

On the Application of Ubiquitous Power Internet of Things to Distributed Energy Resources Trading

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With the rapid development of communication technology, the concept of energy internet has attracted tremendous attention and interest from both industry and academia in the past few years. The smart grid-centered energy internet promotes the integration of multi-energy and application of advanced information technology, which can facilitate the penetration of renewable energy. In 2016, China government formally put forward the concept of “Internet+ Smart Energy”, a new form of energy industry development that integrates the internet with energy production, transmission, storage, consumption and energy markets, aiming at improving the accommodation of renewable energy. China’s first batch of 55 “Internet+ Smart Energy” projects were announced in 2017 to further promote the practice and development of energy internet in China. Meanwhile, some other projects around the world are also exploring the potential benefits of the application of energy internet, e.g. distributed clean energy management platform in USA, smart energy hub in Switzerland.

The internet of things, as an important technology towards energy internet transition, can promote the synergy of cyber physical systems and envision the seamless interconnection of the physical world and cyberspace and their pervasive presence around us. At the technology level of IoT, some studies focus on the core technologies of IoT, e.g. big data analysis, cloud computing, topology control in wireless sensor networks. Besides, recent IEEE Standards also provided a foundation for the application of IoT. At the economic application aspects, a detailed architecture and an implementation of a “last-meter” smart grid embedded in IoT platform is proposed. Moreover, the IoT has also been applied in manufacturing as well as in transportation system to realize information exchange. In 2019, for the first time, the “three-type and two-network” strategy was proposed as well as the construction outline of “Ubiquitous Power Internet of Things” (UPIoT). The Ubiquitous Power Internet of Things came into being, bearing the great hope of grid transformation and aiming at creating an energy internet industry ecosystem.

With the extensive use of advanced information and communication technology (ICT) in smart grids, a smart grid is a highly informative power system with mass measurement, control unit and advanced communication technology, which is a typical cyber-physical system (CPS). In recent years, distributed energy resources (DERs) have played an increasing important role in electrical industry, which imposes great challenges in both the economic operation as well as the reliable of power grids. Due to the limited controllability of DERs and the poor flexibility of power grid, the DERs cannot be fully accommodated, which significantly reduces the utilization of DERs. However, with the support of IoT, the controllability for DERs can be greatly improved, and effectively respond to dispatch signals and submit offers for energy or reserve capacity in electricity market. A wide variety of studies have focus on the IoT-based DERs scheduling and energy trading. This report will address the following the UPIoT based DERs trading:

- (1) A home energy management strategy considering comfort preference of residents is developed to coordinate residential demand response to contribute the grid’s peak regulation, relevant incentive mechanism is exploited to serve the time of use pricing.

(2) The trading mode and settlement mechanism of electric vehicles actively participating in electricity balance market is presented to provide more flexible balance service with promoting variable renewable resources accommodation.

(3) An optimal bidding framework for a V2G-enabled regional energy internet (REI) is proposed to participate in day-ahead markets considering carbon trading. The REI operator aims to maximize the net profits from day-ahead markets while anticipating the real-time adjustments.

(4) A DER sharing scheme is proposed considering communication topology, the proposed model and method will provide important references for construction of Ubiquitous Power Internet of Things.