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ENERGY INTERNET

ICT INSIGHTS

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ICT Boosts the Energy Internet Era

Large-scale electricity networks become modernized with the addition of ICT connectivity and information services.

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Key "Things" about Energy

An Interview with Sanqi Li, Huawei Chief Scientist

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HUAWEI

Huawei's Vision for the Energy Internet

By David He, President, Marketing and Solution Sales, Huawei Enterprise Business Group

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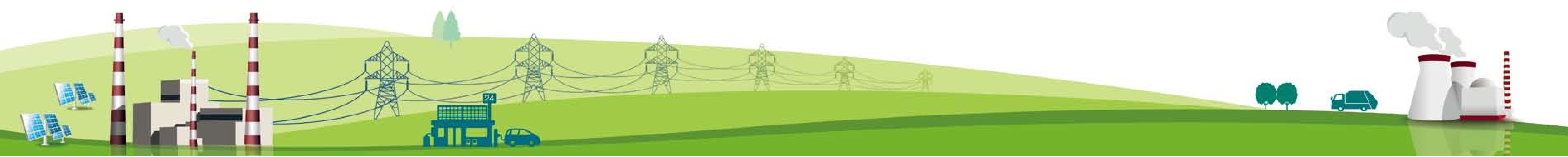
Energy transformation has reached a crossroads. Global primary energy consumption in 2010 was about 550 exajoules, nearly 25 times higher than in 1830 [www.theoildrum.com/node/8936]. Each exajoule is equal to 174 million barrels of oil. Compared with a century ago, we are burning ten times more energy today to support the global production of goods and services. Still, fifteen years into the Millennium, half of the world's population, including 1.2 billion children, lacks adequate access to electricity.

Facing a number of challenging energy issues, such as resource shortages, low efficiency, unbalanced regional development, and environmental pollution, in 2008, the German Federal Ministry of Economics and Technology initiated the "E-Energy: ICT-based Energy System of the Future" project to build a digitally connected, controlled, and monitored energy network. In the same year, the US National Science Foundation Future Renewable Electric Energy Delivery and Management (FREEDM) Systems Center was founded at North Carolina State University to conceptualize a plug-and-play architecture for electric power distribution suitable for renewable energy and energy storage devices. In June 2015, the China National Energy Administration officially released the Energy Internet Action Outline and identified twelve supporting research projects in June 2015. Regardless of the strategy, the Energy Internet is pushing the entire energy industry to "full connectivity."

Among many examples, ICT-equipped Photovoltaic (PV) devices have increased the efficiency of solar power converters by more than three percent. Agile communication networks swiftly adapt to multi-dimensional topology changes over energy networks. Using Big Data technologies, oil companies are improving the success rate for oil exploration, and electric power providers are calculating load predictions and pro-actively preventing accidents.

As is familiar from the transformations of the finance and telecommunications industries, those who embrace the change will become the new industry leaders.

Huawei is working with energy enterprises, providing them with innovative ICT solutions that help the energy industry transform their production modes and explore new business models.▲



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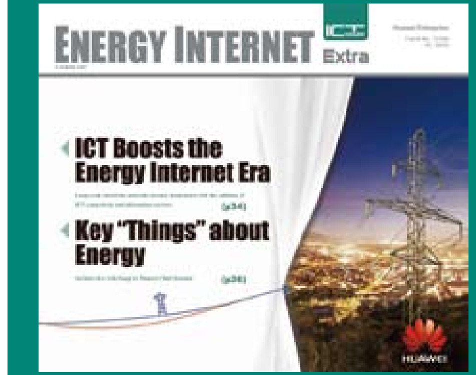

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Yu Liao
Mr. Liao is now working with Berlin Electric Power as Director of its New Energy Project. He specializes in the fields of new energy data analysis and visualization, electricity trade supervision, and Smart Grid and automation control systems.

More than the simple addition of “Internet+ energy” or a business model for energy transactions, the Energy Internet means universal connectivity for the entire industry chain. >>

Energy Internet — Not a Simple Equation

By Yu Liao, Chairman of the Chinese Association for Renewable Energy in Germany

With the inception of the Internet+ era, circa 2015, debate over defining the Energy Internet has begun. So far, even the clearest definition of the concept, using the most accurate technical language, has not delivered a single, clear specification that encapsulates the full scope of technical innovations and business models the industry aspires to achieve.

Persistent digitalization and the evolution of “Smart Grids” are the first, most critical factors contributing to the birth of the Energy Internet. European Union (EU) members have been privatizing power utilities for more than 10 years following Germany’s lead as the electricity transmission hub of Europe. In 2005, the EU established the *European Technology Platform for the Electricity Networks of the Future*. With the number of new energy carriers expected to double between 2007 and 2029, the requirements calling for existing grids to install more intelligent power transmission and distribution networks is rising.

To reduce power consumption without adversely impacting industrial capacity or consumer lifestyles, the Energy Internet proposes to bring alternative energy sources into primary power grids through the use of incentives to encourage greater efficiency.

A Smart Project

The core component of an Energy Internet demonstration project in Austria features a central thermal control room that is connected remotely to a “household energy processing unit” that adjusts the energy output of the entire system. The functional components of the system include a geothermal heat pump powered by biological liquefied gas and a municipal heat supply. A thermal buffer pool containing ninety liters of water provides heating for the entire six-story building, and the thermal control system adjusts room temperatures, humidity, and carbon dioxide levels in each individual unit.

The user management center factors the projected electricity price curve for the next twenty-four hours. When the price is reasonable, the center notifies customers to turn on their heat pumps remotely — electricity that is used to heat the thermal buffer pool; that alone, when full, will satisfy the heating requirements of the entire building for two days.

A monitoring application on each resident’s mobile phone exchanges data processing results with the grid dispatching center that then presents estimated electricity prices over the next twelve hours using a color-coded clock interface that displays price fluctuations. Residents can control their electrical appliances remotely via smart phone. This real-time consumer interaction, in turn, affects the market price because the central power utilities are connected — and in constant negotiation — with the national grid networks. The supervising mechanism is a policy-driven usage management resource whose goal is price-consumption optimization.

The user management center runs on a virtual platform hosted by the power generation plant. The collection and unification of management data from the meta-grid allows geographic and time-limited microgrids to optimize the services provided to individual customers. For example, a German Energy Internet company developed an online energy transactions service that is accessible through mobile phone and tablet applications for real-time news, reports, and analysis.

“Energy plus Internet” will be achieved by ICT-enabled information exchanges and distribution platforms that allow power resources to be accessed and managed through the universe of mobile, PC, and Internet connected appliance-based applications.

Energy Internet Connectivity Across the Ecosystem

As the Energy Internet gains momentum, the ecosystem of transactions will shift from the current Business-to-Consumer (B2C) model to include and then be dominated by Consumer-to-Business (C2B) and even Consumer-to-Consumer (C2C) models.

Huawei estimates that, by 2025, the number of IoT-connected devices serving business and industry will reach approximately 100 billion. “Huawei will apply its cloud-pipe-device architecture to develop innovative ICT technologies and solutions that will include a cloud data center, Big Data, agile networks, LTE, an IoT gateway, and the ‘LiteOS’ open source IoT operating system,” said Jerry Ji, Huawei President of Energy Sector sales for the Enterprise Business Group at the company’s *Global Energy Industry Summit 2015* in Almaty, Kazakhstan.

As more IoT services become commercially available, consumers will find multiple options tailored to suit individual cases. In practice, “Energy plus Internet” will be achieved by ICT-enabled information exchanges and distribution platforms that allow power resources to be accessed and managed through the universe of mobile, PC, and Internet connected appliance-based applications.▲

John D. McDonald
Mr. McDonald is an IEEE Fellow, Vice President of technical activities for CIGRÉ's U.S. National Committee, and past President of the IEEE Power & Energy Society (PES).

Non-operational data from transformer and substation monitoring can account for 80% of the value gained from advanced monitoring and diagnostics. >>

Extracting Full Value from Electric Utility Monitoring Schemes

By John D. McDonald, P.E., Director of Technical Strategy and Policy Development, GE Energy Management-Digital Energy

While a Monitoring and Diagnostics (M&D) scheme has become essential for electric grid operational purposes, the main enterprise value lies in non-operational M&D data uses. Any network plan to support M&D must include operational and non-operational data and ensure that all enterprise parts can take advantage of the data.

Implementing M&D requires an enterprise-wide strategy that relies on Intelligent Electronic Devices (IEDs) and systems as data sources, networks for communications, and M&D analytic applications with response requirements matched to operational and non-operational data extraction from IEDs on transformers and in substations. As operators receive operational data for grid management, enterprise business managers must receive non-operational data to create enterprise value. Without non-operational uses, many utilities are foregoing as much as 80 percent of the potential benefits from the IEDs.

Operational data must reach the control center via a secure network with stringent response requirements. Non-operational data needs a network with higher bandwidth for digitized waveforms and sequence-of-events reports, but this network has lower requirements for security and latency. Intelligence requires constant communication. Investing in transformer M&D and substation automation makes no sense without always-on communications networks.

Designing an information architecture to deliver non-operational data to business managers requires matching their needs to the data sources. A virtual data mart extracts on-demand, non-operational data for processing into actionable business intelligence.

A Holistic Approach

Implementing the communication and presentation of non-operational data to enterprise users is complex and demands thinking outside traditional silos. Third-party facilitation is essential to keep participants motivated, cooperative, and focused on the end result.

Once completed, however, the effort unlocks significant value in resolving business problems, supporting a condition-based maintenance program, and laying the groundwork for future expansion. Specifically, with a good information architecture, new IEDs can be added to the same data-handling arrangement as defined by three types of plans: a data map that includes all IED outputs (data points), an IED template that matches the data points to stakeholders' needs in the utility, and a matrix showing the attributes (e.g., frequency of sampling) that non-operational data must take for each stakeholder. These plans define how non-operational IED data is extracted, routed, and presented.

Ideally, the substation automation system, such as Supervisory Control and Data Acquisition (SCADA), extracts operational and non-operational data from IEDs on transformers, and protection and control equipment using data concentrators. Operational data then goes to the control center, while non-operational data is routed across the firewall to data repositories for on-demand retrieval by business units.

Data for Business Units

To design a transformer M&D and substation automation scheme that make best use of the data, that data must be delivered to the right people at the right place and time in a useful format. Presentation is integral to the outcome. Applications turn data into information and, after further analyses, formats such as dashboards translate the information into actionable business intelligence. The dashboards must be tailored to each business unit's needs.

For non-operational data, business unit managers and operations groups are likely to use the data. More than two dozen business units can make use of the non-operational data generated by transformer M&D and substation IEDs. These business units include maintenance, asset management, power quality, planning, and engineering groups.

The initial step in designing an information architecture to deliver non-operational data is to query business managers about who needs the data, the sort and form needed, and the specific time intervals for capture. The resulting document becomes a resource referred to as an "enterprise-wide data requirements matrix."

Enterprise users must take inventory of available IEDs and corresponding data maps. Users possibly aided by outside consultation must determine what formats best serve their needs. The availability of non-operational data and archived operational data may be new to many people.

> More than two dozen business units can make use of the non-operational data generated by transformer M&D and substation IEDs. These business units include maintenance, asset management, power quality, planning, and engineering groups.

Creating an IED Template

After an inventory, managers must determine which points in each data map have value for stakeholders by creating IED templates. This task is complex, partly because IED characteristics vary by model and vendor. Each model may yield different types of data in different ways. Therefore, every device's characteristics and data outputs must be documented to complete this step.

These characteristics might include a sampling rate that results in a recorded value every two seconds. The available data might represent a mathematical outcome of that sampling or might be event-driven. And, a user might need only the peak or average value for each hour. Perhaps a specific data point is only relevant to a user when the value exceeds a pre-determined threshold.

Data has little value until processing converts it into comprehensible information. Further processing, which can occur at several levels, turns the information into business intelligence.

Users must determine whether the range, average, mean, or some other data variant is useful.

The IED templates and data requirements matrix determine the network architecture required to capture and communicate data from the IEDs to enterprise users. The templates and data matrix require accuracy to produce useful results for the enterprise.

Data Marts

To reach end users, non-operational data is extracted from the IEDs, gathered by a data concentrator, and conveyed by networks through the enterprise firewall to a virtual data mart. Once there, the data is accessed via an enterprise network application. The term "virtual" refers to a data server that sits on top of and is logically linked to a utility's data repositories.

Many utilities rely on several data repositories. This approach adds a federated data server, which manages and routes all enterprise network data. Stored data is transparent to users because the server is logically linked to all data repositories; the server simply finds and delivers requested data.

Enterprise users can request operational data from the enterprise data mart, which is populated from the control center historian (operations SCADA historian). Typically, the internal operations SCADA historian contains the operational data superset for use by operations, and the external SCADA historian contains a subset of operational data for use by stakeholder groups. The internal SCADA historian is within the firewalls of operations, and the external SCADA historian is outside the firewalls of operations. The operations SCADA historians contain a time series of data at a predetermined sampling rate.

To extract maximum value from IED/networking investments, the data management plan must ensure that every potential end user in a utility has desktop access to non-operational and operational data. This fundamental consideration needs to govern the design of the communications networks and all related work.

Converting Data

Data has little value until processing converts it into comprehensible information. Further processing, which can occur at several levels, turns the information into business intelligence.

IEDs or related devices can process data to some extent; other processing can occur in a data concentrator or a substation desktop PC. Processing near the source reduces data amounts that must be communicated upstream for centralized processing.

To produce business intelligence, managers must participate in three activities:

- Identifying the necessary data through the data requirements matrix exercise.
- Selecting and learning to use applications that turn that data into actionable intelligence.
- Deciding how outputs are delivered via visualization so business intelligence is understandable and actionable.

Operations and Asset Management

Though operational data from IEDs alert operators to transformer problems, the aim of the data architecture is to avoid a fix-on-fail approach. Utilities can use non-operational data to become more proactive through condition-based asset management and maintenance to improve transformer diagnostics and extend the useful life of components.

This approach increases grid reliability, safety, and related enterprise value. Patterns may emerge that reveal conditions or operational approaches that hasten a transformer's demise. In other words, the exploitation of non-operational data is a boon to transformer M&D and substation automation.

As grid modernization progresses, new sources of data and new, previously unimagined, uses for the data remain to be discovered and transformed into value for all stakeholders.

Driving Organizational Change

Success in transformer M&D and substation automation not only relies on technical considerations — it has organizational and cultural implications as well. The need for enterprise-wide engagement in a transformer M&D business case presents organizational and cultural challenges to a utility accustomed to tolerating silos and rivalries. These concerns can result in unjustifiable redundant systems. Ultimately, the over-arching goal is to increase reliability and safety, extract the full value of M&D investments, and create customer value.

Utilities cannot afford "islands of automation" created by different operations or business units. Enterprise business unit managers must cooperate with other managers across the enterprise in the data mapping phase and data template creation that help make non-operational data from substations available to all. Territorialism and silos are expensive, inefficient, and unproductive. This is a well-established fact of transformer M&D, substation automation, and data mart setup, confirmed by case studies.

Traditional advice on how to accomplish these outcomes often centers on executive leadership and management buy-ins. Clear direction from utility executives, with an emphasis on staff adaptation and the benefits of working toward the common good, can be effective measures. For a utility staff with an appetite for change, that may be enough — too often it is not. But a utility organization has management tools to ensure that this divide is bridged, perhaps using enterprise-wide metrics in job evaluations and compensation processes. The upside is a stronger business case, better outcomes, and a more nimble organization prepared for even greater changes.

The Grid's Future

An enterprise-wide, holistic approach to transformer M&D and substation automation leads a utility to select enabling communications networks and mix and match them for the utility's specific needs.

Achieving greater visibility into transformer health and substation functions has a broad impact on other systems and a utility's business processes and culture. Strategic planning and implementation provide a classic example of a technology in pursuit of grid modernization and its promise of greater reliability and safety as well as more secure, efficient operations in customer value services. Therefore, the need for a holistic approach, the impact of one implementation on other systems, and the resulting evolution of business processes and utility culture offer a fundamental process applicable to other grid modernization projects.

In fact, improved transformer M&D and substation automation and the changes they propel are just harbingers of changes to come. The full exploitation of operational and non-operational data, relying on enabling communications networks, is only the beginning of the Big Data era for utilities. As grid modernization progresses, new sources of data and new, previously unimagined, uses for the data remain to be discovered and transformed into value for all stakeholders.▲

Yin Cao
Mr. Cao is a member of the expert committees for China Energy Internet Alliance and Intelligent Energy Alliance, as well as the principal advisor to the company PV Plus. He is also an energy columnist for a number of magazines and media.

Over time, China's "Internet+" initiative will transform electric power generation, distribution, and consumption. >>

China's Internet+ Route to Energy Intelligence

By Yin Cao, Energy Internet Lead Researcher of Cinda Securities

Long associated with inefficiency and pollution, China's energy industry has received a push in a positive direction in the past year by the country's Internet+ initiative. In the 2015 Internet+ action plan, Premier Li Keqiang refers to "Internet+ intelligent energy" as the national strategy for the Chinese energy industry. The plan outlines a direction for electrical power systems reform and the development of the Energy Internet in China.

Though most Chinese power generation enterprises are holding onto a wait-and-see attitude, there are a few Chinese entrepreneurs who have begun the development of intelligent power equipment, including remotely controlled platforms and energy crowdsourcing infrastructures. Comparatively, innovators lack the close, historical ties to the two largest electricity distributors with the business leverage to drive change: the State Grid Corporation of China (SGCC) and China Southern Power Grid (CSG).

The electric power industry is not alone in China for delaying the transition from basic Information Technology (IT) to the advantages of "knowledge-based" Big Data analytics. Many other traditional power companies are operating with a bare minimum of IT facilities and are yet further behind the business value generated by Big Data technologies.

The demands of our ongoing technical evolution require power companies to adopt a step-by-step approach for transitioning to Internet+ intelligent energy solutions.

The goal is to enable power companies to evolve to "smart power" platforms through equipment digitization — i.e. the addition of sensors and connectivity to their infrastructures — and follow-through to adopt comprehensive levels of intelligence through real-time analytics in preparation for the eventual realization of complete Internet+ systems.

Digital Energy

The first step in the evolution plan is to add an end-to-end layer of digital sensors to existing energy networks. The data captured from this sensing layer enables power companies to see the operating status and ambient conditions of devices and systems at all times in real time. For example, sensors on primary equipment such as transformers can collect voltage, current, frequency, load, temperature, and physical integrity details.

Unfortunately, this first-level digitization is uneven across the grid in China. There is a higher proportion of networked sensors in the power generation and transmission equipment of larger cities — where the installation of secondary sensors has begun — but often quite little in smaller cities and rural areas.

Generally, the ability to utilize the sensor data for continuous monitoring of the power distribution network is weak throughout China and nonexistent in small cities and rural areas. Even where sensors are deployed, data collection granularity is not ideal. The low-density data is not able to report the actual operating status of the power system. Further, power producers are unprepared to collect, process, or analyze the massive amounts of unstructured data, such as web logs, video, and audio recordings that pass through their IT systems.

