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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

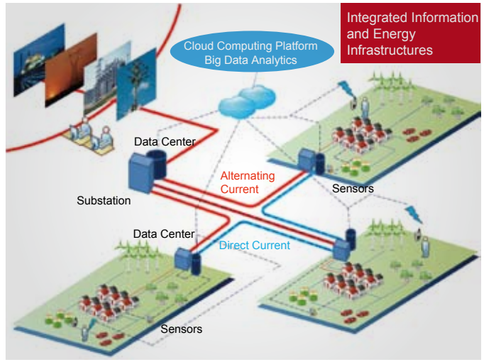
Energy Internet Development Issues

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.▲

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