Electricity Value Network

Digital Solutions for Power & Utilities

GE Digital
Industry In Transition

The electricity industry is undergoing a transformation. This 100+ year old linear model of electricity is being challenged, tested, connected and recreated as the rules of electrification are shifting with wide-reaching impact. Complex interrelationships across the entire energy ecosystem call on power leaders to understand the impacts of these changes. Distributed generation, renewables, smart grids, storage and prosumers are accelerating the rate of change. By embracing digitalization, companies can apply unprecedented insights, new capabilities and innovative business models to capture enormous opportunities.

5 Billion
internet users
2020
Source: The Future of the Internet — 7 Big Predictions of 2020, Dospeedtest.com

3 Trillion
IP devices
2030
Source: Cisco (500 Billion by 2020) and Morgan Stanley (75 Billion by 2020), GE Estimate

400 Million
electric cars
2040

50% reduction in CO2
2050
Source: European Commission — Climate Action

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Digital Transformation of Electricity Through 2025

$1.3T
Industry Value from:
- Service platforms
- Smart devices
- The ‘cloud’
- Advanced analytics

$387B
Asset Performance Management
Value from:
- Lower repair & maintenance costs
- Lower downtime of assets
- Fewer critical breakdowns

$2+T
Societal Benefits from:
- Reduction in carbon emissions
- Net new job creation
- Value creation for consumers

Top 10 Digital Trends

1. IMPACT OF RENEWABLES AND DISTRIBUTED ENERGY RESOURCES (DER)
   As more utility-scale wind and solar reach grid parity, the industry must aggressively adopt digital technology to become more efficient, flexible and compliant with environmental regulations.1

2. ARTIFICIAL INTELLIGENCE (AI)
   We will see a growing number of innovative applications of AI for the energy industry, from autonomous drones capable of inspecting and analyzing remote transmission assets to predicting equipment problems that prevent unplanned downtime.

3. DISRUPTIVE CYBERATTACKS
   Escalating cyber attacks, together with the increase in number of IP-enabled edge connected devices, will necessitate adoption of even more robust and extensive cyber security solutions.

4. MULTI-DIRECTIONAL IS THE NEW GRID
   The future will increasingly be defined by digitally-enabled, intelligent grid technology, multi-directional power flows and higher quality power.

5. THE PROSUMER WAVE
   Prosumers are starting to shape the power industry in transformative ways, requiring energy providers to use analytics and digital platforms to forecast usage, predict and manage two-way grid flows and deliver well-designed mobile customer experiences.

6. CIO ROLES TRANSFORM
   “CIOs are playing an increasingly central role in both OT and IT as utilities are undergoing digital transformation by leveraging IoT to integrate people, business and things,” according to Gartner. New Chief Digital Officer (CDO) and Chief Transformational Officer (CTO) roles are also driving digitalization.4

7. CLOUD + EDGE IS THE NEXT IMPERATIVE
   Cloud + Edge provides powerful, step-function advantages over existing IT/OT infrastructures, including greater speed, end-to-end security, lower costs, better performance, reliability, ability to scale and global visibility across geographies and assets.3

8. THE TALENT CHALLENGE
   Digitalization, mobile, wearable devices and analytics will increase the productivity of energy workers while capturing and augmenting the knowledge of a rapidly retiring workforce.8

9. THE PLATFORM ECONOMY
   The power industry will increasingly be defined by digital platforms that developers and companies use to scale collaboration, rapidly build capabilities that address a huge number of challenges and drive new value creation.5, 6

10. NEW BUSINESS MODELS
    Power and utility companies are increasingly using digitalization to change their business models to compete in a rapidly changing power market driven by distributed generation, renewables, smart grids, storage, digitalization, non-traditional competitors and prosumers.

“Utilities’ traditional business models are under attack, directly and indirectly. Utilities are racing to reinvent their roles and have started a profound transformation journey. The industry will be reborn in 3D: decentralized, divergent, and digital.”