Smart Energy

For the purposes of this article, "smart energy" refers to system upgrades from first-level digitization platforms that have yet to reach a high level of intelligence. Based upon the potential for comprehensive sensor networks, a smart energy system will implement full-domain control through the interactions between different sub-systems of the power generation and distribution plant. In addition, smart energy systems will provide users and system administrators with multiple optimization schemes tailored to match working conditions and environmental factors in ways that enable the system to work most efficiently.

Coordinated smart energy systems will reduce power consumption, improve equipment reliability, and enable power companies to achieve optimal operating results.

Although the smart energy system will implement remote control of substations at some core sites, the system will be far from achieving full-domain remote control. Most field operations will continue to be performed by on-site engineers making on-the-spot decisions — an approach that guarantees slower response times for crew positioning and the risk of introducing errors that may affect system reliability.

Intelligent Energy

Automated smart energy systems based on computer-aided decision-support are enabled by modern data analysis techniques. For power utilities, state-of-the-art information processing technologies are critical to maintaining the levels of reliability that are vital to the good health and profitability of each business and the industry as a whole.

Due to the real-time nature of electricity production and consumption, the primary challenge is maintaining the balance between supply and demand. The ongoing installation of huge numbers of renewable energy generation sites and growing diversification of consumer demand promise to bring greater fluctuations on both the supply and demand

The addition of Internet+ technologies is the final phase of the energy industry evolution as is currently understood. The goal is to actively employ Internet business models to transform the energy industry.

sides. Advanced ICT solutions that include Big Data analytics are the most effective way to manage modern electric power systems.

Advanced power utilities will integrate data from a wide variety of sensor modules deployed throughout the power production, distribution, consumption, and storage systems. The implementation of system-lifecycle modeling will enable intelligent energy systems to learn, adapt, and evolve by themselves.

The power utilities that achieve these objectives will be those best positioned to provide clean and economical electricity by managing the balance between supply and demand.

The adoption of ICT-based intelligent energy solutions will drive two major trends over the coming decades. First, on the supply-side, the production, distribution, and consumption of electricity will be integrated to an unprecedented degree. And second, the application of Big Data to business management will enable the correlation of historical analysis, current status, and predictive modeling of the energy value chain.

Internet+ Intelligent Energy

The addition of Internet+ technologies is the final phase of the energy industry evolution as is currently understood. The goal is to actively employ Internet business models to transform the energy industry according to the following steps:

- Development and deployment of intelligent hardware.
- Systemic software design.
- Release of open platform interfaces.

Intelligent hardware will enable the active control of power system consumption, utilization, and infrastructure resources, including nuclear, gas turbine, wind and photovoltaic generation, power distribution automation; demand-side response based on inputs from intelligent building; and policy-managed energy storage utilization.

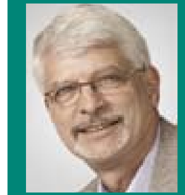
Sensor data from every part of the energy system will feed Big Data platforms. Energy management software suites are being developed to provide real-time asset management and operation optimization services. Software applications include routines for environmental health, safety, and predictive maintenance.

Energy Internet

Enterprise Energy Internet cloud platforms will connect operators with each and every piece of equipment involved in power generation, transmission, distribution, sales, and consumption.

Ultimately, Energy Internet application ecosystems will form around enterprise Energy Internet cloud platforms. Energy Internet App factories will employ social forces to generate the data used to create real-time supply and demand models on Big Data platforms. Enterprise electricity sales service platforms operated by grid utilities will provide reference application modules for deployment on their Energy Internet cloud platforms. In this way, operators become application developers able to provide targeted services for diverse populations of energy users.

The core task of Energy Internet construction is the building of open platforms for implementing end-to-end interactions across the entire value chain. Internet business models and Software-Defined Networking (SDN) are expected to be used to link energy producers and consumers in ways that encourage end-user participation in building the Energy Internet ecosystem. So, while it may not be possible for every utility to implement a user-friendly Energy Internet strategy, it is entirely realistic that Energy Internet-enabled enterprises on the demand-side coordinate the balance of local, renewable electrical generation sources with large-scale, centralized facilities. ▲



Bobby Cameron
Mr. Cameron's specialty is transformative technology use that drives business success in the emerging world of business technology, such as IT value creation, technology-based business innovation, and digital business networks.

In the future, ICT technologies will substantially change the entire oil and gas industry. >>

Digital Transformation Is Redefining Oil & Gas

By Bobby Cameron, Vice President and Principal Analyst, Forrester Research

It might be surprising for many to discover how digital technology is transforming the oil and gas industry as well as other core-process industries. At the Huawei Global Energy Industry Summit 2015, held this past August in Almaty, Kazakhstan, the audience quickly became aware of the impact digital technology is having on oil and gas.

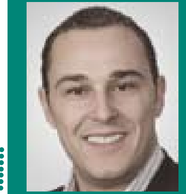
Following the conference theme, "Innovative ICT Enables Smart Energy," our keynote themes were the major challenges and opportunities arising from the transformation in digital process control for oil and gas production. The current deep price cut in the cost of crude oil has the industry focused on rapid, targeted responses to an increasingly dynamic market of hydrocarbon supply and demand.

One challenge in legacy oil production operations is the absence of remote sensor equipment at most wellheads. When production is falling, field specialists traveling between sites to inspect, assess for cause, and coordinate repair must monitor pumps closely. By today's standards, non-networked systems are costly, slow, and, when broken, can lead to critical reductions in scheduled pipeline pressures and production volumes.

However, by implementing sensors, the industry can test for key measurements in real time, such as flow-rates, temperatures, and pressure as well as report on production operations. These sensors, which are already in place through British Petroleum's Field of the Future® and Shell's Smart Fields programs, can provide information that enables the production firm to take informed and targeted action.

At the Kazakhstan summit, Dr. Hatem Nasr, a Senior Advisor for oil and gas to Huawei, presented data from three recent projects in the Middle East in which savings as much as 30 percent came within a few months of the sensors coming online. This instrumentation has opened the possibility for substantive, further cooperation between wireless technology providers such as Huawei and sensor vendors such as Honeywell.

The real payback will come from learning to use both the new data as well as the old. On average, firms today use less than 20 percent of their data. But oil and gas companies are starting to accelerate the usage of more data and at higher speeds to produce actionable insights using Big Data techniques across the globe, including for very remote locations. For example, Chevron uses its iField technologies to manage assets in six continents in near-real time. The results certainly will include digital operational excellence — but also will enable production firms to respond to global market opportunities with rapid, smart changes in extracting and moving product to places where capacity and customers demand it. Understanding real-world complexities — and taking advantage of opportunities that appear rapidly — will create winners in the competition for improved oil and gas extraction and production. ▲

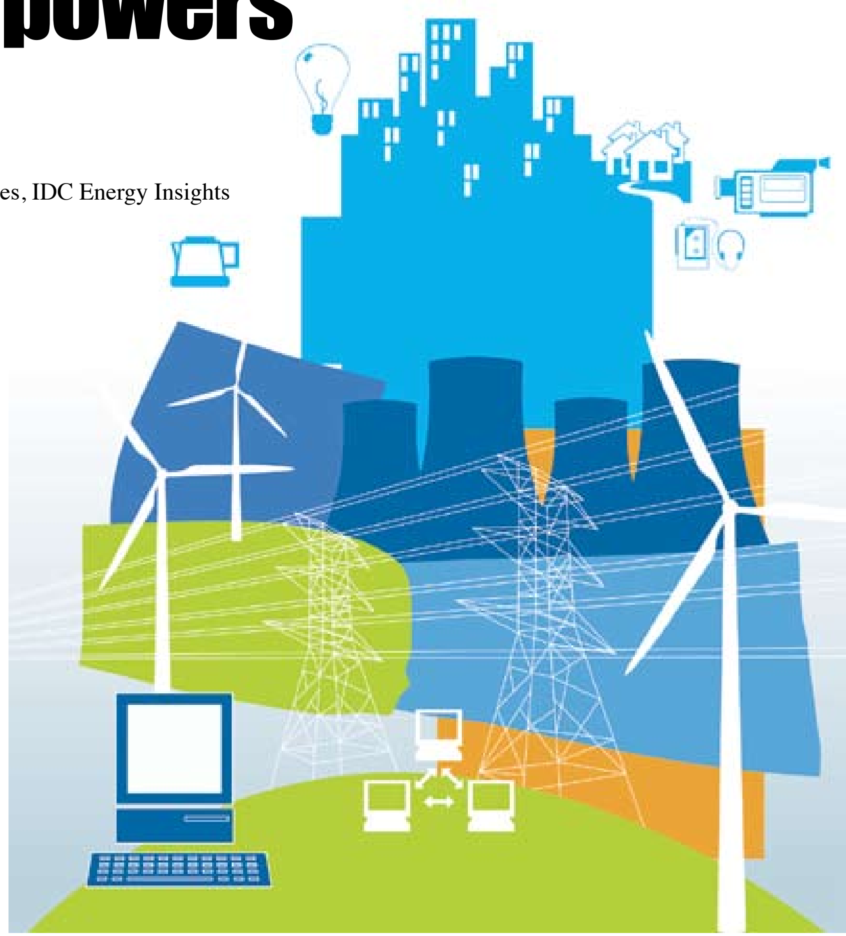


Marcus Torchia
Mr. Torchia analyzes global regional markets for grid modernization, strategic project investment and business transformation for utilities and energy services providers.

Smart Grids transform the future of utility infrastructure. >>

ICT Innovation Empowers the Smart Grid

By Marcus Torchia, Research Manager, Worldwide Smart Grid Strategies, IDC Energy Insights



Informed customers have a growing interest in energy conservation and alternative resources. At the same time, the power utility industry must reduce costs, streamline operations, and meet stringent regulations. Strengthening the Information and Communications Technology (ICT) infrastructures within the electric power grid are strengthening the utilities to improve upon their most rigorous operational and environmental goals with wide-reaching benefits.

Big Data and analytics, cloud computing, mobility, and the Internet of Things (IoT) are leading ICT into a new era. These technologies allow for Smart Grid investments in strategic programs that span reliability, security, energy efficiency, and retail services.

Huawei brings ICT platforms that deliver carrier-scale performance to the power utility industry in the areas of communication networking, security, storage flexibility, and physical durability.

Industry Drivers for Power Utilities

Globally, power utilities operate under diverse market conditions with varying levels of government regulation, economic growth, and infrastructure maturation targets. The following summary provides a shared view of the factors influencing utility technology investment:

- **Increasing asset utilization:** Generation capacity, for example, increases utilization rates by running plants longer and harder, increasing operating levels from 70 to 75 percent in the Asia region and developing countries and peaking at an 80-percent maximum output in North American, European, and other industrialized markets.
- **Optimizing grid operations:** Expanding automation to the grid's edge with smart devices and networks makes optimization possible via analytics using real-time and near-real-time grid data.
- **Improving reliability:** Investments in grid infrastructure assure more stable generation and faster recovery of distribution equipment.
- **Managing demand:** Networked smart meters and intelligent in-home controls now provide utilities with more options to shape usage patterns at home.
- **Energy savings and reduced greenhouse emissions:** State and national Green House Gas (GHG) emission regulations continue enhancing energy conservation.

Third Platform Drives Innovative Trends

IDC predicted the IT industry's shift to a "3rd Platform" for the next stage in innovation and growth. This new platform is founded on four technology pillars: Big Data & analytics, the cloud, mobility, and social.

- **Analytics:** Transmission operators already use powerful analytics to manage for regulatory compliance to state estimators. Additionally, utilities are looking to analytics for a return on Smart Grid investments and to refine business objectives such as outage mitigation and restoration, theft and fraud detection, and predictive maintenance. In Europe and Australia, retail energy providers have turned to Big Data analytics for demand forecasts and customer segmentation for new service offerings.
- **Cloud formation:** *The 2013 IDC Vertical Communications and IT Survey* found that 23.7 percent of utility respondents use the private cloud and 18 percent use the public cloud. The utility industry is prepared to use cloud computing for Software-as-a-Service (SaaS) applications and, within the next 18 to 36 months, will start implementing the cloud for data storage.
- **Going mobile:** Mobile device usage continues to expand with advances in mobile technology, such as mobile broadband networks, high-resolution screens, and mobile work force management software. Many of today's workers use their smart devices for mobile office functions such as GPS tracking, data collection, recording inspections, and work-order completions.

Huawei brings ICT platforms that deliver carrier-scale performance to the power utility industry in the areas of communication networking, security, storage flexibility, and physical durability.

- **Smart Grid investments:** The IoT has long been expanding in the utility industry to automate generation and transmission networks. Maintaining decades-old infrastructure is not uncommon for mature power utilities, but the practice presents an increasingly challenging environment to assure reliability, security, and performance. According to an IDC Energy Insights report on the *Worldwide Utility Smart Grid Spending Forecast 2012-2017*, total expenditures on ICT will exceed USD 42 billion annually by 2017.

Network Converges Information and Operational Technologies

A clear path in Smart Grid development follows the efforts to automate greater portions of the power grid from generation to the consumer. The Smart Grid challenges that utilities face include installing and upgrading communication networks, managing heterogeneous devices, ensuring system reliability and security, and maintaining the network infrastructure.

The centralized command and control architectures of power grid design are yielding to distributed intelligence of smart devices including line sensors, smart meters, synchrophasors, transformers, fault interrupters, power control modules, routers, EV automobile charging stations, renewable generation units, and Remote Terminal Units (RTUs).

> Power equipment and sensing devices with advanced networking connectivity and computing capabilities are transforming the centralized command and control of distributed grid architectures.

A Converged Network Interconnects Transmission

Transmission grids require a high degree of coordination with transmission system operators and interconnections to generation sources for maintaining a balanced, synchronized, and stable grid. Today, Wide Area Network (WAN) performance is more demanding than ever. Two interrelated factors drive this dynamic. First, utility-scale renewable generation, such as wind farms and massive solar arrays, are increasingly being tied to the transmission grid. Often, renewable generation occurs at remote locations; for example, offshore or mountainous terrain for wind, and the desert for solar. The intermittent nature of renewable generation causes voltage drops or spikes as wind speed and cloud cover affect generation rates, often within minutes. Second, Wide Area Situation Awareness (WASA) provides visibility to adjacent transmission grids that may cause cascading outages at neighboring utility sites. WASA gives a utility or transmission operator the ability to identify a small problem in asynchronous phasing before it causes a system-wide collapse.

The requirements for renewable generation and WASA demand sub-second response times that only a wide area, low-latency communication network can provide. Additionally, communication network solutions require implementing a utility's migration path over a multi-year period between the generation plants, substations, and interconnections among utility entities.

The Huawei Transmission and Transformation Communication Solution combines proven Time-Division Multiplexing (TDM) network technology with all-IP networking in a single solution. This approach eases upfront capital costs and disruption risks for the generational transition to IP networking. Moreover, Huawei offers its microwave series products for point-to-point and point-to-multipoint transport and backhaul applications.

Distribution Sensing and Control on the Rise

Power equipment and sensing devices with advanced networking connectivity and computing capabilities are transforming the centralized command and control of distributed grid architectures. Today's distribution communication networks operate well for simple and fast response Supervisory Control and Data Acquisition (SCADA) requirements between substations and control centers. Smart Grids require connectivity and advanced analytics beyond the standards of legacy distribution substations.

Utilities are investing in three major technical development efforts.

First, switchgear distribution automation is being deployed to maintain continuous service around faulty transmission sections due to old equipment and/or weather-related storm damage. Switchgear automation is found in 15 percent or fewer distribution utility substations and feeders in Europe and North America, and even less in the Asia-Pacific, Middle East, and Latin America regions, according to recent research conducted by IDC Energy Insights.

Second, the need for cost-efficient power delivery and energy conservation leads to investments in circuit optimization. By correcting sub-optimal performance in circuits, utilities can reduce generation levels and extend equipment life using analytics such as Volt/VAR optimization.

Third, coordinating grid operations with demand-side management such as Demand Response and customer resources requires rapid adjustments to grid equipment based on advanced and cognitive real-time analytics. Success will require that utilities are able to plug any number of disparate devices into a unified field network throughout the distribution grid.

> Smart Grids of the future will hinge on smarter equipment and IoT sensors interconnected to the next generation of communications network infrastructure and propagated by data-derived services.

Utilities are often faced with difficult choices for enabling networked distribution devices. Today's passive consumer will eventually become a more active participant in energy management. While mass adoption is still years away, consumers may become "prosumers" and act as energy suppliers tying their renewable generation capacity back to the distribution grid. This major trend effectively could force changes to the central control architecture by forcing the adoption of a more distributed intelligence in the electric grid system.

The Huawei Distribution Automation Solution is purpose-built to meet the burgeoning needs of Distribution Automation applications such as Volt/VAR optimization and virtual power plants. The sub-second latency requirements are satisfied through a hybrid xPON and LTE network that combines the speed of fiber with the flexibility and low deployment costs of wireless. This approach provides 99.999 percent reliability for sub-100 ms latency in network and SCADA operations. Implemented on IPv6 protocol, QoS capabilities can prioritize and route traffic based on application latency, equipment fault thresholds, or other data traffic segmentation needs. Using rugged equipment and reliable support for utility-specific protocols such as GOOSE, substations can easily be outfitted.

Cloud Data Centers Secure Operations

Responsible for enterprise infrastructure in the back office, IT is the valued critical partner leading security and data management in business operations systems. Several long-arching trends are bolstering the collaborative efforts that need IT to play a prominent role in the Smart Grid. First, smart device proliferation is creating an expansion of IP-addressable devices attached to mission-critical networks. The new cast of devices increases the vulnerability for attacks beyond the closed-network SCADA devices and engineering domain of operations. Second, cyber security is a new frontier for malicious aggression, and utility control systems are the battlefield. IDC Energy Insights revealed in its 2012 survey that 65 percent of IT departments in the U.S. hold some or the entire security budget. Third, data is growing exponentially as a result of smart meters, distribution line sensors, smart transformers, and dozens of other device types. Larger data volumes require flexible storage and data mining analytics with scalability not foreseen for existing IT structures.

Data center strategies are under consideration, and not just for disaster recovery or redundancy. On-premise data centers can be labor intensive. With the Big Data progression, data center management services create a quick way to reduce costs by outsourcing.

Huawei combines the strengths of traditional data centers and cloud computing technologies to support this vision. Huawei cloud data centers provide a range of flexible services, such as Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), and Software-as-a-Service (SaaS). In addition, they can deliver end-to-end security solutions, as well as unified Operation & Maintenance (O&M) management platforms. Huawei also offers modular data centers, which let customers choose the equipment, features, and services they want pre-installed in the data centers. The results are a quicker capacity expansion and superb customer experiences.

Overcoming Challenges for Smarter Grids

Utility IT and business unit decision-makers encounter a number of challenges in developing a Smart Grid ICT infrastructure. The following business challenges and considerations can be interrelated and share dependencies:

• Usefulness of existing assets: Evaluation of legacy communication network infrastructure impacts decisions on whether to leverage or replace with a new capital investment, such as SONET/SDH or frame relays.

• Buy versus build: Utilities prefer ownership of their ICT infrastructure. In the case of communication networks, utilities prefer ownership 5-to-1 over commercial carrier services.

