperability and the need for faster, more comprehensive development of standards, including physical and cyber security
- ✓ The need to move away from isolated pilots from "testing" to "phased deployments" on a larger scale ("city-scale")
- ✓ Availability and capability of smart grid educational tools for policymakers, regulators and consumers to change thinking and attitude to smart grid technologies

Smart Grid Framework







**The Power of Knowledge
Enabling the Smart Grid**

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Highlights of Smart Grid Solutions

Elements of Today's Smart Grid

Offerings	Customer Benefits	Future Enablers
Grid-Friendly Renewables	<ul style="list-style-type: none"> Controllability: Ramp, curtail... Reduced uncertainty: forecasting efficiency System reliability 	<ul style="list-style-type: none"> Stronger tie with utility EMS Coordination with DER & loads
Grid Control Systems	<ul style="list-style-type: none"> Modular/standard Less cost, time, risk 	<ul style="list-style-type: none"> IEC 61850 Compliant Open architecture
Substation Digitization	<ul style="list-style-type: none"> Performance monitoring Control devices 	<ul style="list-style-type: none"> Standards based IEC 61850 compliant
Intelligent Electronics	<ul style="list-style-type: none"> Asset protection Life extension 	<ul style="list-style-type: none"> Progressive offering Long term services
Monitoring & Diagnostics	<ul style="list-style-type: none"> Performance visibility Remote control 	<ul style="list-style-type: none"> Seamless NMS, Security Multi-applications
Communications Infrastructure	<ul style="list-style-type: none"> Customer billing Demand management 	<ul style="list-style-type: none"> Software upgradeable
Smart Metering	<ul style="list-style-type: none"> Participation in DR programs Utility bill savings 	<ul style="list-style-type: none"> Standards based Software upgradeable
Smart Appliances & Home Controls		

Smart Grid Initial Core Focus

	What it is	Why	Utility Value*
Demand optimization	Manage peak via control of power consumption	Defer upgrades, optimize generation & renewables	\$15MM/yr*** 58K tons of CO2 reduction Res consumer savings up to 10%
Delivery optimization	Reduce delivery losses in distribution systems	Less energy waste and higher profit margins	\$27MM/yr*** 29K tons of CO2 reduction
Asset optimization	Prognostics for proactive equipment maintenance	Reduced outages and focused maintainers	\$12MM/yr ~3.5 yr ROI
Grid Reliability optimization	Wide Area Protection & Control	Increased network performance & reliability	\$21MM/yr Based on a 4hr blackout per year of a transmission utility
Renewables optimization	Use of Forecasting & Smoothing	Compensation for production variability	Key step for meeting RPS targets, especially in areas with weak grids

*Utility savings are approximate annual savings per MM customers
**90% peak load reduction
***Based on 4-20% kWh peak load reduction

The Smart Meter, a Smart Grid Enabler

- Multiple tariff structures, real-time usage and historical usage available in real-time to the customer
- Voltage, Load Profile, Outage, Power Quality all available to support grid optimization
- Conduit for Demand Response and Load Control for Energy Efficiency
- Service Switch for advanced services:
 - Prepayment
 - Demand limiting
 - Outage restoration
 - Cold load pick-up



Leveraging Communications

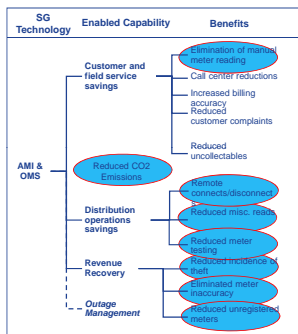
Many Possible Passengers:

- Distribution Automation
- Distribution Substations
- Automatic Reclosers
- Remote Switches
- Distribution Capacitors
- Fault Detectors
- Street Lights



Share the infrastructure
reduce costs

AMI Benefits



Delivery Optimization

Capability Today

Volt/VAR Control

- Decentralized Volt/VAR control

- Centralized Volt/VAR control
 - Conservation voltage reduction
 - Line-loss minimization
- Use of DG resources for Volt/VAR control