— Roberta Bigliani, IDC Energy Insights

FOOTNOTES:
3 Industrial Internet Report for 2015, GE and Accenture.
4 U.S. Senate Committee on Energy & Natural Resources.
5 Platform Economy: Technology-driven Business Model Change from the Outside In, Accenture 2016.
Our Commitment
GE is committed and uniquely positioned to support our customers through a period of unprecedented industry transformation with the following beliefs:

- Access to electricity is a basic human right; every person needs power that is **affordable**, **reliable**, and **more sustainable**.
- Navigating a changing industry requires an understanding across the entire EVN.
- No single technology is the answer. Instead, a broad combination of solutions is needed, based on resource availability, distribution systems, regional dynamics, and customer needs.
- GE’s installed base and new grid, plant and system investments, with digital as a key enabler, will drive tremendous value for our customers.

*Predix is a trademark of General Electric Company.*
Digitalization Yields Benefits Across the EVN

CROSS EVN BENEFITS

Asset Performance Management: Up to 5% reduction in unplanned downtime; 15% increased asset utilization (T&D grid)

Cyber: From avoidance of $1MM per NERC infraction to millions per day in lost production from catastrophic cyber event

Predix: Up to 15% IT cost reduction; up to 30% application acceleration; millions in benefits from cross-EVN data sharing

Digital Worker: Up to 8% reduction in service costs

REAL CUSTOMER RESULTS*

FOSSIL
3% increased fuel efficiency
10% increase in output capacity
3%–4% emissions reduction

NUCLEAR
Up to $2K/MW annual O&M reduction

RENEWABLE ENERGY
10% reduction in O&M cost
8% increase in production

TRANSMISSION & DISTRIBUTION
33% reduction in system interruption
20%+ increased carrying capacity of networks

COMMERCIAL AND INDUSTRIAL CUSTOMERS
Up to 10%–20% reduction overall energy consumption
Up to 70% reduction in lighting costs
GE Digital Solutions

Business Optimization
- Deeper Insights
- Profitability

Operations Optimization
- Better, Faster Decisions
- Productivity

Asset Performance Management
- Real-Time Actions
- Reliability

Digital Worker
- Better, Faster Decisions

Cyber Security

PREDIX

GE Digital Solutions Ecosystem

Generation & Renewable Energy
- Trading
- Grids
- Commercial & Industrial Customers
  - Digital Demand Response
  - Storage Management
  - Intelligent Environments

Microgrids

Virtual Power Plant (VPP)

Business Optimization
- Portfolio Management
- Financial Performance
- Business Communications

Operations Optimization
- Asset Performance Management (APM)
- Security
- Data Capture, Processing & Management

Asset Performance Management (APM)
- Machine & Equipment Health
- Reliability Management
- Asset Strategy Optimization
- Compliance & Integrity Management

Cyber Security
- Security Assessment
- Network Segmentation
- Security Patch Management
- Cyber Asset Protection

PREDIX
- Data Capture, Processing & Management
- Predix Edge
- Analytics Catalog
- Digital Team

Digital Worker
- Mobile Field Service Management
- Parts Management
- Shop Management
- Work Order Management
- Metrics and Reporting & Dashboards

40 new Predix customers

A2A
AES
BC Hydro
Bord Gais
Competitive Power Ventures
Duke Energy
Dynegy
EDF Energy
Engie
E.On
Exelon
Gas Natural Fenosa
General Electric Company of Libya
GMR Power Corporation
Halmore Power
Salt River Project
Sapphire
Sahdai Electricity Company
Sembcorp Fujairah
SSE
Star Buck Power Corporation
Tennessee Valley Authority
PSEG
RasGas
SAB
PSE
Gas Natural Fenosa
General Electric Company of Libya
GMR Power Corporation
Halmore Power
Salt River Project
Sapphire
Sahdai Electricity Company
Sembcorp Fujairah
SSE
Star Buck Power Corporation
Tennessee Valley Authority

Development plans are not guarantees of future solution availability.
"All the operational data goes directly into Predix. By collecting all the data in the GE hosted Predix cloud — instead of spread across many systems — it can be brought together for analysis and machine learning."