• Utilities often face obstacles in assigning the investment costs of a communication network that has multiple projects, applications, and business processes that it will support.

• Governance: Communication networks for the Smart Grid require discussions and planning between Operational Technology (OT) business units

Case Study

Zhuhai Electric Power

Zhuhai Electric Power, officially China Southern Power Grid, is a state-owned energy utility that provides power generation, transmission, and distribution services to China's five southern provinces. The service area covers one million square kilometers and serves 230 million residents.

Zhuhai Electric's property portfolio includes generation plants and a high-voltage transmission network. These assets are interconnected through its carrier-grade communication network infrastructure, which has achieved high automation levels in generation and transmission.

● Challenges

Zhuhai Electric had been using optical fiber rings over medium- and low-signal carriers. As the utility undertook the expansion of its automated substations and began planning Distribution Automation (DA) feeders and low voltage line transformers, several limitations were identified, as highlighted below:

• System downtime of the fiber optic network is typically difficult to identify and repair.

• Repair costs are expensive for optical circuits that get severed or for equipment failures.

• The utility-owned fiber optic network infrastructure is costly to operate and maintain.

• The fiber optic network is a fixed line that is not well suited for swift device deployment, evolving network requirements, or rapid recoverability.

● Solutions & Benefits

In 2011, Zhuhai Electric began making technology selections for a wireless broadband solution. Analysis led the utility to decide on a pilot TD-LTE project based on several factors, including technical performance, technology adoption, industry standards, and vendor reputation. Huawei was selected for network hardware and management software. The Phase 1 project included one Core Network (CN), 10 Base Transceiver Stations (BTSs), and 65 Customer Premises Equipment (CPE) devices. Huawei's responsibilities included network design, system integration, network construction, and training services. The utility identified several benefits:

• Maintenance workload has been sharply reduced as power on the line can be verified remotely.

• Advanced management tools realized significant savings in the final time and expense costs for equipment installation and launch operations.

• Each terminal is IP-addressable, with real-time status available 24/7.

• Future wireless applications will expand to mobile offices and mobile operations for field workers.

(e.g. transmission, distribution, and customer operations) and/or IT network groups.

Essential Guidance for Utilities

First, ensure a governance structure exists that allows IT and the lines of business to work closely together to identify major business objectives and connect all levels of the organization at the earliest stages.

Second, collect the most relevant information about best practices at peer utilities, especially in developing a communication network strategy.

Third, identify the sources of available data and establish a realistic road map for applying analytics.

Smart Grids of the future will hinge on smarter equipment and IoT sensors interconnected to the next generation of communications network infrastructure and propagated by data-derived services. ▲

James Zhou

The future will be shaped through digital industry platforms and ecosystems. >>

The Digital Energy Platform (R)evolution

By James Zhou, Managing Director, Accenture Greater China Utilities

While many businesses are using digital initiatives to harness social, mobile, analytics, and cloud technologies, forward-looking leaders are offering consumers more by unifying such initiatives under a platform. The *2015 Accenture Technology Vision* identifies the platform (r)evolution as one of five key trends fueling the next generation of breakthrough innovation and disruptive growth.

Already, platform-based companies are capturing more of the digital economy's opportunities for strong growth and profitability. According to the Massachusetts Institute of Technology, "In 2013, 14 of the top 30 global brands by market capitalization were platform-oriented companies — companies that created and now dominate arenas in which buyers, sellers, and a variety of third parties are connected in real time."

Digital platforms enable developers to build applications that facilitate collaboration, workflow, and value across industries and geographies more seamlessly and more quickly than ever before. In fact, 81 percent of industry executives surveyed as part of the *2015 Accenture Technology Vision* believe that industry boundaries will dramatically blur as platforms reshape industries into interconnected ecosystems in order to meet consumer demands.

While digital industry platforms have unleashed tremendous value and disruption in other industries, Accenture believes that when it comes to gas, electricity, and water, the industry is poised on the brink of a platform (r)evolution.

For energy providers, the imperative is recognizing that companies in nearly every industry are already creating new digital ecosystems.

From "Me" to "We"

As enterprises move to platform-based models, their technology capabilities are rapidly changing. Innovative companies are embracing platforms to increase their capabilities so they can solve bigger problems and better serve their customers. These innovators realize that their fortunes depend not only on their own successful efforts ("me"), but also on the success of all players in their platform-driven ecosystems ("we").

Whether players include competitors, vendors, employees, consumers, or all of the above, digital platforms are facilitating competition as well as coordination. As one example, China's Smart City platform approach is enabling Siemens and major providers such as Schneider Electric to take an integrated, scalable, and repeatable approach to addressing complex urban transportation, building, and energy management challenges.

Digital technologies require rapid, modular, agile, and flexible capabilities. The best digital solutions take the power of information technology and put it in the hands of the broader ecosystem, which includes management, front-line users, end customers, partners, and developers. The fundamental shift from "me" to "we" means that utilities and energy providers must leverage what is available through the broader ecosystem to address their business requirements.

Ecosystem as an Innovation Sandbox

Leading companies are opening their platforms to external companies that can innovate for them. Organizations can further expand such efforts with platforms serving as an "innovation sandbox" in which alliance partners, startups, and even consumers can safely and creatively experiment.

With digital, businesses can more easily find fresh talent to solve new and complex challenges. Consider San Francisco-based Kaggle — the largest community forum for data scientists worldwide — where participants compete to solve analytical problems. Those who offer a successful solution may be invited to consult on interesting projects for some of the world's largest companies. Businesses are not just outsourcing operations; they are now crowdsourcing problem solving and tapping into a much broader talent pool than in the past.

Teaming up with third parties can create value in a number of areas. For example, the Dutch company Eneco has partnered with Tesla Motors to offer consumers a charging service for electric vehicles. Using the consumer's specified timeline and battery preferences, the service automatically charges the car battery when the price is low. Eneco plans to extend the platform to other car manufacturers. Another example is MeterHero, which lets smartphone users pool their water, electricity, and natural gas usage data to more effectively manage energy consumption. The tool helps users monitor real-time usage and offers cash rebates to consumers who conserve energy.

Such innovative solutions can benefit energy providers and consumers alike. Apple's App Store is a prime example. The quantity and variety of Apps encourage more users to join the platform and more developers to build Apps for it.

Organizations can further expand such efforts with platforms serving as an "innovation sandbox" in which alliance partners, startups, and even consumers can safely and creatively experiment.

Real-Time (Consumer) Business Models

Real-time operations are nothing new to businesses. For the consumer, however, real time represents new territory. Digital platforms enable breakthrough consumer capabilities that include buying and selling excess energy, providing outage updates, and enabling alerts for switching providers when prices reach a certain threshold.

Energy providers have a unique opportunity to provide real-time (or near-real-time) demand-response services to consumers through a platform that leverages smart metering and other data. In Accenture's research, *Delivering the New Energy Consumer Experience*, 93 percent of consumers reported they would like to learn more about personalized advice on actions, products,

Case Study

Mosaic: Crowdfunding Community Solar Projects

As consumers become more comfortable with online investing, Mosaic, a solar project finance company, has found success with crowdfunding community-based solar projects. Through the Mosaic platform, consumers can pledge funds and offer crowdfunding loans for solar development projects. In addition to facilitating investments, Mosaic also enables consumers to apply for solar financing at any time, on any device.

and services to reduce bills, as well as early notifications when the bill may be higher than normal.

Machine-to-machine (M2M) communications could enable real-time energy exchange for energy consumers such as a homeowner whose solar panels produce more energy than required while the neighbor's home needs power. Devices that can transact with each other based on pre-defined business rules will enable seamless, peer-to-peer information exchange and transactions in near-real time, creating an environment where real time is the new normal.

Future Energy Platforms

Many advanced options from energy storage to renewables no longer require the traditional utility role. Consumers are able to move toward energy independence as centralized generation decreases. Online communities are emerging to help connect local consumers with renewable producers in their area, bypassing the need to use the utility.

These changes represent the broader transition of the utilities industry to operations that are digitally enabled and integrated with renewables. Such operations include:

- Offerings that extend beyond traditional services; examples include remote monitoring, home energy management solutions, and smart metering.
- The ability to manage real-time demand and supply and optimize grid performance using location, asset, and consumer information.
- Real-time energy usage information to enable consumers to track, manage, optimize, and automate energy usage decisions.

Value-added industry platforms and digitally enabled offerings and services can span the entire industry value chain. The online retailer Amazon, for example, has upended traditional industries and continues to innovate, pushing its own boundaries into smartphones. The digital platform has enabled Amazon to transform how other players in the value chain interact and realize value, extend its core business capabilities into offering new revenue, and explore value at the edge of its platform. From a consumer value perspective, Accenture sees a range of platform opportunities emerging.

Data and information services — using an interoperability platform and Web portal or other channels to provide energy usage information to consumers.

- Energy Vikings, an initiative of Alphacomm Energy Solutions, BV in the Netherlands, is an independent smart meter monitoring application that offers consumers direct insight into their electricity and gas consumption. Users can remotely read their smart meters to quickly see how much their past usage has cost them. They also can access day-by-day spending to help manage billing costs, access information about available utilities, and assess whether solar would be a wise investment.

Home management services — offering smart devices and automation systems to manage all aspects of the home.

- When used with smart home appliances, the SmartHome automation device by Europe-based RWE offers maximum convenience and optimized energy management. The platform integrates in-home management services with home security features to control door and window sensors, motion and smoke detectors, and remote shutter controls. It also syncs with lighting, heating, and other in-home smart devices that consumers want to control from their mobile phones. ▲

Muhammad Aldhamen

LTE and other wireless technologies are revolutionizing oil field communications with fast, inexpensive broadband connectivity. >>

Mobility in the Oil and Gas Industry

By Muhammad Aldhamen, IEEE Saudi Arabia Section Chairman

Several years ago, the oil and gas industry started serious pursuit of a viable ICT solution for advanced, low-cost communications infrastructures that could efficiently and automatically handle the massive amounts of data required as oilfield operations became digitized and smarter.

"Smart drilling," for example, uses three-dimensional seismic maps and cables equipped with fiber-optic sensors to let oil companies know where to drill and in what direction to steer underground. These map and sensor operations generate massive amounts of Big Data that furthers the capacity for production companies to find and tap new oil and gas reserves previously hidden from older exploration technologies. Access to this new technology requires fast data transmission, massive computing power, and an integration path for interfacing with current and future ICT systems and industry operations.

Mobility is the Key

Mobile infrastructures have become the preferred ICT option for industry. The advantages of mobility are understood to include:

- Speed of execution. Simple architectures are inexpensive to install.
- Clear paths exist for connecting legacy equipment to large ICT infrastructures.
- Fast transmission of field data to monitoring facilities near and far.

As mobile systems mature, new standards for ease-of-use have become integral to digital oil field operations.

The traditional method for remote wellhead monitoring and management — smart drilling — has been to use Very Small Aperture Terminal (VSAT) satellite links. In addition to LTE devices being much less expensive and faster to deploy than a VSAT terminal, satellite circuits introduce a half-second uplink/downlink penalty that is out of bounds for the millisecond latency standards of modern broadband networks. Wireless technologies enable drilling rigs to be connected at optical-fiber speeds to corporate networks hundreds and thousands of miles away.

Smart drilling over mobile infrastructures enables the oil and gas industry to bring new wells online much faster. Besides greater levels of efficiency, the combination also reduces travel time for field technicians to remote sites and improves their safety in rugged environments.

Upstream and Downstream Mobility

A large number of applications dependent on two-way interaction have been developed in the last fifteen years to facilitate critical operational processes such as:

- Real-time monitoring of drilling rigs and remote operational sites and construction offices.
- Protecting the environment by meeting increased regulatory monitoring requirements and creating data archives.
- Workflow efficiency for process automation operations, resulting in cost savings and the reduction or elimination of travel time, distance, and duplication of effort.

Given the growing number of oil and gas companies that are actively building out new mobility infrastructures, it is just a matter of time until the competitive environment convinces the entire industry to adopt mobility solutions for access to critical production information anywhere, anytime. ▲

Junwei Cao
Professor Cao is a Research Scientist and Assistant Dean of the Research Institute of Information Technology; Research Scientist of the Institute for Energy Internet Research, Tsinghua University; Chief Scientist of Beijing Zhizhong Research Institute of Energy Internet; and Vice Director of the Research Institute of Smart Grid Technologies, Jiangsu Province, China.

Open connectivity between end-users and widely distributed sources of renewable energy appear to be inevitable. >>

Energy Internet Paradigm Raises Core Issues

By Junwei Cao, Professor of the Research Institute of Information Technology, Tsinghua University

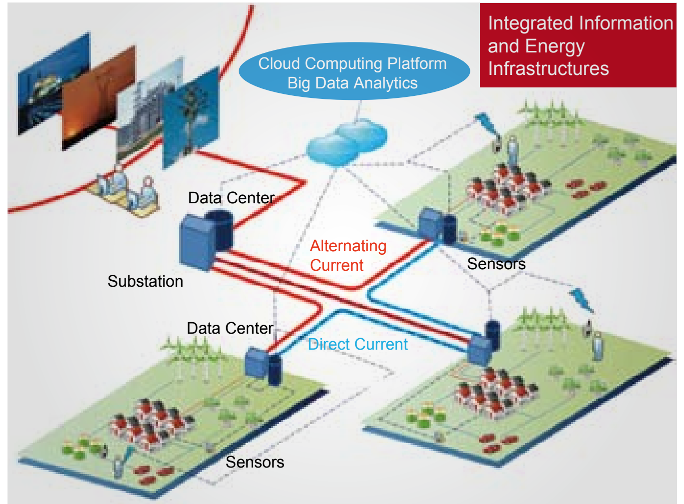
Energy Internet Development Issues

The Third Industrial Revolution, defined by economist and author Jeremy Rifkin as the convergence of Internet technology and renewable energy, is impacting the electric power industry with new production and consumption challenges. Around the world, the market share for alternative energy sources is rising at the same time that conventional fossil fuel reserves are becoming more difficult to recover economically. It is in this context that the Energy Internet introduces an ecosystem that assumes a deep integration of information technologies and renewable energy resources.

The Energy Internet platforms use the existing macro-electrical plant as the backbone for the Wide Area Networks (WANs), and the micro-grids — co-located solar and wind generation facilities — as its Local Area Networks (LANs). This shared architecture establishes an open, peer-to-peer network for transmission of information and energy over the same physical carrier. Designed for maximum flexibility, the Energy Internet architecture dynamically allocates the sources of available energy based on the consumption-demand markets.

Intermittent renewable energy, for example, accounts for more than fifty percent of power production. As a result, the crucial issues impacting the Energy Internet become effective energy exchange and efficient routing.

Policy-driven information technologies are an essential part of the Energy Internet infrastructure. Open interfaces that connect end-users and large-scale providers require complex switching networks to move electricity from the source to the consumer — a process that is wholly dependent on programmed automation to optimize the physical infrastructure of high-voltage switches and transformers.



Typical Energy Internet architecture featuring integrated information and energy infrastructures highlighting the connectivity between energy routers and cloud-based data centers

Energy Router Functionality

Inherent to the Energy Internet paradigm is the development of new techniques to accommodate fluctuations in supply and demand. Energy routers, including hubs and switches, are comparable to the data routers that are responsible for load balancing of traffic over the Internet. In traditional electricity grids, transformer substations are crucial to electricity conversion, but are not designed to decouple power sources from end-user loads. By comparison, Energy Internet routers are designed to support open access and the free exchange of energy. Energy Internet routers facilitate distributed energy management and dispatching based on the optimal, intelligently selected pathways between generation sources and end-users.

Energy routers require the following in the new Energy Internet model:

- Power storage and switching technologies to collect and exchange energy.
- Data centers for information storage and processing.

Large-capacity energy storage devices and power switching electronics devices are currently too expensive to be commercially practical. The measures being taken to resolve this issue include the integration of demand-side management technologies to help reduce costs, such as Combined Cooling, Heating, and Power (CCHP) systems. CCHP, the simultaneous generation of electricity, heating, and cooling from a single fuel source, encourages increased renewable energy consumption and promotes optimal equipment utilization. Instead of the wholesale replacement of high-voltage switches, transitional approaches being taken to lower costs include the deployment of energy storage and power control electronics into the existing power distribution network — resulting in increased redundancy and a continuing return on existing investments.

Energy Internet Management Tools

Energy management software is a necessity for exchanging and routing energy on the Energy Internet. These applications ensure the execution of the following functions:

- Dispatch operations from multiple generation sources.
- Connectivity to newly available generation sources.
- Control and management of power storage equipment.
- Control and management of generation and consumption micro-grids.
- Load balancing of energy sources from connected grids.
- Demand-side management.
- Personalized services.

Connectivity applications coordinate source-network-load interactions with other energy management systems and energy transactions with upper-layer business systems. Normally, energy exchanges over regional grids have been centrally managed; however, the interconnection of multiple grids, large and small, requires new management systems that are organized to operate in layers — from local control to coordination with a larger number of distributed facilities.

The Energy Internet ecosystem is designed to transform the energy industry from top to bottom, from business models to granular control of individual devices. In practice, the result is a platform for continuous innovation based on open, peer-to-peer connectivity.▲

The Energy Internet ecosystem is designed to transform the energy industry from top to bottom, from business models to granular control of individual devices. In practice, the result is a platform for continuous innovation based on open, peer-to-peer connectivity.

Sanqi Li

The Energy Internet is an important segment of overall Industrial Internet solutions. We expect Huawei to empower E2E Energy Internet solutions through partnership and open ecosystem foundations. >>

Key "Things" about Energy

— An Interview with Sanqi Li, Huawei Chief Scientist

By *ICT Insights*

ICT Insights magazine recently interviewed Sanqi Li, Huawei Chief Scientist, about the Energy Internet. What is the Energy Internet? How will it impact ICT? Dr. Li gives us an in-depth and detailed report on the challenges and opportunities, technologies and products, and ecosystems and transformation methodologies in this new field.

Energy Internet Generates New Business Models

ICT Insights: ***Recently, the Energy Internet has become a very hot topic of discussion and debate. How do you see the Energy industry changing, and what are the opportunities?***

Dr. Li: Today, we are living in the new digital world, where we expect more disruptive innovations across traditional industries over the next 10 years than what we have seen over the past 50 years. The Energy Internet is no exception, particularly in the green energy sector. Jeremy Rifkin states in his book *"The Zero Marginal Cost Society" [Palgrave MacMillan, 2014; ASIN: B00JIG9AYO]* that since the industrial revolution (over the last 150 years) energy efficiency has improved from 2 percent to 13 percent. It is important to note that such energy efficiency actually contributed 86 percent to global economic growth. Over the next 40 years, this new revolution is expected to increase energy efficiency to about 40 percent, accelerating the potential for economic growth.

ICT Insights: ***What are the business models that support this change? The energy sector has traditionally been a strong vertical silo; can they make the business case for change?***

Dr. Li: Recently, we have seen the coexistence of three different business models used in forming Energy Internet solutions: the incumbent transformation model, the green energy startup model, and the cloud-overlay light-asset model.

