Transforming Utility Grid Operations with the Internet of Things

Access key process data in real time to increase situational awareness of grid operations.

Challenging Times
It's not an easy time for utility companies as they face falling revenues, rising infrastructure costs, and increasing risk of outages caused by inconsistent energy production from renewable sources. Less money is coming in as more people and organizations take steps to curb their energy use. Utilities are paying more to maintain and build infrastructure due to increasing complexity, resulting from the rising number of intermittent and variable renewable energy sources connected in the distribution grid. A growing dependency on static energy sources (renewable with inverters) makes it harder to plan contingencies compared to traditional dynamic energy sources with rotating electric generators.

Improving Grid Infrastructure
These factors, and others, are disruptive forces on the operation of the grid and long-established utility business models, as depicted in Figure 1. Addressing the escalating grid complexity with traditional "copper" solutions (more electrical equipment, concrete walls, etc.) is not sufficient, because many of the operational problems are rooted in a lack of information. For example, grid stability could be enhanced with a data-driven transformation of key processes, such as real-time monitoring, predictive maintenance, and knowledge management.

Utilities would also benefit from improved situational awareness pertaining to distributed energy production, flexible consumption, and infrastructure health, allowing them to operate closer to the margin, and anticipate and react to network faults. Such steps would enable utilities to "do more with less," thereby avoiding new infrastructure investment.
A new approach is required for operational technology. It is based on the Internet of Things (IoT), which enables an operational system that provides accurate and useful information to support real-time decision making. The IoT connects field sensors, devices, equipment, and field workers (the “things”) to the enterprise environment in a flexible, secure, and cost-effective manner. To accelerate the adoption of IoT in various industries, such as electric power, Intel is working with manufacturers and systems integrators who are uniquely qualified to enable IoT solutions. From edge devices to cloud-based applications, their solutions collect both operational and non-operational data into a big data architecture that serves the needs of grid operators, utility planners, and asset managers.

**Solution for 21st Energy Infrastructure**

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**Putting Data to Work**

IoT solutions take full advantage of IT standards for scalability and security while providing the data needed to increase the efficiency and predictability of the grid. They enable utilities to collect and make use of different types of data, including:

- **Asset Health/Life Cycle Data** – ensure grid and equipment are operating at peak efficiency.
- **Customer Usage Data** – improve energy balancing with a very granular understanding of peak energy usage even as consumption per household is no longer uniform.

The growing popularity of electric cars, solar panels, demand response, etc. makes it imperative to measure time-of-day usage per home.

**Transforming Energy Infrastructure**

The higher level of connectedness and data-driven operations enabled by IoT solutions delivers benefits in a number of areas, including:

- **Reduced CapEx/OpEx**

IoT technologies allow utilities to increase the ROI of their grid infrastructure through efficiencies gained from increased situation awareness, higher levels of data-driven decision making, scalability at a lower cost than SCADA, and interoperability with existing technology investments.
Monitor the condition and performance of assets in real time.

Avoid building new capacity through better use of existing capacity.

**Improved Worker Safety and Productivity**
Wearable technologies help ensure field workers have the information they need at their fingertips to make them safer and more efficient. Remote offices can also directly monitor and observe activities, allowing them to offer better support and more constructive advice.

- Keep workers safe in remote and potentially more dangerous work sites.
- Use video technology to allow onsite workers and remote experts to work ‘side-by-side.’

**New Revenue Opportunities**
IoT solution collaboration can simplify and speed up the design and deployment of new revenue-generating applications and services that improve the utility’s bottom line.

- Offer new types of services, such as HVAC operation comparisons, SLAs for industrial/commercial customers, energy efficiency services.
- Bundle offerings with other service providers (e.g., home security companies).

**Solution Overview**
IoT solutions for the utility grid will typically contain the elements shown in Figure 2. The substation contains equipment that can be monitored by sensors and controlled by actuators. In order to have these sensors and actuators communicate with back office systems, they can connect to a gateway that performs a variety of functions, including:

- **Protocol translation** enables inter-network communications (e.g., between Modbus and TCP/IP).
- **Device management** configures and manages grid edge devices.
- **Data aggregation** combines and filters data from multiple sensors.
- **Data analytics** run close to the edge, facilitating quick, intelligent, closed-loop control.

The gateway can also work in collaboration with mobile computers or process control networks.

Data is transmitted between substations and the back office over wired or wireless networks. In the back office, a second gateway is the conduit to the applications, such as consumption monitoring, predictive maintenance, and data analytics running on servers in the data center.

![Figure 2. Real-time grid monitoring and control](image-url)
Roles of IoT and SCADA

Grid operators typically use a supervisory control center to visualize the status of the grid. With the increasing amount of distributed assets connected to the grid, including distributed energy resources that are not part of the utility assets, maintaining complex grid systems is becoming cost prohibitive and error prone. This is because the number of connection points often exceeds the scalability of the existing supervisory control and data acquisition (SCADA) database, triggering an expensive upgrade. Moreover, as asset changes (e.g., addition, removal, and connection) grow more frequent, it is much more difficult to maintain the SCADA network model used by the operational system and guarantee it accurately represents the physical reality.