— Brian Hoff, Director of Innovation at Exelon

**Exelon**

*Predix application implementation*

**38 GW** of power plants in 48 states and Canada

**Deployed** across fossil, nuclear, wind and solar plants

**20,000+** registered base of Predix developers

**400+** partners

**$60 Trillion** investment in IoT in next 15 years

**The Predix Cloud**

Integrates data from nearly **2 MM smart meters** more than 5,000 relays, 2,000 routers and 30 different OT/IT and legacy systems to a single platform

“...instead of spread across many systems — it can be brought together for analysis and machine learning...”

— Brian Hoff, Director of Innovation at Exelon
A Digital Twin is a digital replica of any industrial asset — like a gas or wind turbine that is used to monitor, analyze and improve its performance.

A Digital Twin continuously collects sensor data on the asset and applies advanced analytics and self-learning AI to gain unique insights about its performance and operation. Self-learning techniques ensure more refined model accuracy the more they are used.

Digital Twins predict and respond to any customer problem and improve the operational and financial performance of an asset, plant or fleet.
Asset Performance Management
Increase asset reliability and availability while reducing maintenance cost

APM CAPABILITY — COMBINED CYCLE GAS TURBINE PLANT

Today GE’s APM analytics provide 65% coverage of the most critical NERC failure modes with a goal of 100% coverage of critical failures by 2018.

APM FOR GAS/STEAM
+10% starting reliability
+3% total plant availability

APM FOR RENEWABLES
+1.5% site/farm availability
-5% maintenance cost

APM FOR GRID
+15% asset utilization

Plants utilizing APM are more reliable and have fewer annual unplanned outage hours than plants without APM. (Source: 2015 ORAP Data)

“IT is critical for Whitegate, which provides electricity to up to 10% of Ireland’s households, to be available for power generation when called upon by the national grid. GE’s new software technology is an ideal solution to help increase our plant’s reliability and availability, while making the most of our planned maintenance outages.”

— Rory Griffin, Operations Engineer — Whitegate, Asset Operations, Bord Gáis Energy
Operations Optimization
Driving the most profitable use of resources for market conditions

Operations Optimization

Generation
- Efficiency
- Flexibility
- Availability
- Capacity
- Emissions

Grid
- Grid Optimization
- Grid Stability Management System

Commercial & Industrial Business
- Prosumer Optimization
- Building Energy Management System

Substation
- Nuclear
- Wind
- Hydro
- Gas
- Steam
- Solar

Distribution
- Transmission
- Marketing
- Operations

Prosumer
- Nuclear
- Wind
- Hydro
- Gas
- Steam
- Solar

Transmission
- Grid Energy Management System
- DFR Integration (EIM)

With sophisticated analytics and optimization software, power leaders now have the ability to balance trade-offs in real time.

“Operations Optimization provides us with visibility and the insights to our KPIs and allows us to look at the actions that will improve performance at lower costs.”

— Richard Lopriore, President of Fossil Generation, PSEG

Business Optimization
Linking energy operations with energy trading

Business Optimization

Generation
- Nuclear
- Wind
- Hydro
- Gas
- Steam
- Solar

Grid
- Grid Optimization
- Grid Stability Management System
- DFR Integration (EIM)

Commercial & Industrial Business
- Prosumer Optimization
- Building Energy Management System

Portfolio Optimization
- Market Intelligence & Forecasting
- Financial Performance

INPUTS
- Demand
- Generation
- Contracts
- Transmission Limits
- Market Prices
- Market Conditions

OUTPUTS
- Financials
- Physical Data

Portfolios, Settlements
Communication with Third Parties and ISO

Increase annual AEP by 10%
Cyber Security
Protecting critical assets and operations

Baseline
Immediately identify security issues that can impact operations, even if the environment is thought to be "air gapped."