- **Incumbent transformation model:** Incumbents in the energy sector are traditionally monopolized, vertically integrated, highly regulated, heavily asset driven, and highly segmented in silos of energy generation, transmission, conversion, storage, and consumption. They will be in a constant struggle between a sustaining OPEX-focused model and a disruptive growth-focused model, between closed systems and openness, and between a diminishing monopoly and a new ecosystem value proposition as a part of transformation.

For example, Industry 4.0 activities in Europe have been largely emphasizing how to embrace such transformations given European industries' leadership positions in manufacturing and infrastructure from the previous industrial revolution.

- **Green energy startup model:** This model will likely remain a minority option in this early stage of development but has enormous potential to disrupt the existing energy. Green energy opportunities extend from more traditional generation and transmission to include natural resources, technology, economics, and marketing. In the U.S., companies such as Tesla Motors continue to invest in renewable energy. Tesla recently announced plans to build a "gigafactory" for batteries so it can produce an electric car for the mass market and possibly make batteries for city-level solar energy storage. Collaborations and partnerships among greentech companies and incumbent utilities are essential to driving the transition towards decentralized Energy Internet solutions.
- **Cloud-overlay light-asset model:** Unless incumbents are able to embrace the transformation to disrupt, they can be disrupted by pure Over-the-Top (OTT) cloud platform players. Perfect examples are Uber and AirBnB startups in the consumer space, where they can quickly establish new creative monopoly business models based on their pure software-defined light-asset cloud platform without owning any heavy assets (cars and hotels). They simply rely on their customer front-end and relationship management software asset to differentiate and compete. Telecom service providers have seen a massive disruption when non-traditional players such as Apple, WhatsApp, Facebook, and Tencent started providing OTT voice and messaging services.

Some incumbents in the energy sector in China have been trying to build strategic partnerships with leading pure cloud overlay players to accelerate their digital transformation. Such partnerships are likely to be difficult, since the core energy business (and thus, the core value delivered to the consumer) is still very asset-heavy, and utility-priced.

ICT Insights: ***Can a century-old, utility-based industry really change all that much? Partnering with Internet technology companies seems pretty far away from what we think of when we look at the traditional Energy industry.***

Dr. Li: Every business will become a digital business in the new digital world. The Energy industry is already leveraging technology to increase production and transmission efficiency, lower costs through automation, and reduce manual labor with remote meter reading, online bill processing, and hands-off infrastructure management systems.

In recent years, the ICT industry has been going through major software-defined transformation ranging from virtualization and automation across computing, storage, and network resources to highly distributed cloud service platforms and Big Data analytics. In contrast, most incumbent enterprise IT infrastructures in production today were built with 1990s technology, using highly fragmented and vertically integrated stacks. This heavy-weight foundation not only causes runaway eighty percent IT OPEX, but creates an inflexible platform that is incapable of supporting the upcoming cloud-based and Big Data-driven digital transformation.

The essence of the Energy Internet is to digitally transform the heavy-asset-oriented Energy industry through software-defined light-asset capabilities empowered by the newly transformed ICT industry, leveraging the three basic business models.

> The Energy Internet is part of Industrial IoT, which captures the new industry revolution across manufacturing, energy, agriculture, transportation, and other industrial sectors of the economy, accounting for nearly two-thirds of the global GDP.

3-Layer Industrial Internet Architecture

***ICT Insights:* How does the Energy Internet relate to Machine-to-Machine (M2M) and Internet of Things (IoT) trends that we hear so much about?**

Dr. Li: The Energy Internet is part of Industrial IoT, which captures the new industry revolution across manufacturing, energy, agriculture, transportation, and other industrial sectors of the economy, accounting for nearly two-thirds of the global GDP. In general, the Industrial IoT solution platform is vertically formed through a so-called three-layered Internet model:

- Communication Internet across various carrier, wireless, field, enterprise, and home networks.
- Industrial Internet, which digitally transforms all devices, equipment, and facilities in the physical world and hence connects them through sensors via the Communication Internet.
- (Digital) Logistics Internet, which encompasses the cloud data centers with advanced software analytics and data intelligence capabilities to empower new technologies and business innovations.

***ICT Insights:* What is Huawei doing in research and product development that fits into this vision of the future? What technology can be applied to the Energy Internet?**

Dr. Li: In the communications industry, energy sourcing, power efficiency, green-energy technologies, and energy storage have been key topics for quite some time. Just as the Energy industry changes have helped telecommunications transform, we believe that the telecommunications and ICT industries can help the Energy industry transform as well.

As a primary ICT infrastructure and platform provider, Huawei has been investing substantially across all three Internet layers for many years.

At the Communication Internet layer: Huawei has successfully driven the transformation of telecom networks from voice to data, from fixed to mobile, and from TDM to IP over the last ten years, forming the current-generation Communication Internet. Moving forward, the next-generation Communication Internet will focus on IoT services beyond human-to-human communication. SDN, NFV, Cloud, and 5G technologies will drive scalability, robustness, agility, and App-awareness across vertical markets. Network infrastructure will be transformed to a distributed cloud network across not only carrier networks but also non-carrier networks such as enterprise networks, data center networks, in-field networks, and home networks.

At the Digital Logistics Internet layer (i.e., cloud data center): About five years ago, Huawei executives made a major strategic decision to invest in the Cloud-based data center infrastructure market. Cloud technologies, along with disruptive IT business transformation, have fundamentally changed data center infrastructure requirements, including virtualized and containerized servers, software-defined storage, and software-defined networks to cloud infrastructures and platforms.

Since 2011, Huawei has achieved sustained annual double digit growth in the cloud-based data center infrastructure space. Huawei today is among the top four server product providers in the world. Our data center equipment has been deployed in more than 400 data centers, and our OpenStack-based Cloud software infrastructure, FusionSphere, has been installed in over 120 data centers around the world, largely in the enterprise market. Our Hadoop/Spark-based Big Data analytics engine, FusionInsight, has been deployed in the core of enterprise businesses, including key worldwide implementations in leading banks and tier-one telecom operators. Today, Huawei has emerged as a leading global data center infrastructure solution provider.

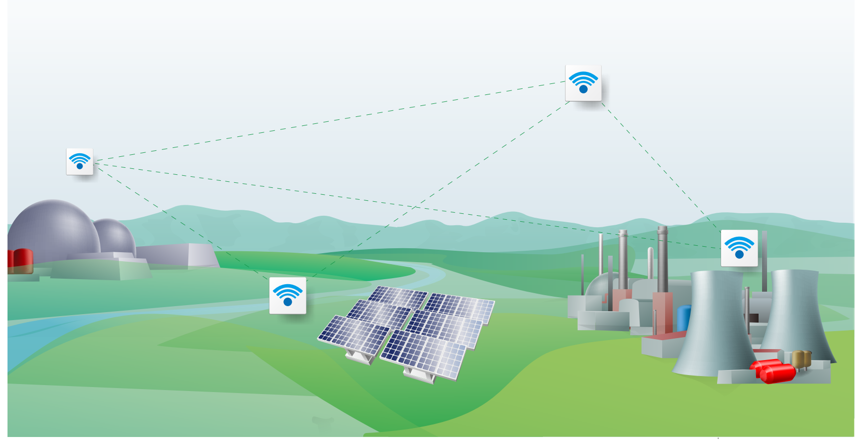
At the on-premise Industrial Internet layer, Huawei has focused mainly on building ecosystem foundations across various industry silos:

- **Communication modules:** Commonly shared by various industry devices to connect to a wide range of dynamic networks (short range, long range, industry, carrier, home, etc. through multiple generations), communications modules must meet different service requirements for latency, bandwidth, power consumption, reliability, security, and so on. Huawei has been working closely with leading automotive manufacturers for telematics; governments and public safety organizations for Smart Cities; leaders in education to connect classrooms and remote schools; and dozens of other industries to create solutions to common cross-industry connection challenges.
- **Unified OS in IoT devices (Huawei LiteOS initiative):** 100 billion rapidly emerging, highly diversified IoT devices will be connected to the Internet by 2025 with a wide range of constraints including CPU, memory, power, network, life-cycle, and many others. It is critical to develop a unified OS across diversified IoT devices for functional abstraction, software programmability, connectivity, and hardware decoupling.
- **IoT gateway:** An IoT gateway often sits in the middle between IoT devices and telecommunication networks, not only providing the necessary network connectivity, but also supporting additional intelligent functions such as event processing, protocol conversion, data aggregation, security, and Big Data streaming. Most existing industry field networks today are fragmented and proprietary, and the IoT gateway can serve as an overlay device to connect diversified industry field networks to industrial management and IT-based systems in a more standardized and open framework.

Notice that all the above three major Huawei developments have been addressing the fundamental first steps toward industry digital transformation: making industry on-premise devices digitally connect to the Communication Internet and digitally interact with the Digital Logistic Internet.

Since 2010, in the rapidly emerging green energy field, Huawei has focused on Photovoltaic (PV) inverters, which directly connect solar panels to local and public electric grids, and on other deployable energy solutions. Today, Huawei is a top supplier of PV inverters in the China market in addition to having achieved rapid growth in Europe and other international markets, with a total global installed capacity of about 10 GW. Our success is largely due to the significant technology advantages that achieve high efficiency, high reliability, and low OPEX, and are driven by the need to power ever-expanding networks around the world.

PV inverters are a critical component in solar energy systems but far from forming E2E Energy Internet solutions. In one example, Huawei adopted our eLTE devices to digitally connect all PV inverters

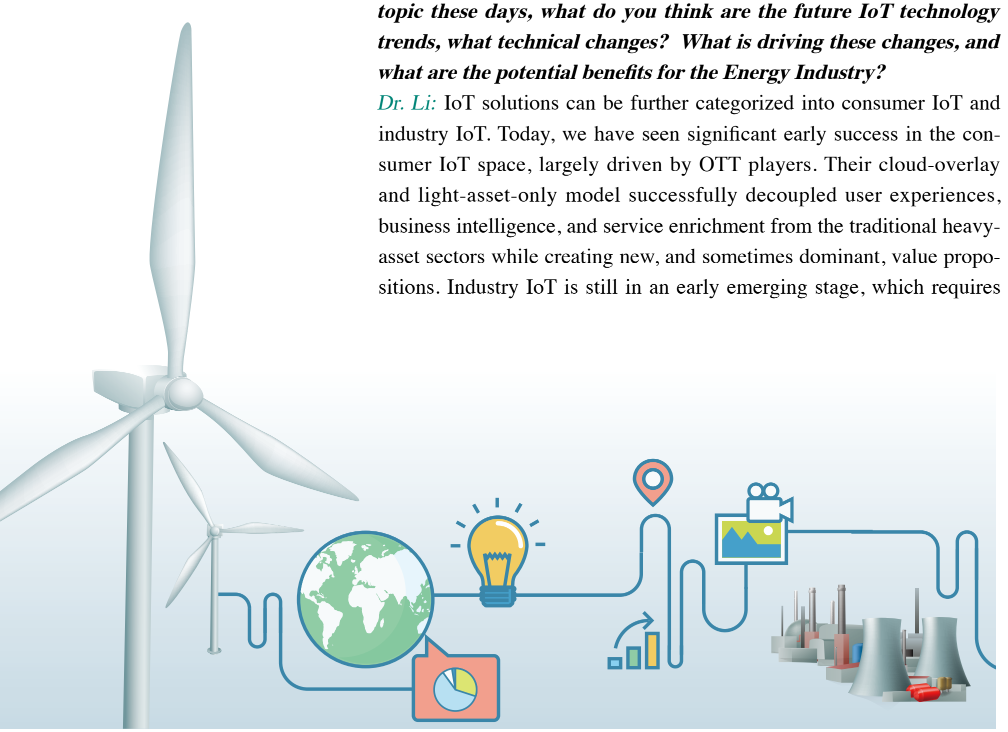


along with other existing electric grid devices to the mobile Communication Internet and integrated our cloud infrastructure solution at the enterprise centralized operation and management DC, essentially forming the basis of the future E2E Energy Internet framework.

Open Cooperation and Distributed Intelligence

ICT Insights: ***The Internet of Things (IoT) is also a very popular topic these days, what do you think are the future IoT technology trends, what technical changes? What is driving these changes, and what are the potential benefits for the Energy Industry?***

Dr. Li: IoT solutions can be further categorized into consumer IoT and industry IoT. Today, we have seen significant early success in the consumer IoT space, largely driven by OTT players. Their cloud-overlay and light-asset-only model successfully decoupled user experiences, business intelligence, and service enrichment from the traditional heavy-asset sectors while creating new, and sometimes dominant, value propositions. Industry IoT is still in an early emerging stage, which requires horizontally crossing multiple industry sectors, which is traditionally very difficult.



Sensors in industrial systems have been connected and integrated for decades, especially in the Energy industry (remote oil platforms, power meters, energy distribution networks), but have thus far lacked the openness, programmability, and agility that is predicted with the Energy Internet. Connecting things in the Energy industry will continue and accelerate, driving the real challenges around the data and context, and in realizing the value of the data and identifying new initiatives driven by that data.

Without large traditional industry enterprise participation and collaboration, pure OTT players must meet great challenges to be successful in the Industrial Internet. The data and operations of the Energy industry are locked within incumbent Energy industry systems. There is not a strong culture of openness and cross-industry ecosystems today, limiting the potential collaboration and innovation options available. So the first prediction is that openness and cooperation to share data currently embedded in Energy systems will become routine.

The second prediction is that dispersion will occur. The Energy industry has been traditionally divided into multiple sectors from generation and conversion to transmission, storage, and consumption. Like most Industrial Internet solutions, the Energy Internet solution needs to have an IoT platform across all the three Internet layers from cloud DC to network edge and then to on-premise industry devices, across multiple industry sectors. Today, the major challenge in building such an Industry IoT platform is where and how to build its distributed intelligence, especially at the distributed network edges. In other words, a substantial amount of IoT platform functions such as session connectivity, event processing, data aggregation, data streaming, discovery, and security will push to distributed network edges, closer to the consumers of energy, and closer to on-premise machines and devices.

ICT Insights: ***The IT industry talks about "Cloud" as a consolidation and centralization effort, but you are predicting that processing will spread beyond the cloud? Doesn't this conflict with the IT trend?***

Dr. Li: There are three different models about where such distributed network edges are defined to support IoT edge intelligence: overlay, underlay, and native.

The overlay model assumes that distributed network edges are located at different data centers (e.g., on-premise or central hybrid cloud). Such a model has certain limitations as on-premise data centers are typically owned by one enterprise to cover one specific sector, hence all the cross-sector M2M connectivity (which can be very substantial) has to be carried out in the central cloud DC and DC interconnects that do not scale.

The underlay model is simply to integrate such IoT edge middleware intelligence into the on-promise network devices. From a telecom providers point of view, such distributed network edges occur at their external access networks, such as industry field networks, Wi-Fi access, enterprise networks, and home networks. Obviously such networks only cover local area IoT connectivity and hence are fundamentally limited to specific local devices and data, and only in their specific sectors.

The third model is called the native model, more from the telecom network operator perspective. Distributed network edge intelligence can be integrated into the telecom network infrastructure, where edges can be dynamically distributed either at access, metro, or core networks depending on requirements and demand. Being based in the distribution of the network, this model allows a single site, location, or region to be aggregated into a logical processing hub. Logically, an oil field, a power generation plant, and a neighborhood served by a power substation are all examples of geographically related and energy sector aligned telemetry, which is most meaningful in the local context. This model has unique advantages to provide intelligence nearby to the objects and resources that are being measured and managed.

> There is a great analogy between what has happened in the telecom industry over the last 10 to 20 years and what is happening now in the energy industry. They both are monopolized and highly regulated industries.

In the long run, all three business models will co-exist. Huawei is currently developing its IoT platform with emphasis on building IoT edge middleware intelligence uniformly in support of all three business models. This solution strategy is differentiated from pure OTT players by enabling our partnership with major industry players and building a common foundation and ecosystem.

Energy Internet Revolution

ICT Insights: ***The traditional telecommunications industry was also very siloed and vertically aligned 20 years ago, like the Energy industry today, until it was first hit by Internet expansion. Huawei has already experienced this Internet transition and fast-paced evolution, and has accumulated a variety of skills and experience. How does this experience help the Energy industry transform and evolve to the Energy Internet?***

Dr. Li: There is a great analogy between what has happened in the telecom industry over the last 10 to 20 years and what is happening now in the energy industry. They both are monopolized and highly regulated industries. Telecom has successfully made three network infrastructure transformations: from voice-centric to data-centric, from TDM-based to IP-based, and from fixed-oriented to mobile-oriented, forming the basis of the content-driven Communication Internet today. Especially over the last 10 years, we have been ob-

> In reality, what is holding us back are not technologies, but the legacy silo systems in place and their associated vertical and fragmented organizations and traditional inward-focused and process-driven corporate cultures.

serving a paradigm shift about how content has been produced, processed, converted, distributed, stored, and consumed across the Communication Internet. To a great extent, telecom operators have been successful in building their Communication Internet to efficiently cope with such content dynamics, but they have not actively participated in the content ecosystems until very recently.

If you look 10 years ahead at the energy industry, the Energy Internet will undergo transformation much like what content dynamics went through on the Communication Internet. Huawei certainly has gained substantial experience and knowledge in building network infrastructure migration and transformation in support of such content flow dynamics, which is valuable as the Energy Internet matures and evolves. This will obviously include significant existing infrastructure migration and transformation while protecting the integrity and investment of current heavy assets and processes.

The Telecom industry largely missed a golden opportunity to leverage both their hard-asset and soft-asset strengths to build new value before the encroachment of OTT services into even their core service silos (voice and messaging). The incumbent players in the energy industry sector should study the lessons learned from the telecom industry sector, seeking to protect sustaining business while expecting and embracing disruptive business changes.

In recent years, the Telecom industry has initiated a new wave of transformation across network infrastructures, data centers, operations, and business-enabling platforms, empowered by rapidly emerging SDN, NFV, cloud, Big Data, and distributed system technologies. Huawei's overall strategy towards this transformation is called SoftCOM, basically embracing Software-Defined-X where X stands for network infrastructure, data center, operation and business transformation enabling. Software is commonly referred to as a light asset once it is decoupled from any hardware-based heavy asset, hence has significant cost advantages in terms of distribution, integration, operation and business management, service agility, and collaboration.

In the Industrial Internet, digital transformation implies very much the same as Software-Defined-X. That is, through the abstraction and programmability of heavy-asset industry devices one can then leverage the light-asset nature of software across the three Internet layers to accelerate the E2E digital transformation. Such an optimized combination of heavy-asset infrastructure and light-asset software will fundamentally change the traditional operation and business models to allow energy industry enterprises to become more lean, agile, efficient, and super-scalable vertically and horizontally. In fact, the current new wave of telecom industry transformation shares much more in common with the upcoming industry IoT transformation. Our direct experiences and rich knowledge gained from the current telecom industry transformation are key drivers for Huawei to strongly contribute to the newly emerging Energy Internet transformation.

ICT Insights: ***For the Energy Internet to succeed, what are Huawei's biggest challenges and difficulties?***

Dr. Li: In reality, what is holding us back are not technologies, but the legacy silo systems in place and their associated vertical and fragmented organizations and traditional inward-focused and process-driven corporate cultures. This is true of both the telecommunications industry and of the major incumbent players in the energy industry.

