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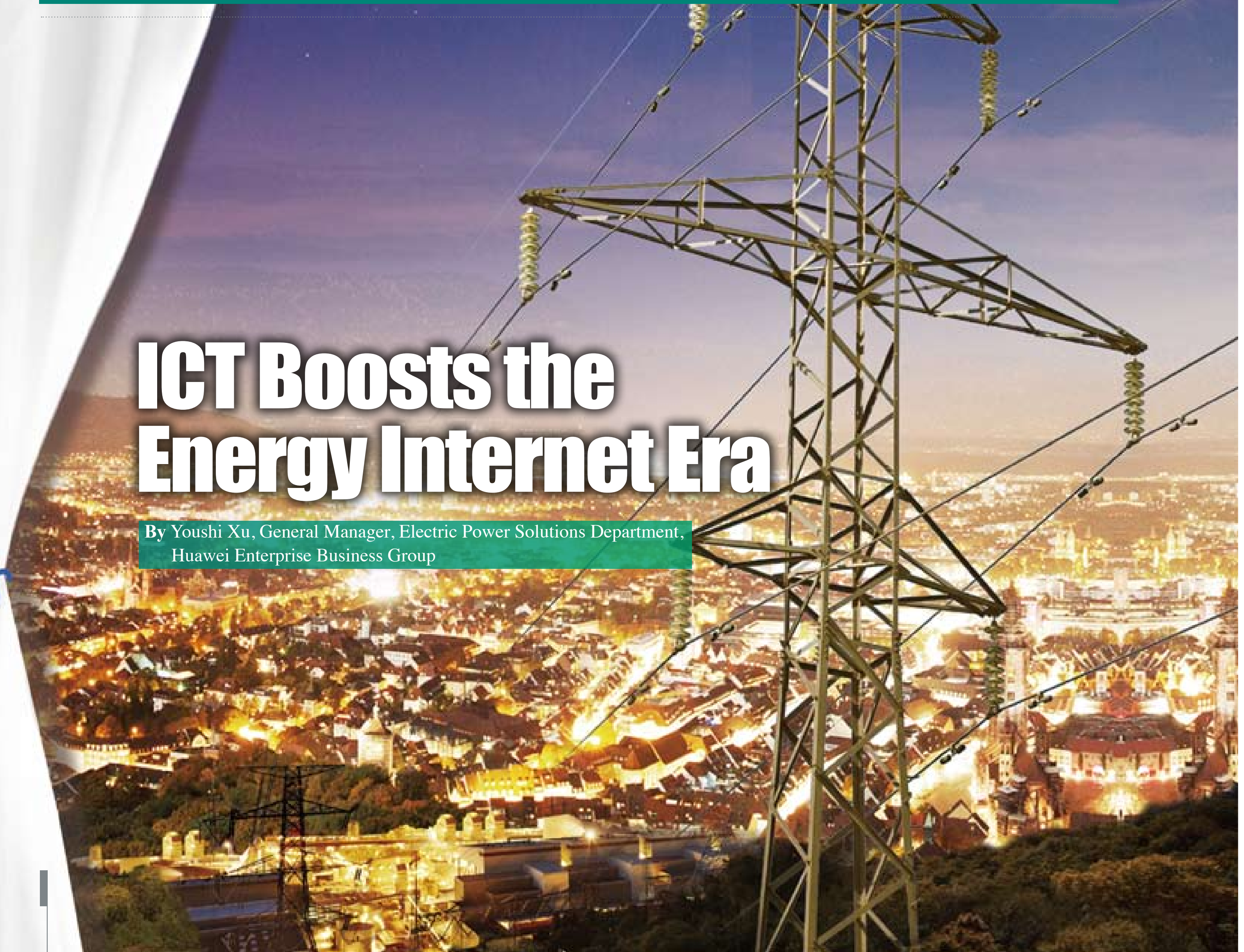
Large-scale electricity networks become modernized with the addition of ICT connectivity and information services. >>



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.

[Special Report]

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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.

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. ▲

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