Utilities expanding their legacy operational technology to address this changing environment may find the cost of scaling proprietary communication technology and protecting proprietary systems against cybersecurity threats a high-risk, high-cost proposition. Utilities need real-time infrastructure monitoring to achieve situational awareness for 21st energy infrastructure, which IoT enables at a much lower cost than most solutions based on SCADA. Upgrades to operational capabilities using IoT technologies complement, not replace, existing SCADA solutions.

Intel’s Tenets of IoT Solutions

By 2020, it is expected that more than 50 billion devices will be connected to the cloud and each other using IoT. Before this can become a reality, solution providers must recognize and tackle the complexity of IoT solutions to ensure secure and reliable IoT deployments. Along these lines, Intel, working with its ecosystem partners, defined a system architecture specification (SAS) for connecting nearly any type of device to the cloud. SAS helps solution providers design IoT solutions in keeping with five key tenets:

Services to monetize IoT infrastructure
- Data management from edge to cloud

Analytics infrastructure to provide value for utilities
- Real-time, insightful, and secure data analytics

Seamless data ingestion and device control to improve interoperability
- Broad protocol normalization support and closed-loop control systems

Automated discovery and provisioning of edge devices to ease deployment
- Device setup from box to cloud in minutes

World-class security to deliver the requisite data and device protection
- Robust hardware and software-level protection

IoT-based Solutions for Energy Infrastructure

In support of IoT solutions for energy infrastructure, Intel offers capabilities that fall into several categories:

- **Intel-based Hardware for Utility Market**

  Utilities are deploying Intel® computing and communications technology across the power grid and in data centers to increase the utilization of existing electrical capacity and optimize the use of alternative energy sources. Distributed intelligence, based on Intel® Xeon®, Intel® Core™, and Intel® Atom® processors, decentralizes control and improves energy efficiency. A wide range of operating systems, development tools, and security solutions are available to assist application developers.

  Smart grid solution developers of nearly anything – from handheld devices to data center servers – can choose from three families of Intel processors (Figure 3) that can all run the same software, which provides an exceptional level of scalability.

- **Intel Atom processor product family** provides low power and thermally-efficient application performance in small form factor devices. The processors feature enhanced media and graphics performance, error correcting code,
industrial temperature range, built-in security, and integrated image signal processing.

- **Intel Core processor product family** delivers exceptional compute, graphics, and media performance, along with enhanced security and I/O flexibility. Designed for small form-factor applications, the 7th generation Intel® Core™ processor (U-processor line) uses a multi-chip package (MCP) that integrates a low-power CPU and platform controller hub (PCH) onto a common package substrate.

- **Intel Xeon processors** are designed for compute-intensive applications that demand the highest available performance, combining multi-core performance and exceptional compute density with hardware-based manageability, security, virtualization, and power management.

- **Intel Security**
  With more and more energy sources connecting to the grid, it becomes increasingly ever more important to monitor and control these assets to avoid a catastrophic incident, like a transformer blowing up. There is also a need for robust cyber, network, physical, and application security, and Intel is addressing these needs with up-and-coming technologies:

  - **Automate secure onboarding of devices**
    For many utilities, device onboarding is a manual process that could be susceptible to security holes. Intel is developing an automated onboarding solution that preserves device anonymity and does not rely on default passwords that leave devices exposed to security risks.

  - **Ensure devices and data are secure**
    Utilities connecting device and systems to the outside world can take advantage of Intel solutions for integrity protection, network security, and logging. Specific capabilities include identity provisioning and verification; remote security management; remote firewall management and device attestation; and management for logging, syslog, and secure syslog.

  - **Reduce deployment effort with devices with built-in security**
    Devices and systems comprising smart grid infrastructure require a high degree of security and integrity protection. In cooperation with ecosystem partners, Intel is developing a silicon-based security solution to ease security deployment and provide security capabilities across various products, form factors, and device types by taking advantage of field-programmable gate array technology.

**Collaborating on 21st Century Energy Infrastructure**
Intel has developed an entire ecosystem around IoT solutions for the power grid, enabling utility companies to pull together all the necessary developers, systems integrators, and OEM/ODMs needed to construct a solution. This includes the Intel® Internet of Things

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Figure 3. Intel provides unique performance scalability with three processor families
Solutions Alliance whose members provide the hardware, software, firmware, tools, and systems integration that developers need to take a leading role in IoT. Contact your Intel field sales representative to learn how Intel and its IoT ecosystem can help develop a pilot to better understand how IoT technologies can help improve profitability.

**Resources**

Intel® Internet of Things Solutions Alliance
Members of the Intel® Internet of Things Solutions Alliance provide the hardware, software, firmware, tools, and systems integration that developers need to take a leading role in IoT.

Intel® IoT Gateway Development Kits
Intel® IoT Gateway development kits enable solution providers to quickly develop, prototype, and deploy intelligent gateways. Available for purchase from several vendors, the kits also maintain interoperability between new intelligent infrastructure and legacy systems, including sensors and data center servers.

To learn more about Intel solutions for the energy industry, visit [www.intel.com/energy](http://www.intel.com/energy).

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2. IDC*, Intel forecast.

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