The new digital economy is a shared and leveraged economy and the fundamental requirements of Energy Internet solutions require horizontal integration and open relationships across every associate energy industry sector ranging from production and conversion to distribution, storage, and consumption. This will form new ecosystems with unknown and emerging new business models. Such transformation will obviously have a direct impact on current sustaining business models of various vertically integrated segments and silos, which have been traditionally monopolized and highly regulated through the previous industrial revolutions.

ICT Insights: ***What is Huawei's position on the Energy Internet? Can Huawei help build the Energy Internet ecosystem?***

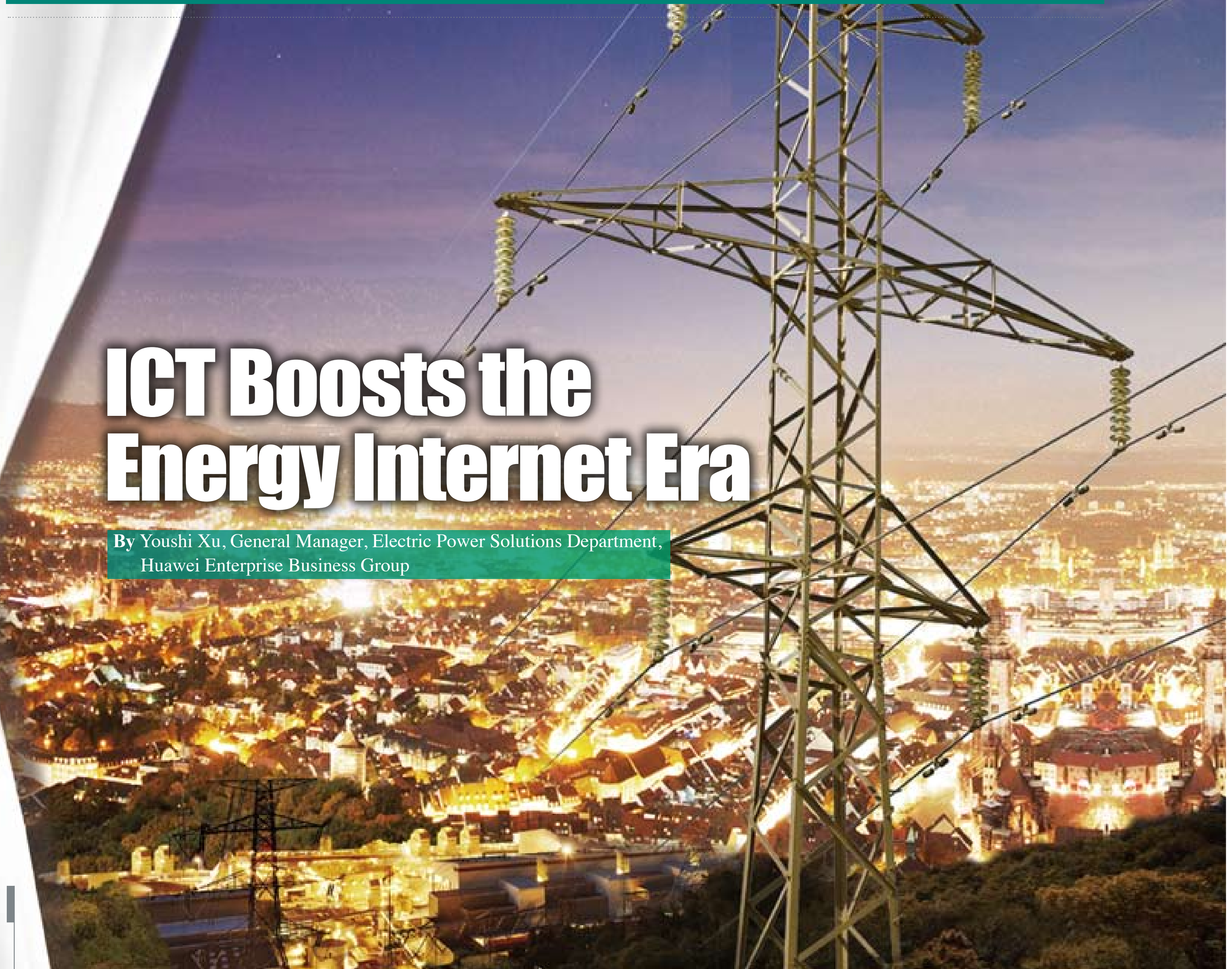
Dr. Li: Huawei is a world leading ICT infrastructure solution provider, especially in forming the next-generation Communication Internet and building new cloud-based data center infrastructure for the Digital Logistic Internet. Our Communication Internet products and solutions have been expanded from telecom networks to networks at enterprise, industry, and home premises. The new digital world is based on shared economies and collaborative commons. In recent years, Huawei has been recognized as a major technical contributor in many emerging open source communities, a cornerstone of partnership, integration, and collaboration. We see Huawei as an excellent partner contributing value to the new ecosystems, but these ecosystems will need to be driven by the energy industry itself.

Toward the rapidly emerging IoT solutions, Huawei has been developing a new cloud-based IoT platform with emphasis on IoT edge intelligence at the distributed network edges to truly enable horizontally scalable IoT solutions across various industry sectors and on-premise local network silos. For the on-premise Industrial Internet, our main focus has been on providing key components such as common communication modules and IoT gateways. Huawei is promoting a unified and scalable open source OS software framework for the industry adoption across various IoT devices through our LiteOS project initiative. To support and accelerate IoT industry alliances, Huawei has established strategic partnerships with key leading technology companies in Europe across various industry sectors, such as SAP, Accenture, ABB, Audi, NXP, STM, and Fraudhofer. In China, Huawei has established strategic partnerships with key players of different industry sectors to empower the government-led "Internet+" transformation.

The Energy Internet is an important segment of overall Industrial Internet solutions. We look for Huawei to empower E2E Energy Internet solutions through partnership and open ecosystem foundations. Achieving E2E Energy Internet solutions will require ICT infrastructure and IoT platforms in place across all three Internet layers to truly empower the collaboration and partnership among the three business models (i.e., incumbent transformation, green energy startups, and cloud-overlay light assets). Huawei has been well positioned to drive these transformations and partnerships from business, solution, and technology perspectives.▲

Youshi Xu

Large-scale electricity networks become modernized with the addition of ICT connectivity and information services. >>



ICT Boosts the Energy Internet Era

By Youshi Xu, General Manager, Electric Power Solutions Department, Huawei Enterprise Business Group

In February 2015, Zhenya Liu, President of the State Grid Corporation of China (SGCC), published his latest book, *Global Energy Internet*. This book has prompted renewed interest in the Energy Internet among industry insiders.

According to Zhenya Liu, the world has experienced a process in which the primary energy sources have evolved from firewood to fossil fuels, such as coal, oil, and natural gas. However, it is all too clear that an excessive reliance on fossil fuels is unsustainable and largely responsible for accelerated resource depletion, increasing costs, toxic environment pollution, and life-threatening climate change.

Fully Connected Power Grids

The connected energy concept proposed by Zhenya Liu argues that Information and Communications Technology (ICT) is a fundamental prerequisite for realizing the Energy Internet.

According to Essence Securities, a leading Chinese financial services company, the market value of Energy Internet in China exceeds USD 786 billion, and will create numerous business opportunities for the distribution and marketing of electricity by using micro grids to trade energy products, value-added services, equipment, and e-commerce solutions. The priority is to build Energy Internet platforms that include industry and building demand-management, intelligent wind farms, Photovoltaic (PV) solar power plants, and electric vehicle charging piles and stations.

The United States (US) and Germany have made significant progress in Energy Internet construction compared with China. In the US, General Electric (GE) has built an Internet of Things (IoT) that connects power generation, transportation, distribution, and consumption, all of which facilitate trading in the financial markets based on the value of the electricity industry vendors. GE's revenue from value-added energy management services is USD 7 billion. In Germany, more than 1,100 companies are engaged in electricity sales, and various startup companies are providing services in solar generation, power storage, and electric vehicle support.

So, what is Energy Internet? According to Professor Junwei Cao, Research Scientist of the Research Institute of Information Technology, Tsinghua University, Energy Internet is "a new type of Wide Area Network (WAN) that deeply integrates information and energy." This WAN uses existing macro grids as its backbone network and autonomous energy units, such as micro grids, and distributed energy sources as its Local Area Networks (LANs). These components are used to build an open, interconnected, peer-to-peer shared architecture that allows two-way, on-demand transmission, including the connection of new-generation sources to existing grids. Regardless of the different perspectives from which industry experts interpret Energy Internet, the fundamental expectation is to achieve a secure, clean, efficient, and sustainable source of energy as the world moves to an industrial era less dependent upon fossil fuels.

Huawei believes that Energy Internet has the following characteristics when compared to traditional energy systems:

- Connection of diverse, new, and distributed energy sources to existing grids.
- Use of elastic grids to support real-time, bi-directional demand-side interaction.
- Establishing open energy trading platforms.
- Massive numbers of intelligent, connected terminals.
- Generation and use of Big Data-derived information.

At the *2014 Huawei Electric Power Industry Summit* in Brisbane, Australia, Huawei and IDC jointly released a white paper entitled *Innovative ICT Empowers a Better Connected Smart Grid* in which Huawei first proposed the concept of a fully connected grid. At the summit, Christopher Holmes, Managing Director of IDC Insights Asia Pacific, emphasized the role of ICT as the bridge to link power grids and intelligent automation for enabling interaction between grids, power utilities, and consumers. In other words, to connect everything that can benefit from connectivity.

> To date, Huawei has deployed over five hundred Big Data projects, and more than two hundred partners have chosen Huawei's FusionInsight platform to develop their vertical solutions.

Huawei's definition of a fully connected grid includes: unified collaboration through the comprehensive sharing of grid data; agile communication networks; and intelligent dispatch and control.

Grid Data Sharing

Shared grid data enables geographically distributed resources to be integrated using cloud computing and Big Data platforms. This integration achieves the following:

- Efficient, centralized computing.
- In-depth data mining.
- Policy-driven business intelligence.
- Decision-support automation.
- Production control management and automated dispatch.

Large-scale electricity generation and transmission systems are generating vast amounts of data that pose a serious challenge to system operations in the areas of relevant analytics — a needle in the haystack problem — and the extraction of relevant information for managing significant, potential business growth. For example, the US started a nationwide installation of Phasor Measurement Units (PMU) in 2009. Because PMU measurements (voltage, current, GPS location, and others) are taken up to thirty times per second from multiple nodes, data payloads easily aggregate into the terabyte (TB) range. In China, several hundred million smart electric meters collect data once every 15 minutes, resulting in terabytes of information every day from only this source. The value of such enormous amounts of information is not always fully utilized. Using data mining and analytics, large utilities in the US and Europe have begun to build generation and consumption models based on the unstructured data collected from smart electric meters with weather data and building information. The benefit is that suppliers can authorize high-value users access to their consumption data, and thereby help them to finely tune the management of their energy demands.

The Huawei SD-DC^2 distributed cloud data center architecture is designed to improve the management and operating efficiency of both new and traditional services. The core functionality of the SD-DC^2-equipped data centers is the on-demand activation of available resources to match real-time service demands. The SD-DC^2 architecture enables customers to implement flexible data sharing and enhanced scalability, which, in turn, permits the experimentation of business models (resources versus price versus margin versus ROI). Worldwide, Huawei has deployed more than 160 cloud data centers, including systems delivered to global energy giants that include the State Grid Corporation of China (SGCC), China Southern Power Grid (CSG), China National Petroleum Corporation (CNPC), and Saudi Electricity Company (SEC).

Developing Big Data platforms is a strategic priority for Huawei. Starting in 2009, Huawei has invested heavily in Big Data research and development. Huawei is the fourth largest continuous source-code contributor to the Apache Hadoop and Apache Spark communities. To date, Huawei has deployed over five hundred Big Data projects, and more than two hundred partners have chosen Huawei's FusionInsight platform to develop their vertical solutions.

In 2014, Huawei collaborated with Guodian Nanjing Automation Co., Ltd. to carry out joint development for the power distribution field. The two companies succeeded in migrating power distribution services from traditional Supervisory Control and Data Acquisition (SCADA) master stations to the Huawei cloud platform. SCADA services are a fixture of traditional data centers, and have high requirements for real-time performance and reliability. Testing results proved that the solution fully meets the actual needs of power utilities. This solution has three core values. First, the hardware resource utilization of power distribution master stations is improved. Second, the capacity of master stations can be flexibly expanded to keep up with the rapid growth of power distribution networks. Third, the traditional 1+1 backup mode is upgraded to 1+N, which enhances the security of master stations. Huawei believes that, in the near future, these next-generation cloud technologies will be applied in key production activities of the energy industry.

Agile Communication Networks

Agile communication networks require rapid, secure, and large-capacity backbone networks to implement high-speed, bi-directional access.

In the power systems market, data is carried over both high-voltage copper and fiber-optic circuits — sometimes strung over the same transmission towers, sometimes routed independently. The electric power network is also a highly reliable broadband data channel. Broadband networks connect massive data collections with Big Data applications at cloud data centers. Because electric power systems are a component of our primary infrastructure, the associated backbone communications network is carrying increased service data traffic flows over multiple circuits that, in total, demand real-time responses to standard deviations.

> Agile communication networks require rapid, secure, and large-capacity backbone networks to implement high-speed, bi-directional, ubiquitous access.

Upgraded systems must anticipate continuing data growth for years ahead. Thailand, for example, is experiencing exploding demand for data and video services, and requires that the backbone data circuits over their new 8 TB pilot WDM network be over 10 GB each.

Huawei meets or exceeds the standards for self-healing backbone communications between long-haul, high-capacity sub-stations by enabling single networks to carry multiple types of electric power services. Embedded Phase Change Memories (PCM) — non-volatile memories that are 500 to 1,000 times faster than Flash — are the physical devices used at the substation level upon which many such all-in-one communication services are facilitated.

Backbone networks are defined by high capacity and reliability. The baseline reference for utility-scale power systems are continued, redundant operations of backbone networks between substations under stress. For instance, in 2008, China's southern provinces were heavily damaged by a severe ice storm. The pylons supporting the transmission towers for China Southern Power's (CSP) 500 kV electricity and optical fiber line collapsed and circuits were severed. Because of CSP having installed a redundant optical Synchronous Digital Hierarchy (SDH) ring-network, dispatch communications never failed and a widespread power failure was averted.

Huawei's OptiX-series Wave-Division Multiplexing/Optical Transport Network (WDM/OTN) equipment cross-connects 8 Tbits/s throughput per optical fiber. Ample bandwidth affords electric power companies the opportunity to expand their services by leasing spare bandwidth for new revenue streams. The Multi-Service Transmission Platform (MSTP) supports both TDM and IP communication planes in a single device with the flexibility to migrate to an all-IP path. OptiX equipment is deployed in the backbone networks of SGCC, E.ON — a Dusseldorf, Germany energy supplier, and the South Korean Electric Power Corporation (KEPCO).

As the global electric power industry accepts and adopts that "informatization" is the new normal, many more types of service flows will flood the power data networks. Emerging diversified services will be a second-order norm. Managing such activities is squarely in the domain of Software-Defined Networking (SDN) to interconnect computing, storage, and network functions within the area of electric power services. Huawei's SD-DC^2 is, by definition and in its entirety, a software-defined (virtualized) computing, networking, and storage platform that stages an end-to-end agile network architecture with the Agile Controller at its core. Logical services include Agile Branches, Agile Campuses, Agile Data Centers, and Agile WANs as the four supporting pillars. The SD-DC^2 agile network architecture is built to optimize the electric power resource utilization and improve service agility. Huawei Agile Network Solutions have been successfully applied to more than 300 WAN and data center networks, including SGCC, CSG, CNPC, and Guangdong Yudean Group, an electric power generation and power equipment manufacturer.

Intelligent Terminals

Huawei smart IoT gateways adapt to open Machine-to-Machine (M2M) platforms. Application interfaces establish channels for connecting electricity terminals to Energy Internet networks by retrofitting sensors to field and terminal equipment that enable high-speed, bi-directional connections with intelligent terminals and controllers.

Huawei predicts that, by 2025, one hundred billion IoT connections will exist worldwide. Ninety percent of these connections are expected to come from connections between items or machines. In recent years, China, alone, has witnessed tens of millions of new smart meters coming on-line annually. *The Power Distribution Network Construction & Reform Action Plan*, from the Chinese National Energy Administration, specifies that, between 2015 and 2020 no less than USD 314 billion will be invested in upgrading the power distribution network. The China plan also points out that the construction of smart distribution networks is the focus of all future power grids. The European Union's Third Energy Package aims to achieve eighty percent smart meter penetration by 2020 and requires intelligent terminals for power generation, transmission, transformation, and asset management. Intelligent terminals are connected to intelligent gateways through wired or wireless, close proximity Near-me Area Networks (NAN), and onto a backbone access network through the intelligent gateway. The completed signal path is an aggregation of Big Data point sources that make monitoring and remote control possible.

Ease-of-installation for massive numbers of intelligent terminals — both physically and the software configuration for local functionality and system connectivity — is a world-class challenge.

Power-Line Communication (PLC) technology is widely used in the electric power industry to transmit data over existing copper circuits because it can be easily implemented without having to pull new cable. Traditional PLC technology is limited by low transmission rates and poor communication reliability. At a communication rate exceeding 2 Mbits/s, Huawei's HiSilicon Hi-PLC chip is more than twenty times faster than any previous generation of PLC equipment. Based on adaptive frequency band selection, the Hi-PLC chip is compliant with the IEEE1901 standard for transmitting broadband data over power lines. In addition to actively suppressing noise, the Hi-PLC is able to dynamically select the optimal frequency band for transmitting data over high-voltage electric power lines. Throughput and reliability are greatly improved. Hi-PLC-equipped smart meters, tested in Huawei's Advanced Metering Infrastructure (AMI) project — an IPv6 environment — achieved a one-hundred percent meter reading success rate.

Long-Term Evolution-M2M (LTE-M) is the latest generation of 4.5G technology. A narrow-band LTE derivative oriented to IoT, LTE-M provides up to one hundred times the coverage area and more than one thousand times the connection capacity, at one-tenth the power consumption. Requiring only 200 kHz of allocated spectrum and re-using existing network resources, LTE-M addresses the practical problems of energy enterprises such as wide distribution areas and large numbers of low cost, intelligent terminals. A 2015 LTE-M pilot project with China Unicom Network Technology Research Institute successfully tested smart parking services in Shanghai.

Huawei provides an open, unified IoT Operating System (OS) that enables its partners to drive industry standardization. Officially released at the Huawei Network Congress in May 2015, at 10 KB, LiteOS is the most lightweight IoT OS available. LiteOS supports zero configuration, auto-discovery, and auto-networking — and can be widely applied to intelligent sensors and terminals in home and industry. Like the Android OS for mobile smart phones, LiteOS is open to all developers to simplify and accelerate smart hardware development.

