# Technology and applications of industrial internet of things in power industry

The Power industry-Internet of Things (P-IoT) plays an important role in promoting the low-carbon transformation of energy and improving the quality and efficiency of the power grid. Currently, the global power industry is not satisfied with the effectiveness of low-carbon energy transformation. According to the data from Statistical Review of World Energy published by British Petroleum (BP) in 2018, although the penetration rate of renewable energy is increasing, the share of fossil fuels (36%) and coal (38%) in the fuel for power generation does not change significantly. As the electricity demand grows, and more types of equipment are connected to the power system, the power grid is becoming more complex. This increases the pressure on reliable, secure, and efficient operation of the power grid. At the same time, as the social-economic formation is changing in the direction of the Internet and digital economy, the conventional power industry requires a digital transformation. With the help of P-IoT infrastructure, the supply chain and demand chain can be connected directly and a multilateral power market can be established.

The P-IoT can promote panoramic perception, intelligent analysis, and accurate prediction of renewable energy, which supports the integration and improved utilization of various clean energy greatly. With the help of P-IoT, global awareness of the generation, transmission & distribution (T&D), consumption, and energy storage can be achieved, as it complements the existing information and communication technology (ICT) infrastructure in power systems. The adoption of the P-IoT can accelerate the pace of the digital transformation of the conventional power industry.

P-IoT is a specific application of IoT technology in the power industry. Similar to the concept of IoT, P-IoT is an infrastructure of interconnected objects and system of power generation, transmission, distribution, consumption with intelligent services to allow them to process information of the physical and the virtual world and make necessary decisions to react.

The key technologies of P-IoT should include the following parts: 1) Connectivity, 2) Processing and sensing, 3) Memory, 4) Security. Connectivity solves the fundamental issue of P-IoT. The modern connectivity technologies include next-generation satellite connections, the 5G communication system and low power wireless access networks (LPWAN). These technologies provide P-IoT with ubiquitous connection ability. The processing and sensing technology enables smart sensing by combining, integrating and associating data obtained from various sensors to obtain more comprehensive knowledge about observed things, situations and context. The memory technology, like the concept of virtual representation of things and devices as well as decentralized storage of data on the product itself allows for larger scale. In addition, this facilitates the setup of IoT business networks or supply chains that are not centrally orchestrated. The power industry requires high security, which needs a security mechanism, including the cloud side, management side, interface side, and user side to ensure the security of data sharing among different platforms and layers.

According to the data shared by CIGRE Working Group (WG) D2.53 members, some pilot projects of P-IoT have been launched across the world and realized outstanding achievements. The State Grid Corporation of China (SGCC) integrates IoT technology with the application of the renewable energy accomodation, virtual energy storage, and power line monitoring using unmanned aerial vehicles (UAVs). The operational state of various clean energy resources is perceived by IoT and forecasted accurately. A subsidy mechanism is implemented. At noon, when the photovoltaic generation is high, customers proactively increase electricity consumption in response to the price reduction, which promotes the consumption of renewable energy. The subsidy mechanism compensates these customers according to their contributions to load adjustment. The total capacity of demand response is expected to increase to 15 GW in the next 5 years, resulting in the cost reduction in energy consumption at about 4.5 billion RMB. Turkish Electricity Distribution Company utilizes electronic card to improve the security of distribution centers. Electricity distribution centers and the equipments inside are instantly affected by external factors in their regions. Air temperature, air quality, humidity, possible flooding and fire conditions directly affect the operation of distribution centers and the remaining life of the equipment inside. The lack of an effective security system in the distribution centers limits the operator's remote maneuverability and increases the safety risks. By developing and designing the firmware of electronic card, the security performance can be improved greatly. The eThekwini Electric Power Company in South Africa uses long-range (LoRa) communication technology to monitor the oil level in 132kV and 33kV high-voltage cables. Now the oil level in cables can be automatically monitored within several kilometers, which greatly reduces labor costs.

Although the IoT technology is beneficial for power industry, there are some challenges and issues. Firstly, creating and maintaining a holistic security model able to cope with the dynamic changes of P-IoT is becoming increasingly difficult. The continuous adding of devices involving different equipment vendors, different sensors and different physical facility security approaches increases security complexity. P-IoT is struggling with connectivity issues around maintaining sessions and not losing connections. Secondly, P-IoT system face daunting challenges on its ability to deal with system or component failures. Designers of power industry provide operational support and emergency responses requiring the ability to deal with system or component failure and still maintain functionality, full understanding and plan for such occurrences. Thirdly, P-IoT is dealing with unparalleled amounts, types, locations and sensitivities of data. P-IoT system and the platform that serve them are experiencing explosive growth in the numbers of end-points and the sensors that connect them in edge environments. Multiple architecture patterns further complexify the process of where, when, why and how the data is provided and analyzed. Device- and entity-oriented data are requiring higher abstraction layers. P-IoT asset heterogeneity is causing problems in gaining data access to multiple sources. All the mentioned issues slow down the pace of the P-IoT application.

To address the aforementioned issues, future P-IoT system will provide “holistic security capabilities” spanning the whole lifecycle of it, covering design, development, operation and maintenance. These new capabilities will take into account interdependencies, for instance, between business IT and operation technology (OT). Thus, P-IoT platforms will provide risk management as well as self-healing capabilities to detect and defeat potential cyber attacks. To improve system resilience, trustworthy security collaboration management systems will be established spanning devices, platforms and different enterprises. These security collaboration systems may run new

kinds of intelligence mechanisms to exchange security-related information in a trustworthy manner between organizations. In addition, the envisioned smartness features of P-IoT require more advanced capabilities to identify the “things” involved, such as sensors, devices and services, and to ensure data integrity, data ownership and data privacy. A new federated identity and access management is required for collecting, integrating and processing heterogeneous data from different sensors, devices and systems. New capabilities to ensure controllable data ownership across enterprise boundaries must be provided by P-IoT systems, to support the envisioned future power use cases.

The aim of WG D2.53 is to establish a reference document on a P-IoT platform solution for the electric power industry, including recommendations and best practices for related specifications,standards, and designs. So far, WG has held two meetings on 7th, June 2020, and 18th, August 2020, respectively. The agenda of the first meeting included the introduction of the working target and the content of WG. During the second meeting members discussed the Technical Brochure (TB) outline and task allocation.
CIGRE D2.53 WG will keep working on the promotion of P-IoT, supporting the digital transformation of the power grid corporations across the world.