Voltage Sensing

- Voltage regulator controller
- Recloser controller
- Meters (end-of-line)

- Voltage regulator controller
- Recloser controller
- Meters (end-of-line)
- Cap bank control
- PT's and CT's

Communications

- 900 MHz Spread spectrum (MDS)
- Fiber
- Cell networks

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- AMI network

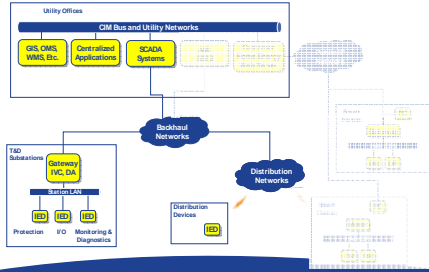
Key Challenges

- Value proposition quantification (distribution system modeling and simulation capability need)
- Meeting targets under load uncertainty
- Quantifying impact of renewables

- Cost
- Quantifying value of AMI voltage feedback

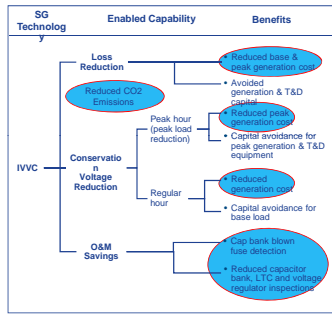
- Cost
- Lack of standards
- Prioritization of real-time vs non-operational data
- Use of bandwidth on AMI networks

Delivery Optimization – Efficiency (IVVC)

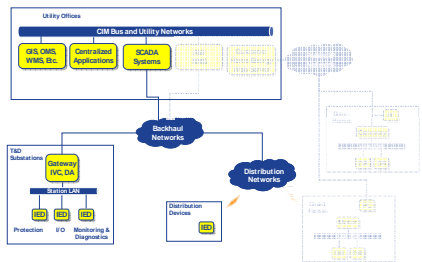


Voltage Control & Loss Reduction: Optimized control of distribution capacitor banks and voltage regulators/load tapchangers to improve the power factor to reduce system losses and to control voltage to improve load management.

IVVC Benefits

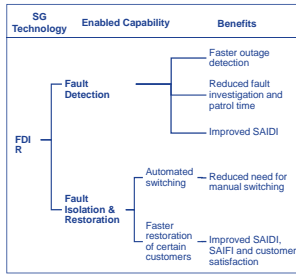


Delivery Optimization – Reliability



Remote Control and Automation: Optimized control of substation and distribution devices to improve customer service and improve system reliability by reducing outage times.

Reliability Benefits



Asset Optimization

Capability Today

Monitoring

- Separate, function-specific M&D devices (H2, H2O, Multigas...)
- Devices that monitor and allow some control (LTC...)
- Use of third party technology where needed

Diagnostics

- Embedded operational diagnostics
- Diagnostic Models
- DGA interpretation
- Off-line test interpretation

Prognostics

- Operational level 'next steps' when alarms are reported
- Need SME to evaluate all data to arrive at a health & risk index

Target Capability

- Modular M&D devices build into a single solution
- Specific solutions based on type of transformer
- Develop functions not covered today (bushings)

- Embedded operational diagnostics
- Update embedded models
- DGA interpretation
- Off-line test interpretation

- Automated health and risk indices computation
- Behavioral analysis to detect changes
- Automated reporting
- Alarm functions with recommended next steps, based on health and risk indices

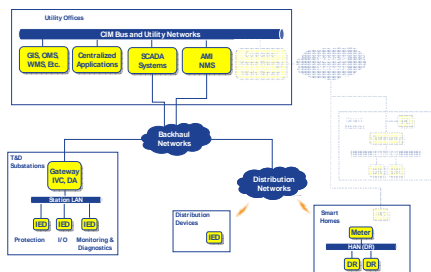
Key Challenges

- Integration of legacy M&D devices
- New M&D Platform to include functions not offered today