The Future of Energy Internet

The ultimate goal of Energy Internet is to integrate global energy solutions with the capability to deliver a broad range of services. For electric power enterprises, Energy Internet can produce valuable Big Data results based on energy and consumption as follows:

- Collect the running data of every component in an electric power system to monitor the real-time status of equipment and components.
- Analyze the growth trends for increasing high-voltage loads.
- Report consumer use-habits to promote moderation in power consumption.

Huawei has come to realize that a fully connected grid lays the foundation for Energy Internet. With optimizations in areas such as Big Data, cloud computing, agile networks, and intelligent chips, ICT technologies are positioned to continue generating unexpected benefits for the energy industry.

For consumer services, Energy Internet is commonly associated with smart homes. Smart homes meaning that each family is its own network gateway within the Energy Internet, through which is connected solar micro-grids, electric vehicles, refrigerators, air-conditioners, and all manner of everything big and small. Each Energy Internet unit will maintain its balance with the regional power grid through intelligent adjustments based on supply and demand.

It can be predicted that, as the Energy Internet develops, the efficiency of transporting electricity transmissions from generators and consumers will significantly improve. Energy Internet will eventually reach consumers in the form of home energy management and smart communities not covered by the Industrial Internet. Consumer Energy Internet can be expected to foster broadest possible range of innovative business models.

Huawei has come to realize that a fully connected grid lays the foundation for Energy Internet. With optimizations in areas such as Big Data, cloud computing, agile networks, and intelligent chips, ICT technologies are positioned to continue generating unexpected benefits for the energy industry.▲

Haoxiang Zhang

Huawei's power-line solution significantly improves communication in the Advanced Metering Infrastructure processing system. >>

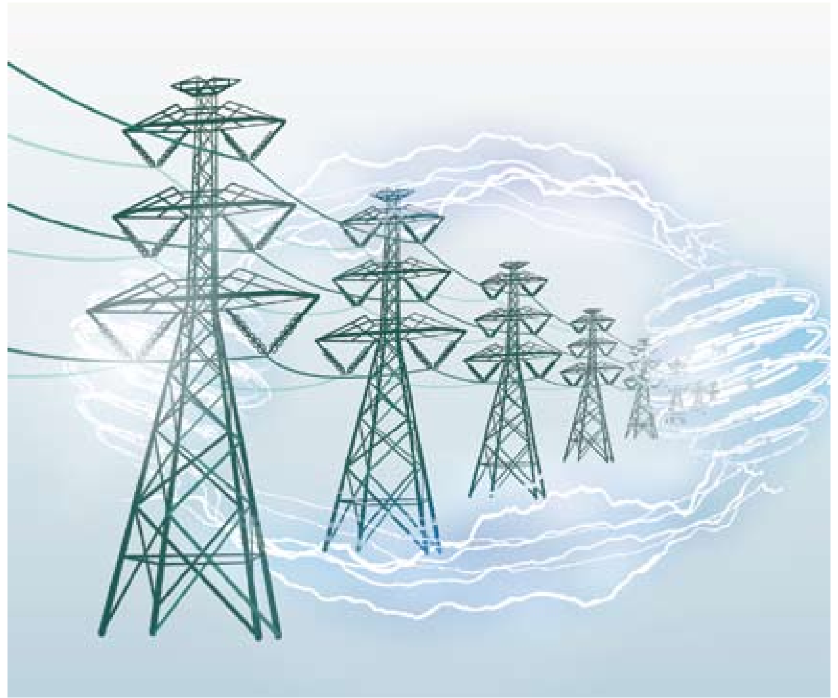
Enabling Interactive Electrical Grids

By Haoxiang Zhang, Senior Marketing Manager, Huawei IoT Gateway Product Family

The Advanced Metering Infrastructure (AMI) is a network processing system that measures, stores, analyzes, and applies consumer electricity consumption information. The AMI system includes the following:

- Smart electrical meters at user premises.
- Data management systems at power utilities.
- Communications for network interconnection.

AMI implementations provide a technical support platform for comprehensive, two-way interaction between users and the power grid by adding a digital communications return path for consumer data. Sensor networks capture measurements at circuit and device levels for efficiency and use-reduction analysis.



Power Line Interference

Intelligent meter reading systems include the older Automatic Meter Reading (AMR) technology and the newer, two-way capable AMI systems. AMI supports real-time monitoring, remote-controlled switching, and dynamic pricing.

The AMI network platform includes the use of Power-Line Communication (PLC) and Radio Frequency (RF) for communications. Despite significant noise interference penalties that complicate network data integrity, two-way PLC technologies are deployed in 60 to 70 percent of the installed base using the existing last-mile copper distribution to minimize cost.

Unlike conventional transmission media, copper power lines were never designed to transmit digital data. High-speed, grid-signaling data transmitted over electrical power lines are subject to interference, attenuation, and loss. Typical problems include:

- Distribution transformers block power-line carriers.
- High data rates induce carrier-signal attenuation.
- Background noise degrades signal transmission.

Significant Improvements to AMI

In Europe, the PoweRline Intelligent Metering Evolution (PRIME) and G3 Alliance have adopted a new generation of anti-interference multi-carrier PLC technologies based on Orthogonal Frequency-Division Multiplexing (OFDM) that are now deployed on local and regional power grids.

Huawei has launched a patented, wideband OFDM communications circuit that integrates PLC modules with external ICT routing, switching, and security technologies.

Huawei analyzed large amounts of data from grid operators on the interference characteristics of data transport over power-line channels. The result is an anti-attenuation, anti-noise solution that optimizes signal transmission frequencies automatically for delivering fast, secure communications over power-line carriers.

The Huawei wide-band PLC Solution significantly improves AMI communication quality:

- **OFDM:** Strong anti-interference characteristics and high spectrum utilization make OFDM one of three key LTE technologies. OFDM is a parallel transmission and multi-carrier modulation method that encodes digital data on multiple carrier frequencies and will be a primary modulation method for the coming 5G era.
- **Frequency band self-adaption:** In grid communication, noise distribution varies based on changing attenuation, noise, and load conditions over time. Typically, the frequency for noise registers below 1 MHz and will intermittently reach 2.5 MHz. Low-frequency noise reduces power amplifier efficiency by causing signals to lose energy, while high-frequency noise attenuates signals as transmission distances increase.

> The Huawei PLC Solution results from combining products, technologies, and capabilities to deliver a significant improvement in data communications transport quality in the AMI network processing system.

Huawei determined that power-line frequencies must be kept between 2 MHz and 12 MHz and coded a self-adaptation algorithm to dynamically select the ideal pass band for error-free throughput.

- **Anti-noise technology:** The Huawei wideband PLC Solution provides pulse noise detection and a clearance algorithm for time domain narrowband noise detection in the frequency domain. The solution uses multi-phase switch policies to contain the multi-phase noise produced by concentrators at the transformer stage.

Two key components enable the integration of Huawei's intelligent PLC technology into larger ICT architecture:

- **Huawei LiteOS:** A lightweight operating system designed for terminal devices on the Internet of Things (IoT), LiteOS uses plug-and-play communication modules that enable grid operators to dynamically update last-mile network communication environments based on local characteristics.
- **Huawei AR Series gateway:** Deployed between the public network and internal meter reading networks, the AR Series handles several upstream and downstream communication methods. Integrated firewalls and Virtual Private Network (VPN) functionality ensure channel and data security.

The Huawei PLC Solution results from combining products, technologies, and capabilities to deliver a significant improvement in data communications transport quality in the AMI network processing system.▲

Yuquan Zou

Smart Grids require intelligent communication networks to implement dispatch automation. >>

Preparing Smart Grids for IP/MPLS Networks

By Yuquan Zou, Network Architect, Huawei Fixed Network Product Line

On the morning of March 20, 2015, the Northern Hemisphere experienced a total solar eclipse. To astronomy fans, the eclipse was exciting; however, due to the quality of their grid management protocols, for the operators of Photovoltaic (PV) power grids, the temporary loss of direct sunshine was just another day at the office.

By the end of 2014, Germany had installed on the order of 1.5 million PV systems with a capacity of 38.5 GW, leading Europe and the world with 26 percent of all the PV capacity on earth and producing more than 30 percent of the nation's renewable electricity. During the sunniest hours of the year, Germany's PV systems provide up to 50 percent of the country's supply of electricity.

Prior to the 2015 solar eclipse, experts had predicted that a solar concealment event would result in "nothing interesting" for the European power grid. Per expectations, German PV systems managed to handle the steep ramp-down that began at 9:28 am. As the eclipse progressed, the electricity output of the German PV system plummeted by 1.2 GW — an effect equivalent to taking 10 nuclear power plants off-line simultaneously.

With the reappearance of full sun at noon, the PV systems had restored 1.9 GW of electrical power to the grid, the equivalent of nearly 20 nuclear power plants. In the end, this wide fluctuation of solar power posed no serious threat to power supply stability.

Intelligent Communications at Work

Smart Grids are making a worldwide contribution to the planning and implementation of progressive policies that support the advancement of national and regional electricity utilities. Unlike conventional power grids, Smart Grids make full use of advanced ICT technologies by enabling dependable, high-speed two-way communication channels for operation and management. Sensor-based measurement and control methods are combined with sophisticated ICT platforms that achieve reliable, cost-effective power grids that are secure, efficient, and environmentally friendly.

Electricity production and delivery is a real-time process in which consumption drives generation, transmission, and transformation in a dynamic equilibrium. Traditional grids provide a unidirectional flow from large-scale generators to end-users over high-, medium-, and low-voltage distribution lines — and, the majority of low- and medium-voltage circuits need minimum communication coverage. It is the addition of decentralized, renewable electricity generators — PV and wind — that require the expansion of intelligent control networks to manage the flow of energy from intermittent, often unstable, sources to and from large-scale storage fabrics and live transmission lines.

Smart Dispatching

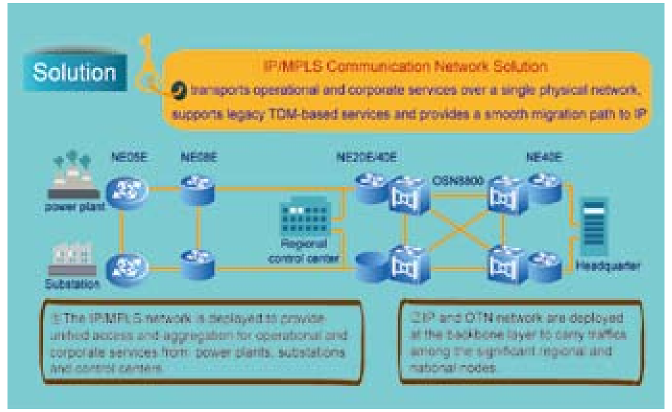
Electric utilities are focused on implementing smart dispatching to expand command and control coverage, optimize real-time performance, and promote the intelligent use of electricity. The adoption of ICT solutions is an essential component to achieve these objectives.

Dispatching services include relay protection, Supervisory Control and Data Acquisition (SCADA), electricity metering, and a dispatching telephone system. These services have low requirements on bandwidth but demand reliability and real-time performance. Power-line communication networks have traditionally been constructed using Synchronous Digital Hierarchy (SDH) circuit switching. As more Smart Grids and digital substations appear, SCADA and dispatching telephone systems are gradually transitioning to IP-based communication platforms that, in turn, support the introduction of new services such as wide-area Phasor Measurement Units (PMUs) and wide-area System Protection Schemes (SPSs).

> Huawei's automated management tools help users migrate services quickly while ensuring service continuity and stability. Simplified visual interfaces significantly reduce the cost of IP network O&M.

Huawei Empowers Intelligent Dispatching

To help Smart Grid operators implement intelligent dispatching, Huawei has launched the Smart Grid IP/MPLS Communication Solution. This solution supplements traditional communications functions with a flexible connectivity platform that handles the emergence of new access points, such as distributed power generation, large-capacity electricity storage



systems, and electric vehicle charging stations. Each of these components is designed to conveniently integrate with intelligent dispatching.

• **Carrier reliability:** The Huawei IP/MPLS communications network uses IP hard pipes to ensure secure and reliable real-time performance for Smart Grid dispatch communications. So, even when the network is congested, high-quality core services experience less than 5 ms transmission delays. This network solution also provides comprehensive equipment-level protection and end-to-end network-level protection so that fail-over services can be switched over within 50 ms of fault detection.

Huawei developed its own hard pipe technology for high-value customers to assure that strict, end-to-end jitter and delay requirements are met for relay protection services. Physically isolated in hardware, IP hard pipes deliver network performance at levels nearly equal to Synchronous Digital Hierarchy (SDH) technology. The deployment of hard pipe planes on IP/MPLS networks guarantees service-specific bandwidth completely free from congestion.

• **Efficiency and flexibility:** The Huawei IP/MPLS communications network includes a statistical multiplexing resource that improves packet channel network utilization by performing flexible Ethernet service processing. The solution provides quick, reliable protection for "Ethernet private Line" (E-Line) and "Ethernet transparent LAN" (E-LAN) services.

These features solve the lower efficiency of Traditional Time-Division Multiplexing (TDM) networks, which also lack flexibility in Ethernet service dispatching.

• **Powerful O&M:** The Huawei IP/MPLS communications network implements the U2000 unified Network Management System (NMS) to manage transmission, access, and routing equipment. U2000 provides an O&M dashboard that is derived from Huawei's SDH network interface and provides visualized IP network management and one-stop services deployment. Huawei's IP Flow Performance Measurement (IP FPM) function precisely detects packet loss ratios and signal path delays in real time to help users quickly locate faults in their networks. The uTraffic tool monitors and analyzes end-to-end service performance and provides users with detailed data analysis and network O&M reports referenced to published specifications.

Huawei's automated management tools help users migrate services quickly while ensuring service continuity and stability. Simplified visual interfaces significantly reduce the cost of IP network O&M.

The Huawei Smart Grid IP/MPLS Communications Solution supports uniform access to many types of information services — including packet-switched services needed for intelligent dispatching and a full range of low bit-rate management services over the live distribution network — for the electric power industry.▲

Yang Liu

Using an IPv6 IoT network, CNPC has simplified network O&M, and boosted the rates of oil and gas recovery. >>

China National Petroleum Corporation Transitions to IPv6

By Yang Liu, Key Enterprise Market & Solutions Sales Department, Huawei Enterprise Business Group

China National Petroleum Corporation (CNPC) is China's largest oil and gas producer, a major international oilfield services provider, and an engineering construction contractor. With operations in nearly 70 countries, CNPC is active in exploration, refining, storage, transportation, engineering services, and trading.

The two major challenges facing CNPC, and oil and gas enterprises in general, are that crude oil and natural gas are becoming increasingly scarce, and that market competition is intensifying.

Worldwide, the oil and gas industry is growing increasingly automated. The system-wide addition of networked sensors at every measurement and control-point has brought the entire industry to the threshold of creating a ubiquitous Internet of Things (IoT) for oil and gas production and distribution. It is within this context that CNPC chose to enhance their competitiveness by upgrading their digitized production automation platform to a fully intelligent solution.

Limits of IPv4

IoT-enabled oilfields rely on intelligent infrastructures built on the integration of information and communications components. For legacy plants, like CNPC that have developed their digital automation capabilities step-by-step, one of the primary technical issues standing in the way of a fully realized IoT environment are the communication networks based on the IPv4 address protocol. Because the inventory of available IPv4 addresses has been exhausted, the requirements for a complete IoT solution are impossible to meet using this old protocol.

In the production areas where IPv4 has seen continued use, address-block allocations are often discontinuous, which force artificially higher Operations and Management (O&M) costs. In addition, shared physical connections between production networks and office networks have a negative impact on service quality and security.

For all practical purposes, IPv6 breaks the limitations of overextended IPv4 networks by having an unlimited number of IP addresses. IPv6 is highly

After careful evaluation, CNPC selected Huawei as its exclusive IPv6, IoT network solutions provider, including network survey, planning, design, and installation.

efficient and supports clear network hierarchies and convenient network expansion. Based on these ease-of-use factors alone, IPv6 users have immediate information management advantages and gains in competitive position.

IPv6 Maturity

With the understanding that new technologies take time to mature, network operators worldwide have adopted a step-by-step approach to the transition of their business operations to an IPv6 platform. China, for example, has chosen several provinces for its pilot deployment of IPv6 services — an approach that CNPC also took in its transition to IPv6.

According to the “China’s Twelfth Five-Year Plan” (from 2011 to 2015), the government has selected Chinese oil and gas producers to pilot the construction of dedicated IPv6 communication networks. The goal is to establish examples for using IPv6 in IoT environments with an emphasis on collecting security research data and developing security protection solutions.

Within the framework of the plan, CNPC outlined a blueprint for its IPv6 network construction, with the following major tasks:

- Build a three-layered, dedicated IPv6 backbone network (Access, Aggregation, and Core), for oil and gas wells. Trial networks would be built in production plants and in regional sites in a piecemeal manner until a dedicated IPv6 network for the entire oilfield is completed, including the construction of wireless IPv6 networks to transmit wellhead production data from the field.
- Design and deploy secure information exchange solutions between the (IPv4) CNPC intranet and the (IPv6) wellhead production network.
- Support access to production monitoring and management databases on both IPv4 and IPv6 networks.
- Implement three-layer information security architecture, including boundary defenses between internal and external networks for data center applications. Conduct encrypted-transmission experiments.

IoT Production Network

After careful evaluation, CNPC selected Huawei as its exclusive IPv6, IoT network solutions provider, including network survey, planning, design, and installation.

Huawei designed a two-phased solution based on CNPC’s dedicated network.

- NE40E high-end routers were deployed to build a core layer between the information and data centers.

- CloudEngine CE12800 switches for internetworking Layer 2 traffic with legacy switches using the Spanning Tree Protocol (STP).
- S12700 Agile Switches as gateways to terminate Layer 2 traffic and perform Layer 3 forwarding.
- Implement Virtual Router Redundancy Protocol version 6 (VRRPv6) and Dynamic Host Configuration Protocol version 6 (DHCPv6) for IPv6 functionality.

Designed for data centers and high-end campus networks, Huawei’s CloudEngine switches have five unique features:

- Orthogonal Switch Fabric design.
- Clos non-blocking, multi-stage (crossbar) switching architecture with fewer ports.
- Cell switching.
- Virtual Output Queuing (VoQ).
- Super large buffer.

S12700 Agile Switches utilize the fully programmable Huawei-developed Ethernet Network Processor (ENP) chips that support the smooth evolution to Software-Defined Networking (SDN) for CNPC.

Most important, the CNPC IPv6 IoT solution fully illustrates the advantages of intelligent oilfields, and has laid a solid foundation for the company to implement advancements in geology, engineering, and management.

Phase One construction of CNPC’s dedicated IPv6 IoT network has been completed, and Phase Two is underway. The Huawei solution has included security, reliability, scalability, and extensibility. Huawei’s advanced products are meeting CNPC’s business needs.

All Huawei network products support standard interfaces for proper communication with devices on existing networks. In addition to incorporating advanced technologies such as MPLS VPN, IPv6, IPv6 VPN Provider Edge (6VPE), and VRRPv6, the CNPC solution incorporates years of Huawei’s accumulated experience in large-scale network delivery.