Protect
Implement security monitoring and defensive layers to comply with standards and strengthen the security posture.

Prevent
Pursue proactive and predictive security measures such as running attack scenarios on cloud-collected data. "Digital twins" can replicate operating environments and simulate defenses to measure threat impact and improve security.

Why Cyber Security Now?
- Unplanned outages/trips cost ~$500K a day on average (modeled on 500MW Block)
- In the Ukraine, 225K people lost power due to cyber attack in December 2015 — and again in December 2016
- NERC CIP carries $1M per day fine for security compliance violation

Results of GE Assessments Performed for Power Generation
96% at least one system with a vulnerable OS
92% at least one system with an expired end-point solution
88% user access practices that do not align to industry best practices
96% at least one "dual-homed" systems (circumventing firewall)
8% at least one system where malware has been detected
0% effective Cyber Security monitoring
12+ years longest duration since administrator password changed

64% of power and utilities executives believe that their security strategy is not aligned with today's risk environment. (Source: Ernst & Young)
Digital Worker

Digital technologies will augment the abilities and power of workers of every skill level

- 18% increase in technician productivity
- 8% reduction in services costs
- 13% reduction in the time it takes to repair equipment
- 13% increase in service revenue

Digital workers must be enabled with the most efficient device for their role.

NAMED A LEADER
FOR FIELD SERVICE MANAGEMENT

2016 GARTNER MAGIC QUADRANT
Create a More Strategic Capital Allocation Approach

**Asset Management and Operations Insights** — Improve measurement and forecast of current and future load, asset health, criticality, life and performance leveraging data insights.

**Financial Trends and Forecasting** — Utilize digitalization to ensure greater forecasting accuracy by leveraging new and multiple data sources to understand and optimize upstream supply, market, and internal financial scenarios.

**Customer Intelligence and Service** — Understand the specific needs and demands of customers across the system through use of distribution-level and customer-site data.

**Regulation and Compliance** — Create flexible scenario planning with digitalization around legislation and regulations, (environmental, cyber security, etc.) that could affect new and existing infrastructure, as well as the development of new business models and service offerings.

**Cloud Computing** — By leveraging cloud technologies and data management, capital planning for the entire EVN can be accomplished with a common data source.

**New Business Models** — Transitioning business models can signify significant changes in asset planning, capitalization, depreciation and retirement. The ability to study the impact of these changing models across EVN assets provides a more refined assessment of new model impacts.

**DIGITALIZATION ENHANCES CAPITAL PLANNING**

From every point along the Electricity Value Network — machine sensor data is captured to contribute to capital planning success.
Digital Transformation

A digital transformation requires a vision, strategy, and roadmap that is aligned with long-term business goals and metrics. Success will be determined by the ability to set a strategy, deliver results, cultivate partnerships, transform culture, and capture growth opportunities.

- **Strategy Is Paramount** — Establish a vision, assess the environment, understand your capabilities, and define the metrics for success.
- **Early Wins Deliver** — Drive productivity in existing operations and build support and credibility across the organization.
- **Partnerships Are a Force Multiplier** — Expand the view and nature of partnerships to accelerate the transformation internally and externally.
- **Transformation Must Be Intentional** — Transformation is complex. It requires change across people, process and technology.
- **Digital Is a Growth Multiplier** — Digitalization enables new business models that take advantage of emerging value creation opportunities for your operations and customers.