- Cost effective solutions,
- Turn key install & commissioning of M&D devices
- Rules building and testing

- Cost
- SME time and talent
- Economic model to apply to different applications
- Behavioral analysis engine

Transformer Asset Optimization



- Asset Management's main benefit lies in reduced maintenance spend and early detection of incipient failure
- Asset Management's has added benefit of reduced black-out probability and improved asset life expectancy

Transformer M&D Benefits

SG Technology	Enabled Capability	Benefits
M&D	Condition based inspection	Reduced inspection cost
	Condition based maintenance	Reduced maintenance cost
	Early detection of failures	Reduced corrective maintenance cost
		Reduced blackout probability
	Loss revenue during blackout	
Improved asset life	Less capital spending	
Improved system throughput	Improved power sales	

Demand Optimization

Capability Today

Challenges

Response

- Several in development

AMI/Communications

- Smart Meters
- WiMAX (MDS, GridNET)
- 900 MHz Mesh (SSN)
- BPL

Responsive Load

- Solar PV
- Smart appliances

Target Capability

- Dynamic Pricing: TOU, CPP, RTP
- Direct Load Control
- Load aggregation
- Dynamic resource (renewable-following capability)
- Ancillary Services
- Demand Dispatch

- Smart Meters
- WiMAX (MDS, GridNET)
- 900 MHz Mesh (SSN)
- BPL
- DSL & Cable

- Solar PV
- Home energy management
- Smart thermostats, appliances
- Intelligent Load Panel
- Storage management (PHEV)

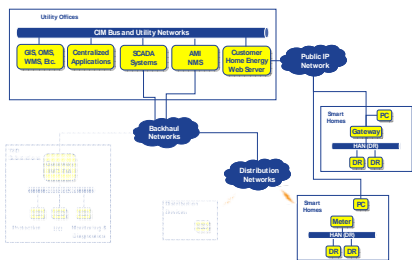
Key

- Optimal supply/demand balance
- Baselines and verification
- Data management, aggregation, disaggregation
- Bandwidth, latency
- Interfacing with utility control platforms
- Uncertain tariff and market structures

- Bandwidth vs capability
- Security Standards
- Infrastructure not deployed

- Cost
- User Acceptance
- Demand response forecasting
- Persistence in usage
- Standards

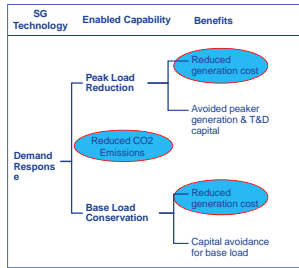
Demand Optimization



Demand Response provides the means to reduce system load by:

- Direct control (turn-off) of customer load (such as air-conditioners) during peak system load periods, or by changing demand response behavior by applying Time of Use (TOU) rates and Critical Peak Pricing (CPP), where different energy charges are set based on periods of peak and base load

Demand Response Benefits



The Future Home ...



Demand Optimization – Various Capabilities

(Demand Response, Customer Choice, Distributed Resource Management)

Customer Choice & Control

- Multiple Rate Choices
- Critical Peak Pricing
- Time of Use Rate
- Green Power Choices
- CO₂ Management Choices
- Prepaid Metering
- Voluntary or Automatic Control
- Usage Management – by Appliance
- Home Energy Management
- Net Metering – KWH, KVH, Voltage, PQ

Security & Safety Management

- Energy Theft
- Tamper Detection
- Visual inspection during installation
- Monitoring and baselining
- Interruptions and usage pattern changes
- Detect voltage on load with disconnect

Distributed Generation

- PV
- Wind
- BioMass
- Geothermal

Distributed Storage

- Li-Ion Battery
- Fuel Cells

Enabling New Programs

- Load Management Programs
- Distributed Generation
- Storage Management
- Automatic Meter Reading
- New Communications with Customer
- Power Quality Management
- Remote Service Switch
- Cold Load Pickup
- System Cyber Security
- System Management