IoT Benefits

Most important, the CNPC IPv6 IoT solution fully illustrates the advantages of intelligent oilfields and has laid a solid foundation for the company to implement advancements in geology, engineering, and management. Following this installation, CNPC has seen higher productivity and a significant improvement in the recovery rates for oil and gas — including progress in the production of cleaner energies, such as coalbed methane. Other benefits of Huawei’s solution include lower network O&M costs, a lighter human workload in harsh environments, and improved security for coalbed methane production.

By completing a dedicated IPv6 IoT production network, CNPC has achieved the goal of cross-connecting its IPv4 and IPv6 networks. CNPC has gathered basic research data and gained important experience for the construction of subsequent IoT networks across China and around the world.▲

Jianyuan Jiang

Sensor networks combined with data mining analysis of critical operations are bringing the oil and gas industry into the IoT era. >>

Prediction Models for Oilfield Production

By Jianyuan Jiang, Solution Architect, Huawei Products & Solutions Marketing and Solutions Design Department

In the *2015 Report on the Work of the Government*, Chinese Premier Li Keqiang proposed the strategic direction for "Internet+" and the development of the Internet of Things (IoT) for all industries be led by the oil, gas, and petrochemical sector.

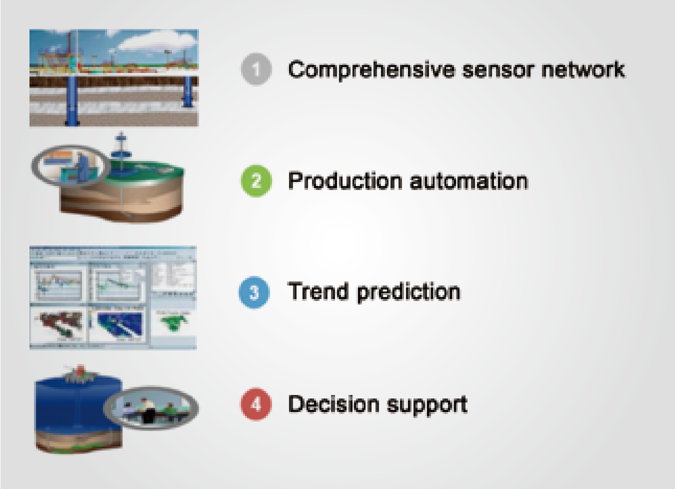
Data Mining Becomes Critical

Oil production has experienced tremendous benefits with smart digitization for extraction, pipeline, and station operations. Centralized management and control now stretches end-to-end with IoT-generated production data from wells, storage, pumping, transport stations, and processing plants, as well as equipment status information through the production command and control centers. IoT also creates additional information from the data captured between interconnected equipment.

Rapid IoT development in the oil and gas industry is propelling oilfields from "digital" to "intelligent." According to Le Deren, Chinese Academy of Sciences and the Chinese Academy of Engineering member and worldwide expert in remote sensing, "While digitization can provide offsite personnel full visibility into an oilfield, intelligent oilfields can be managed remotely and controlled by engineers in real time from thousands of miles away." The key to digital oilfields is data acquisition, in which data is collected quickly, summarized, and analyzed during oilfield exploration and development. Intelligent oilfields step up the game with predictability from data mining analysis.

Case 1: Use-Modeling

Oilfield production activities generate multiple streams of reference data every few seconds. Typical data payloads include: pump stroke length, pump speed, task duration, power consumption, fluid production, dynamic liquid level, and submerged depth.



Overview of an intelligent oilfield

The accumulation of historical data requires modeling and analysis to extract useful information. The use of IoT platforms for predictive optimization allows dynamic adjustments by examining real-time variations in wellhead productivity.

Case 2: Analytics Reduce Costs

The operating efficiency of wellheads directly affects oilfield yields. Maintenance and management of wells are important in production planning to detect, analyze, and resolve mechanical issues in a timely manner. Often, faults that are easily overlooked or hard to locate will have a direct impact on recovered volumes. Failing pumps must be stopped and repaired as quickly as possible to minimize downtime.

The resolution to many problems can be fast-tracked with the deployment of oilfield sensor networks. Common instrumentation includes load displacement, flow metering, differential pressure, and temperature measurements. Digital transducers enable IoT platforms to collect real-time data to render pumping unit diagram displays, wellhead productivity detail, water content, and other key production information. The pattern of changes in production data are recorded to establish a range of models to depict the normal and anomalous ranges for pump unit operations, sucker-rod vibration effects, pump liquid supply deficiencies, sand production, and heavy oil viscosity. These models provide a reference for well maintenance and management personnel to identify individual well problems, assess related events, and take immediate measures when the expected norms are exceeded. Data monitoring procedures are designed to trend for proactive and predictive maintenance, optimal pumping unit efficiency, long service lives, and, ultimately, maximum wellhead production.

Case 3: VR Training

Virtual Reality (VR) technology advances now include simulations of offshore drilling platforms. By means of three-dimensional (3D) displays of drilling platforms and interactive virtual peripherals, the simulation platform supports remote 3D inspection and emergency drilling operations, as well as staff training on complex equipment.

Huawei's IoT architecture is a four-layer [1+2+1] construction that fits well with the energy industry's transition to intelligent oilfields and equips oilfields to evolve using intelligent optimization from Big Data analytics.

- **3D inspection:** True-to-life inspection experiences use the real-time operating status of remote drilling platforms to graphically display live data for inspection personnel.
- **Staff training:** Staff members interact with simulated drilling platforms using visualization devices for improving the training experience, such as VR helmets, gloves, and physical touch screens.
- **Emergency drills:** By simulating accidents, such as leaks, fires, and explosions, operating staff can train and plan to handle actual emergencies and prevent further escalation.

Evolution to Intelligent Oilfields

Huawei's IoT architecture is a four-layer [1+2+1] construction that fits well with the energy industry's transition to intelligent oilfields.

- The first "1" refers to a central host platform with open connectivity for applications.
- The "2" refers to open network access, including wired and wireless.
- The final "1" represents LiteOS, the open IoT operating system.

The Huawei IoT solution equips oilfields to evolve using intelligent optimization from Big Data analytics.▲

Zongbin Zheng

The Jiujiang Branch of China energy giant Sinopec is implementing an intelligent factory strategy as a model for Industry 4.0. >>

Sinopec Jiujiang Pioneers an Intelligent Factory

By Zongbin Zheng, Reporter for *Energy Magazine*

On the bank of the Yangtze River and at the foot of famous Mount Lushan, Sinopec Jiujiang began as Jiujiang Refinery in 1980, and eventually became one of Sinopec's forty-four subsidiaries. Thirty-five years later, the Jiujiang refinery's production plant, equipment, and methods were lagging behind its peers. In response, the management of Sinopec Jiujiang is acting on the promise of Industry 4.0 technologies by committing to build smart business applications for planning and scheduling, energy management, safety, environmental protection, device operation, and IT governance. The company's efforts have created a model for implementing Industry 4.0 factory intelligence in other Sinopec subsidiaries throughout China.

Industry 4.0 in the Petrochemical Industry

Any enterprise choosing to deploy an "intelligent factory" is aiming to achieve operational and management excellence through the use of innovative technology. The concept of "Industry 4.0" includes highly computerized, modular, and integrated factories under visualized control.

According to Jianfeng Li, Deputy Director of Information Management for Sinopec, their intelligent digital factory for oil and gas production is designed to incorporate and achieve the following:

- Build a comprehensive sensor system.
- Coordinate business operations at all levels.
- Improve forecast and warning capabilities to enhance production safety and meet best-practice standards for environmental protection.
- Use cloud computing and Big Data technologies to support better decision-making.

Operationally, the goal of every intelligent factory is to provide data capture, analysis, forecasting, and process optimization capabilities for the enterprise. Although the Intelligent Factory embraces the advanced concepts of fully-networked Industry 4.0 solutions, real-world implementations remain in their infancy. According to Jianfeng Li, intelligent hardware deployments for pilot projects in China are doing well, but progress with application systems is slow, as many systems must be developed from the ground up.

To achieve company objectives, Sinopec Jiujiang plans to construct three large platforms, consisting of eight primary production systems and two supporting IT systems for each. The three platforms are expected to handle every business activity inside the company, from development and construction to production operations management and control. To help guide their business focus, the intelligent factory project at Sinopec Jiujiang is incorporating input from business departments across the organization in contrast to previous projects within Sinopec that were run by the IT department alone.

Intelligent Factory Initiatives

Sinopec Jiujiang began planning for the intelligent factory in March 2011. The 2012 goal was to define a foundation that included upgraded ICT systems and applications such as Enterprise Resource Planning (ERP) and Manufacturing Execution Systems (MES). Through 2014, key systems installed include:

- Health, Safety, and Environment (HSE) emergency command.
- Energy optimization.
- 3D factory visualization.
- Enterprise business analytics and operations monitoring.
- Business process optimization.

Completion of these items has pushed Sinopec Jiujiang to the top tier of Sinopec's ICT capabilities. Once fully operational, Sinopec Jiujiang expects to achieve an annual production capacity of one million tons.

Strategic Partnership with Huawei

Sinopec Jiujiang chose Huawei to design and build its intelligent factory solution.

The Huawei intelligent factory solution for the oil and gas industry includes a converged wired and eLTE wireless communication platform that considers the special conditions of petrochemical refineries. For example, oil refineries are dense with thousands of meters of steel pipe that block and interfere with radio transmission signals. The Huawei eLTE solution uses radio frequency technologies with optimized diffraction and penetration performance.

"In the future, new intelligent sensor technologies and smart applications will continue to emerge," says Qiming Tian, Senior Solution Architect for Huawei IoT. "Various information systems will be gradually integrated to form a unified intelligent platform and communication network. Technical development will also contribute to changes in organizational structures and gradually dismantle the barriers between departments. The result is that intelligent factory construction will play an increasingly important role in business development across all industries."

The development of Industry 4.0 intelligent factories is a long-term process. In the petrochemical sector alone, it will take years of continuous investment to achieve the desired result — and Sinopec Jiujiang has only just begun.

With a clear vision of the improvements that a completed intelligent factory will offer, Weizhong Qin, Sinopec Jiujiang General Manager said, "Imagine the complete interconnection of everything: from digital oilfields to chemical logistics, from oil and gas exploration to intelligent process control automation, where all goods and devices carry an electronic label for unified communication between devices, devices and things, things and things, and everything with people. Thanks to Huawei's leadership, our vision for an intelligent refinery is becoming a reality."▲

Voice of the Customer

"Once we begin intelligent factory construction, our journey will not end. We will continue to advance our efforts as new technologies and business needs emerge."

— Jianfeng Li, Sinopec Deputy Director of Information Management

Jianfeng Yan

Players from various industries turn to cross-border convergence to accelerate the construction of “Internet+ photovoltaics.” >>

Achieving Grid Parity with Photovoltaics

By Jianfeng Yan, Senior Product Manager, Solar Inverter Marketing Support, Energy Solution Department, Huawei Enterprise Business Group

The Yellow River Hydropower Development Co., Ltd. (YRC) is an early adopter of smart Photovoltaic (PV) power generation. Further encouraged by China’s Internet+ initiative, the YRC move to an intelligent grid aims to transform traditional industries into economic drivers.

The economic goal is to reach “grid parity,” which is the ability to generate electrical power at a cost that is less than or equal to the price of power to the grid using conventional sources, such as coal, gas turbine, or nuclear.

In March 2015, Xiaoping Xie, YRC’s Chairman and General Manager, outlined the company’s vision for intelligent PV in a press conference showcasing the company’s achievements. He said, “By combining digital information technologies, Internet technologies, and the operational systems of photovoltaic power plants, we expect to achieve intelligence in PV power generation and significantly improve the yield of our PV power plants by improving the efficiency of our management and operations. We have organized ourselves to

Smart ground PV plant project in Laxiwa, Qinghai Province, China

achieve grid parity as quickly as possible.”

China’s PV industry embarked on an Internet+ business model with the launch of a Big Data center in conjunction with the commission of a Phase III, 200 MW smart PV plant in Golmud, and the 12 MW smart PV plant in Laxiwa, both in Qinghai Province.

Building Intelligence for PV Power Plants

YRC owns twenty-five PV power plants with a total installed capacity of 1,620.1 MW. Among the factors that handicap the industry in China are solar farms that are in the most remote and harshest of all possible environments. Combined with non-urban living conditions, it is a tough sell to find Operations and Maintenance (O&M) staff willing to relocate.

To accelerate large-scale development of its PV power plants and resolve its O&M and power plant construction problems, the YRC worked with Huawei to integrate new digital information, Internet, and PV power generation technologies. The collaboration has succeeded to build smart PV power plants with significantly increased yield and O&M efficiency.

Huawei Industry-leading LTE wireless systems specially developed for PV systems were deployed in Golmud and Laxiwa to provide broadband wireless coverage for each entire plant. These systems helped YRC construct broadband infrastructures that support intelligent monitoring, remote diagnosis, and real-time maintenance of large-scale PV power plants, with performance metrics well above what had been the previous O&M baseline.

The Huawei Smart PV system uses an integrated combination of LTE, Bluetooth, and Power-Line Communication (PLC) technologies to seamlessly integrate intelligent handheld terminals, mobile applications, and intelligent unmanned aerial inspection vehicles with PV systems. “Smart PV power plants integrate monitoring, security, production, operation, and prediction systems into an intelligent monitoring system,” according to Yingtong Xu, Huawei General Manager of Intelligent Photovoltaic Power Plant Solutions. “The Huawei solution saves money by supporting the implementation of an intelligent management mode that requires few, if any, on-site personnel.”

> The Huawei Smart PV system uses an integrated combination of LTE, Bluetooth, and PLC technologies to seamlessly integrate intelligent handheld terminals, mobile applications, and intelligent unmanned aerial inspection vehicles with PV systems.

Scattered across four provinces — Shanxi, Gansu, Ningxia, and Qinghai — YRC’s PV power plants are a potential troubleshooting and maintenance headache. For example, technical specifications for the power plants cannot be analyzed accurately on a timely basis, making it difficult to achieve production safety and effective management.

“PV power plants have huge numbers of devices, so it is impossible to perform manual monitoring on them. The Huawei Smart PV Solution uses LTE to transmit data and identify faults at the level of each PV string,” says Xiaoping Xie. “Huawei has simplified on-site fault diagnosis, production management, and preventive maintenance. The remote expert assistance service can be directed to capture photos of on-site conditions. The photos are forwarded to technical experts who are able to troubleshoot remotely to locate faults as quickly as possible. The Huawei solution also supports automated troubleshooting for quick fault remediation — which reduces the overall workload of technicians, and improves the efficiency of their jobs.”

At the press conference, Huawei engineers and YRC O&M personnel participating remotely from the Laxiwa plant demonstrated the following networked control functionality:

- Mobile O&M.
- Remote diagnosis.
- Preventive inspection by unmanned aerial vehicles.
- Big Data analysis.

Huawei provides a variety of advanced products for the energy industry. These products have been widely deployed by enterprises in the energy industry, helping to build Huawei's brand recognition in energy products.

• Intelligent security. The demonstration allowed the guests at the conference to experience first-hand the sophistication of a modern, smart PV power plant.

In addition to remote expert assistance service using real-time audio and video communication, local and remote personnel also demonstrated real-time data collection, cloud storage, Big Data mining, and an online, automated system for maintenance analysis that generates recommendations for optimal cleaning cycles and component replacements. "If a 500 KW inverter stops working for one week, the electricity loss will amount to USD 3,000," added Yingtong Xu. "The intelligent monitoring and remote diagnosis functions help implement real-time maintenance and minimize the wait time. Such maintenance is easier to perform and can effectively reduce electricity losses caused by faults. The Huawei smart PV Solution has attracted the attention of the global PV industry. More than 50 industry professionals from Japan, Germany, and the United States have visited our smart PV power plants."

Internet+ PV = Smart PV

The YRC has plans to install another 46.5 GW between 2016 and 2020, including 40 GW of hydraulic tracking PV capacity.

ICT technologies have changed from support systems to production systems that drive value creation. This trend creates more strategic choices for enterprise leaders, making it easier for enterprises to break from traditional business limitations. Xiaoping Xie said, "Smart PV power plants have higher electricity conversion rates and lower construction and operation costs. They also interwork with grids better than conventional power plants, promoting healthy development of the industry."

"While there is still plenty of room for further integration of Internet and solar PV technologies, the YRC's Laxiwa PV power plant is a good example of the benefits that occur when the two technologies are combined," concluded Dinghuan Shi, Chairman of the Chinese Renewable Energy Society, in his closing remarks. "The Laxiwa project is a success due to the joint efforts of the Qinghai Province, YRC, and Huawei, who achieved synergistic advantages beyond Internet+ PV construction."

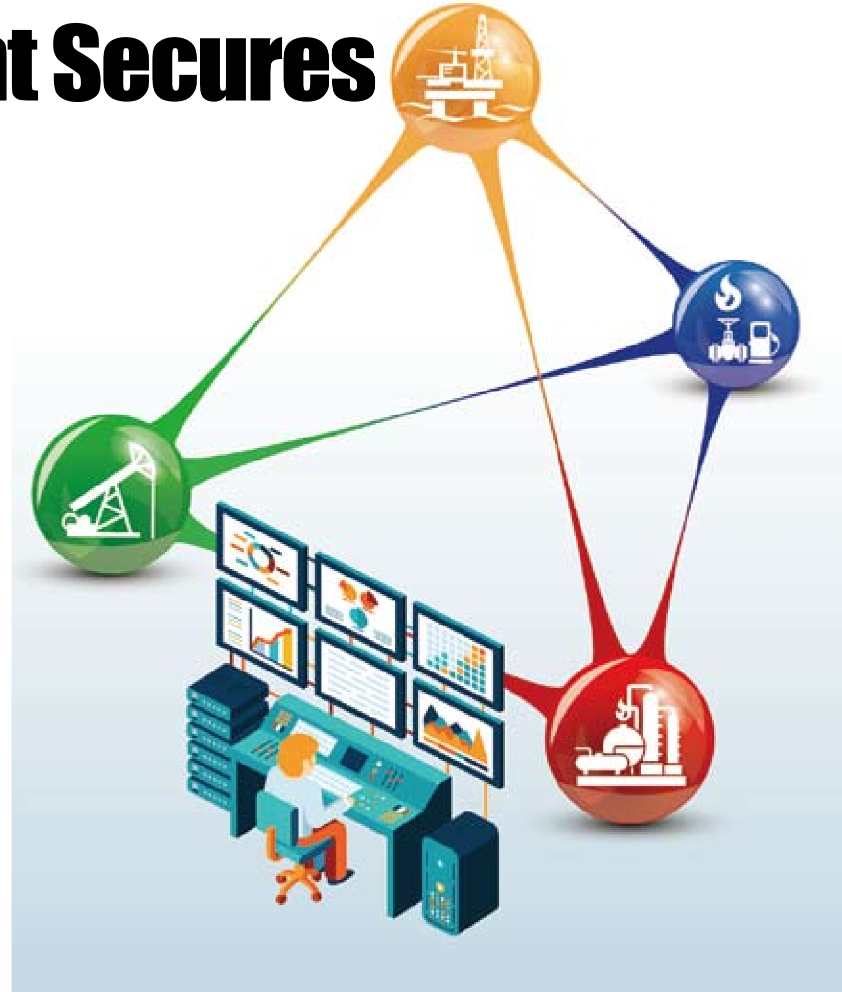
Huawei provides a variety of advanced products for the energy industry, including intelligent inverters, wireless broadband trunking systems, industry-grade switching routers, multi-functional telepresence systems, and high-end servers and storage products. These products have been widely deployed by enterprises in the energy industry, helping to build Huawei's brand recognition in energy products.▲

Shaofeng Hou

Xin Huang

New automation, security, and remote management technologies allow pipeline engineers thousands of kilometers apart to collaborate effectively. >>

Remote Management Secures Vital Gas Pipeline



By Shaofeng Hou, Solution Architect, Energy Solution Department, Huawei Enterprise Business Group and Xin Huang, Solution Sales Manager of Oil & Gas Industry, Central Asia Solution Sales Department, Huawei Enterprise Business Group

The Central Asia-China Gas Pipeline was built and is operated by Asia Gas Pipeline (AGP) LLP, a joint venture between China National Petroleum Corporation (CNPC) and KazMunaiGas, Kazakhstan's state-owned oil and gas company. Consisting of three parallel gas lines, the pipeline stretches 1,833 km from the Amu Darya River, separating Turkmenistan and Uzbekistan, to the western Chinese border town of Horgos.