GE Digital Professional Services Ensure a Successful Transformation

**STRATEGIC PROJECT SERVICES**
Guidance for new revenue opportunities

**DELIVERY SERVICES**
Speed time to value with rapid installations

**SUPPORT SERVICES**
Monitor and respond to minimize production impact

**DESIGN THINKING**
Create modern and solid system architectures and UI

**MANAGED SERVICES**
Operate with integrity and transparency

**EDUCATION SERVICES**
Train and coach toward independent operations

China Datang Group will implement China’s first and most advanced Monitoring and Diagnostic Centre, co-developed with GE Power Digital Solutions, which will help increase plant performance and reduce maintenance cost through big data analytics. This represents an intelligent digital hub servicing the entire Asia-Pacific region and will be the cornerstone for Chinese power groups to begin their digital transformation.
The GE Ecosystem: 400+ Partners Signed and Growing

GE Digital has joined forces with other industry leaders and innovators to build a powerful ecosystem of companies committed to advancing the new digital industrial era.
New Utility Business Models

As power and utility companies seek growth opportunities, they are increasingly investing in, testing, and launching digitally-driven and digitally-enabled business models to tap new sources of value for customers, grid operators, and others across the ecosystem.

ENERGY RESOURCES

Digital Power Plants, Renewables, Energy Storage, Distributed Generation

New and legacy energy resources utilize digital solutions to monitor and manage assets, drive new operating efficiencies, and optimize value creation opportunities.

ENERGY CONNECTIVITY

Virtual Power Plants (VPP), Microgrids, Distributed Energy Resource Management Systems (DERM), Blockchain Technology

Digital solutions are enabling the aggregation of resources, the connectivity of systems and collaboration across the grid, as well as new transaction mechanisms both centrally and at the edge, to drive value across the ecosystem.

COMMERCIAL AND INDUSTRIAL BUSINESS

Energy Efficiency, Mobility Services, Smart Cities, Retail Marketplaces, Community Energy, Intelligent Environments

Power and utility customers are leveraging digital solutions for new businesses and solutions that extend beyond traditional energy services for commercial and industrial customers.
Dynegy is always looking for ways to economically increase output, reliability and efficiency at our power stations while upholding our commitment to safety and environmental responsibility. Through our collaboration with GE, Dynegy is upgrading four of our facilities with some of the latest technologies to achieve these goals.

— Marty Daley, Executive Vice President, Dynegy

“By working with GE to increase the flexibility and efficiency of our power plants at EGAT North and South Bangkok, we are strengthening power security for our country in the event of different gas compositions (WOBBE INDEX) while also improving air quality and reducing fuel consumption.”

— Mr. Charin Kanjanarat, EGAT Assistant Governor

Digitalization Drives Powerful Eco Results

- 3% reduction in CO₂ emissions
- 40% reduction in start-up fuel consumption
- 3% increase in fuel efficiency
- 10% NOx reduction
- 20% hidden transmission capacity optimization — avoid costs of new lines
- 25% decrease in renewable curtailment resulting in less CO₂ emissions
- 1% efficiency improvement at thermal plants reduces CO₂ emissions 2–3%
- 3% reduction in CO₂ emissions
- 40% reduction in start-up fuel consumption
- 3% increase in fuel efficiency
- 10% NOx reduction

Applied to global thermal fleet, this equals offsetting of ~50K wind turbines

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This digital solutions platform supports our primary mission to provide customers with low-cost, clean, reliable power with the industry-leading energy infrastructure and services they value.”

— Gil C. Quiniones, President and Chief Executive Officer, NYPA

“As the only Fortune 100 company in the electricity sector, we have a unique opportunity to lead the energy industry in the exploration, development and deployment of the next generation of clean, diverse energy technologies.”

— Chris Crane, President and Chief Executive Officer, Exelon
Leadership To Help Drive Your Digital Transformation

Steve Martin
CDO — GE Power

Sanjeev Addala
CDO — Renewable Energy

Bill Ruh
CEO — GE Digital

“Our foundries bring together power and utility innovators with GE digital engineers, data scientists and design experts to bring their vision of digital transformation to life. It’s at these collaboration centers where the work is done to blueprint the path to business success with Predix.”

— Bill Ruh, Chief Executive Officer, GE Digital