With a pipe diameter of 1,067 mm each, and a combined delivery capacity of 30 billion cubic meters per annum, Lines A and B became operational in December 2009 and October 2010, respectively. For Line C, with a 1,219 mm pipe diameter and a delivery capacity of 25 billion cubic meters per annum, construction began in 2012 and came online in 2014.

The 55 billion cubic meters combined capacity is approximately 20 percent of China's annual natural gas consumption and provides the equivalent energy of 73 million tons of standard coal. The use of natural gas rather than coal will eliminate 78 million tons of carbon dioxide and 1.21 tons of sulfur dioxide emissions every year. This enormous capacity has created a billion-dollar marketplace for trading natural gas to China from its neighbors to the West.

The more recent construction of Line C, provided an opportunity to incorporate the most advanced communications technology for remote command and control.

> Together, KazStroyService Ltd. and Huawei proposed an open, multi-vendor, end-to-end broadband communications platform for voice, data, and video feeds for command and control, monitoring, and security systems.

Secure, Automated Pipe

During pipeline construction, AGP decided that the information infrastructure, including a communications network and Supervisory Control and Data Acquisition (SCADA) system, would be built along with the pipeline using the most advanced automation technologies available. A state-of-the-art operation would be assured from the start.

Given the remote, rugged terrain, difficult climate, and demanding security requirements, construction of the Kazakhstan-China gas pipeline would not be easy, and, once operational, routine on-site inspections would be few and far between. AGP required a broadband communications system accessible from many terminal types for real-time analysis, effective troubleshooting, and support for a comprehensive security management system to quickly neutralize threats of theft, sabotage, and other "forces majeures."

Building an Intelligent Pipeline

A system integrator was needed with responsibility for managing the communications and SCADA systems.

Together, KazStroyService Ltd. (KSS) — an Almaty, Kazakhstan-based engineering, procurement, and construction company — and Huawei proposed an open, multi-vendor, end-to-end broadband communications platform for voice, data, and video feeds for command and control, monitoring, and security systems.

KSS and Huawei won the bid to deliver this solution in June 2010.

• Building an Intelligent Pipeline

A fiber-optic network with satellite backup was deployed using an all-IP infrastructure. For terrestrial transmission, optical trunk cables were deployed alongside pipelines. The satellite communications system provides link redundancy to the Almaty Control Center (ACC) from five pumping stations, two monitoring stations, and thirty-three valve stations.

To protect the terrestrial network, the optical plant is a typical Synchronous Digital Hierarchy (SDH) ring topology. If the optical circuits ever go offline, critical SCADA and emergency voice circuits are routed to the emergency satellite backup. The failover time is 50 milliseconds, and is invoked by protection circuits at the board, device, and system levels.

• Inter-Station Communications

Huawei developed a custom communications system for the control centers, pumping stations, and valve stations. An IP-Private Branch Exchange (IP-PBX) voice system and videoconferencing system were deployed over a low-latency, high bandwidth trunking system for routine communications during production operations.

To protect pipeline and station equipment from damage or theft, ensure personnel safety, and respond rapidly to production accidents, Huawei deployed an Intelligent Video Surveillance (IVS) system and Intrusion Detection System (IDS) that includes a station access control system and industrial-grade broadcast system. The IDS system and access control system are linked at key points with the IVS system so that security staff is able to receive and respond to alarms as quickly as possible.

Huawei also provided a comprehensive security defense management platform to reduce Operations and Maintenance (O&M) complexity and associated costs by interworking with third-party IVS systems.

• Remote System Management

With Huawei's help, the Kazakhstan-China gas pipeline implements a true end-to-end communications system, featuring redundant transmission links and a visualized control management interface for uninterrupted communications and "anytime, anywhere" access.

In 2013, the communication system deployed by Huawei for the first section of the Kazakhstan-China natural gas pipeline (AGP-A & B line) passed acceptance testing and was put into operation — and has now operated for more than two years without incident. The remote control and communications systems for the pipeline stations ensure that alarms from Kazakhstan are monitored from as far away as Beijing by audible alert, SMS, and/or email.

> In 2013, the communication system deployed by Huawei for the A & B sections of the pipeline passed acceptance testing and was put into operation — and has now operated for more than two years without incident.

The communications alert system has been built to pinpoint preventative maintenance activities and detect latent problems early enough to reduce or eliminate the extra costs that occur in the event of a full-scale crisis.

As the monitoring center for the entire pipeline, the ACC receives, processes, and summarizes data collected over the pipeline communications channels, including the data generated by the SCADA system. Assisted by an integrated security management system, the A & B pipeline operations team, located in control stations separated by thousands of kilometers, use Huawei's cross-platform integrated Network Management System (NMS) to monitor pipeline status in real time. The NMS also offers fully automated analysis and statistics systems for visibility into the pipeline's operating status, assisting pipeline managers to head off latent issues.

3rd of Three

The design, procurement, and construction of the communications system for Line C of the Central Asia-China Gas Pipeline are currently underway by Huawei. Upon completion in 2016, AGP will enjoy having the latest-generation digital communications solution to provide remote real-time monitoring, uniform data transmission, and management services for all the stations along Lines A, B, and C of the pipeline, making for a secure, stable, and efficient "artery of energy" across the Asian continent.▲

With oil prices falling, producers need the efficiency of mobile solutions built on the IoT. >>

Huawei's IoT Vision for the Digital Oilfield

By Stephen McBride, Editor, *ITP.net*

Huawei's digital-oilfield concept rests on the company's overall vision for a four-layer Internet of Things (IoT) platform. This article describes that platform and several of the crucial technologies needed to apply the IoT to meet the needs of oil and gas production, including mobile solutions and security capabilities.

These topics were in the spotlight recently at the *Global Energy Industry Summit 2015* in Almaty, Kazakhstan. Attendees expressed a variety of concerns about efficiency, employee safety, and network security.

Dr. Hasem Nasr, Senior Advisor, Digital Oilfield, Kuwait Oil Company, warned that with the average production cost for oil approaching USD 42 per barrel, "We are almost at the point where the entire industry is losing money."

Nasr asserts that the sensor coverage in today's oil fields is totally inadequate. "How many wells in the world today are there for which we know daily production figures? Less than ten percent. You should be shocked by that number."

His closing comment: "Go digital or perish."

Go Mobile

"It is time now for enterprise mobility," declared Mohammed Al Dhamen, IEEE Saudi Arabia Section Chairman and a twenty-seven year veteran of Saudi Aramco.

He explains that efficiency is not the only reason to set up remote sensing of oilfield equipment parameters. "Right now, if you want to get a reading from one of your wells, you have to send someone to do it manually, and they have to travel in pairs; they cannot travel alone for safety reasons. Enterprise mobility is the need of the hour."

Al Dhamen cited a survey of mobility specialists in which eighty-nine percent of respondents stated that enterprise mobility solutions could revolutionize the oil and gas sector.

Building the IoT

Huawei has implemented a number of digital oilfield solutions in regions as diverse as the Arabic Gulf Cooperation Council (GCC) countries, Norway, and China. These IoT solutions range from unified communications to Bring Your Own Device (BYOD).

Some employ sensors in pipelines and other infrastructure that relays information in real time to decision-makers. These applications are an integration of software and machinery in a convergence of information and oilfield operations technologies.

Huawei's IoT infrastructure is a four-layer construction. The first is the application layer, where Huawei relies on expert partners to develop specialized oilfield management programs. The fourth layer consists of sensors, sourced from multiple vendors, to which Huawei adds the communications module.

Huawei's core expertise is directed to the second and third layers of the IoT infrastructure: the platform and network layers. The platform layer provides the functionality for managing connections, networks, and sensors. The platform layer is the tier within which the Application Programming Interfaces (APIs) give access to the application-layer solutions for integration with the IoT platform.

In the third (network) layer, most functions are similar to any traditional network layer except for the IoT gateways that must work in environments of extreme heat, cold, and vibration.

Huawei also provides the LiteOS real-time open-source operating system, designed specifically for IoT. Over the past four years, Huawei has hired about 20 top global specialists in operating systems design to develop this OS. These specialists reduced a software kernel with more than 10 million lines of source code to just 10 thousand. The result is that Huawei's partners and customers can install LiteOS in small, low-cost sensors and controllers. Further, the response times using LiteOS are extremely short, which is vital when responding to critical oilfield issues.

Assuring Security

While the IoT offers obvious benefits for oilfield management, some enterprises hold back due to security concerns. High-profile attacks, particularly the 2012 muggings of Saudi Aramco and Qatar RasGas personnel, have given pause, but today's defenses are much improved.

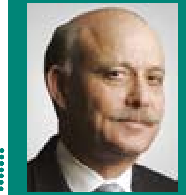
> With a broad portfolio, Huawei offers solutions for energy production that extend from back-office management to oilfield equipment for the oil and gas industry, worldwide.

Huawei has invested in network and cyber security for more than ten years, and the company's security portfolio now includes a robust firewall, intrusion prevention, intrusion detection, anti-Distributed Denial of Service (anti-DDoS), anti-Advanced Persistent Threats (anti-APT), and sandboxing functionality.

Huawei is one of the few vendors in the world offering an anti-APT solution. Using Big Data to uncover patterns of aggression by analyzing the whole network, the anti-APT software monitors all four layers of the IoT infrastructure to detect suspect activity.

This infrastructure-wide security view is in contrast to traditional approaches that monitor only a single point, or perhaps several nodes of a network. When a traditional approach detects and repels an attack at one point, the threat is thought to be averted. The use of Big Data analysis now detects whether an attack at a single point is part of a pattern that requires a broader response. For this type of situation and other threats, Huawei's security functions provide the assurance needed to bring the benefits of an IoT platform into full play.

This assurance is timely, since the viability of the global oil and gas sector may well depend on the use of IoT capabilities to realize the widespread implementation of digital oilfields. With a broad portfolio that includes unified communications, LTE networks, enterprise mobility, cloud computing, machine-to-machine functionality, and high-performance computing, Huawei offers solutions for energy production that extend from back-office management to oilfield equipment for the oil and gas industry, worldwide.▲



Jeremy Rifkin

Mr. Rifkin is the bestselling author of twenty books on the impact of scientific and technological changes on the economy, the workforce, society, and the environment.

Historically, economic revolutions have sprung from the convergence of new communication technologies and new energy systems. Today, Internet technologies and renewable energies are about to collide to create a powerful new infrastructure for a Third Industrial Revolution. >>

The Third Industrial Revolution

Book Review by Yanjing Xiao

Renowned economist, social critic, public speaker, and activist, Jeremy Rifkin is the founding theorist of "The Third Industrial Revolution." President of the Foundation on Economic Trends in Washington, D.C., his work entitled *The Third Industrial Revolution: How Lateral Power is Transforming Energy, the Economy, and the World* outlines a grand vision for a sustainable economic model in a post-carbon era and the notion of an "energy Internet."

In his book, Rifkin envisions hundreds of millions of people producing their own green energy in homes, offices, and factories, and sharing it with each other over an energy Internet, much the same way they share information online today. This socialization of energy will fundamentally change the way human beings relate, conduct business, govern, educate children, and engage in civic society.

The final stage of the Second Industrial Revolution, which includes fossil-fuel technologies, among others, is upon us. Rifkin believes that this reality might be hard for some people to accept, pushing them to make a swift transition to a new industrial energy system.

Rifkin's insight shows that, historically, economic revolutions have sprung from the convergence of new communication technologies and new energy systems. Today, Internet technologies and renewable energies are about to collide to create a powerful new infrastructure for a Third Industrial Revolution.

The following are some highlights from Rifkin's book:

1. Mounting evidence shows that the fossil-fuel era is aging and the earth's climate is changing as a direct result of petrochemical combustion; however, to maintain the status quo, some people still expect to discover more oil and natural gas, when in fact both are running out.

2. Five pillars of the Third Industrial Revolution are: (1) shifting to renewable energy; (2) transforming the buildings of every continent into micro-power plants to collect renewable energies locally; (3) deployment of hydrogen reservoirs and other storage technologies in every building, and throughout the entire infrastructure, to store intermittent energies; (4) transforming the power grid of every continent into an energy-sharing Intergrid that acts analogous to the Internet; (5) transitioning transport fleets to electric plug-in and fuel-cell vehicles that buy needed electricity from an interactive, continental power platform.

3. The cost of maintaining old infrastructures continually grows, while the cost to build new infrastructures remains relatively low. In return, new infrastructures boost economic development by creating new jobs and supporting new enterprises.

4. While 70,000 jobs will be created in the plan to build 24 new nuclear power plants in the State of New Jersey — at a cost of at least USD 200 billion and taking 20-plus years to build — it is also estimated that 300,000 jobs will be created if only 25 percent of electric power is generated from renewable energy. The positive economic developments arising from an increasing reliance on renewable energy can help a city like San Antonio, Texas fulfill its commitment to lower greenhouse gas emissions by 20 percent while increasing renewable energy by 20 percent between 2010 and 2030.

5. The cost of photovoltaic power generation is expected to fall by eight percent annually — by half every eight years. Research by Stanford University on global wind energies shows that the capture of 20 percent of Earth's wind energy would generate seven times the current level of global electricity consumption.

6. Governments, local businesses, and civil organizations should all actively participate in the Third Industrial Revolution. Transformations in municipal, regional, and national infrastructure will affect everyone eventually, changing the way people live, work, and play.

7. More farmers are transforming their farms into micro-power plants, harnessing wind, solar, geothermal, and bio energies to slash energy consumption. Energy conservation is passed down to consumers through decreasing annual fees.

8. Both "shared savings contracting" and "energy performance contracting" are collaborative business models within the Third Industrial Revolution.

9. Fields such as clean energy, green construction, electronic communication, and micro-power generation systems are gaining economic momentum in the presence of the renewable energy revolution, and new doors are opening for emerging technologies, products, and services.

10. Due to its distributed nature, the most-suitable business scale for the Third Industrial Revolution will likely emerge from collaborative alliances made up of affiliated enterprises and consumers.

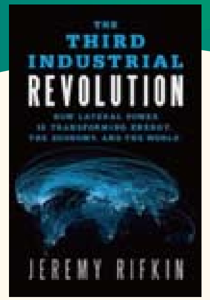
11. Supporters believe that the first and second revolutions relied on fossil fuels, which can only be produced in certain areas and secured by large military and geopolitical operations. Therefore, only developed countries benefit from them. As renewal energies are available everywhere, the new revolution can be realized by developed and undeveloped countries.

12. Conventional, centralized, top-to-bottom business operations that are characteristic of the first and second industrial revolutions will face increasing challenges from the new, collaborative business practices of the Third Industrial Revolution.

13. Social Darwinism posits that progress is the result of conflict in which the societies that adapt best are those that will prevail. This is analogous to the conclusions of recent scientific developments regarding geochemical progression: evolution is a process of mutual adaption that ensures the continuity of life within the ecosystem.

14. Transformations from fossil fuels to distributed renewable energies will redefine and reprioritize international relations from an ecological perspective. Although renewable energies are in abundance, widely available, and easily shared, harnessing this energy will require an active, collaborative management of the earth's ecological systems — which, in turn, is likely to open further possibilities for global cooperation.

In his book, Rifkin not only posits that a third industrial revolution will be brought about by the convergence of Internet technologies and renewable energies, but also discusses how the democratization of energy will profoundly impact society, economics, and political practices around the world for generations to come.▲

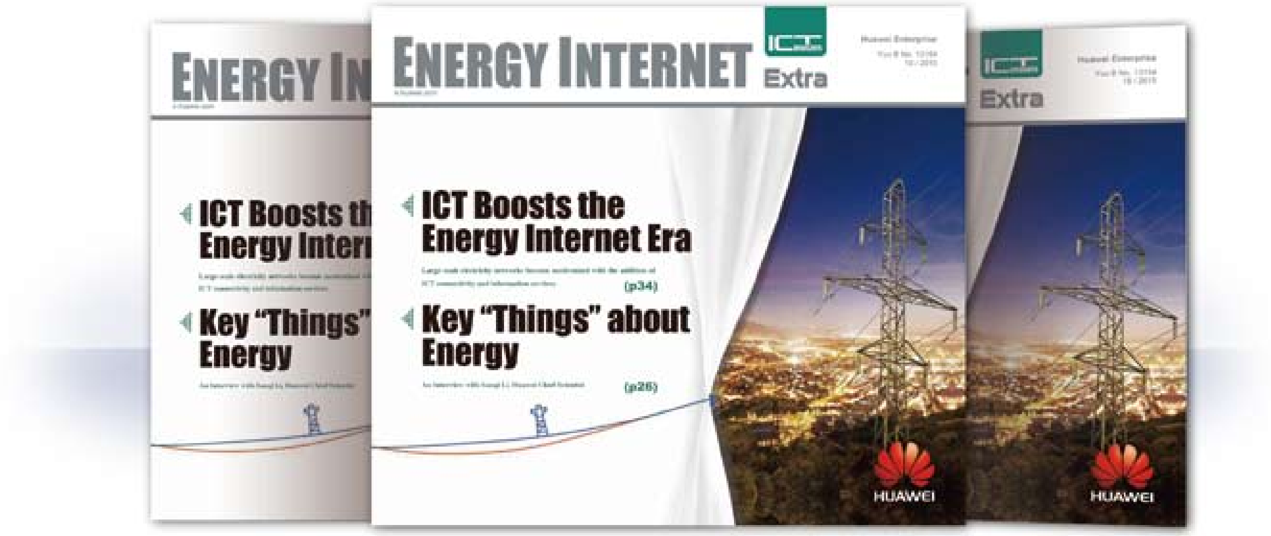


The Third Industrial Revolution

How Lateral Power is Transforming Energy, the Economy, and the World

By Jeremy Rifkin

Jeremy Rifkin is a renowned economist, a social critic, and a best-selling author; he is the founding theorist of "the Third Industrial Revolution." Rifkin is also the president of the Foundation on Economic Trends in Washington, D.C.



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