Research on Standards for Information Supportive System in District Energy Internet Construction

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Abstract—At present, the concept of Energy Internet has attracted great attention around the world, and is generally considered to be an important means to realize carbon neutrality. In terms of the overall structure, the Energy Internet is composed by physical network system, information supportive system, and value creation system. As is known to all, the information supportive system is the nerve center of the Energy Internet. While to establish the information supportive system of the Energy Internet, standards and specifications are in urgent need. Therefore, this paper mainly focuses on standards for information supportive system in the Energy Internet construction. First, the overall structure of the information supportive system is proposed. Then, the functional characteristics of each layer in information supportive system are analyzed respectively. In addition, the existing standards for information supportive system are summarized. Meanwhile, standards that need to be formulated in the future are analyzed as well. Finally, suggestions are given for the formulation of construction of information supportive system in the Energy Internet.

1. INTRODUCTION

Energy Internet is an inevitable trend for the coordinated development of energy, environment, and economy [1,2]. The production, transmission, conversion, storage of multiple energy systems can be flexibly interacted with users through the advanced Internet of Things (IoT) technology in the Energy Internet, which can enhance the complementarity efficiency of different energy sources, and smooth the fluctuations caused by renewable energy with high penetration rate [3].

Energy Internet is composed by three important parts, including physical network system, information supportive system, and value creation system. Physical network system mainly refers to the traditional physical infrastructures of multiple energy systems. Information supportive system is a digital intelligent system covering all aspects of energy development, energy utilization and related social activities for information collection, transmission, processing, storage, and control. Value creation system is not an actual system. It is the value extension of Energy Internet. Among all the above-mentioned systems, information supportive system is the nerve center of Energy Internet [4]. At present, researches on the information supportive system of Energy Internet are mainly focused on key digital technologies [5], system reliability analysis [6], application scenarios [7], etc. While the norms and standards for information support system, which will support the construction of Energy Internet, are still relatively defective. Due to the fact that district government managers have greater autonomy and initiative in the construction of actual Energy
Internet projects. Therefore, this article focuses on the standards for the information supportive system construction of Energy Internet at the district level.

In this paper, an overall structure of information supportive system is put forward in Section II, and the functional characteristics of each layer in information supportive system are analyzed respectively as well. Then, the existing standards for information supportive system are summarized in Section III, as well as standards that need to be formulated in the future. Finally, suggestions are given for the formulation of construction standards of information supportive system in the Energy Internet in Section IV.

2. OVERALL STRUCTURE OF INFORMATION SUPPORTIVE SYSTEM

In this paper, information supportive system is divided into four layers, namely data collection layer, communication network layer, development platform layer and system application layer. Overall structure of information supportive system is shown in Fig.1.

![Fig.1 Overall structure of information supportive system](image)

2.1 Data Collection Layer

The essence of data collection is to use ubiquitous sensing technology to realize real-time collection and aggregation of multi-source devices, heterogeneous energy systems, and other environmental information. The core of this layer is to build a set of accurate, real-time, and efficient data collection systems. In this layer, some data is processed locally through protocol conversion and edge computing, while the other data is uploaded to the cloud for cloud computing processing.

The collected data type is various. From the perspective of energy categories, it can be divided into electricity data, thermal data, natural gas data, etc. From the perspective of energy supply forms, it can be classified into distributed energy data, centralized energy station data, energy network data, etc. Apart from direct energy-related data, indirect data that affects the operation of energy systems is also within the collection range, such as market price data, meteorological data, and environmental data. Generally speaking, the data collection frequency of direct energy-related data from physical network system is not less than 15 minutes per time, and data accuracy depends on the sensitivity of the sensors. While the indirect energy-related data like the GDP, corporate information, and district population can be read automatically through the third-party platform.

2.2 Communication Network Layer

Communication network layer of Energy Internet includes two parts: the backbone communication network and the terminal access network. The former mainly covers the construction of regional and municipal backbone transmission networks, and data communication networks, which strives to improve the network's reliable and efficient capacity. The latter mainly focuses on realizing the integrated energy service access through remote access network and local access network. As for Energy Internet at district level, the latter should be paid more attention on.

Remote access network mainly meets the high-reliability, low-latency, and differentiated communication requirements between the cloud master station and the terminal aggregation node. The
communication methods include optical fiber technology, power wireless private network, wireless public network like 4G/5G, etc. Under normal circumstance, optical fiber communication method is the first choice. In areas that cannot be reached by optical fiber communication networks, carrier and wireless communication are used as supplements. Local communication network mainly satisfies communication demands between terminal aggregation nodes and the terminal equipment. Power line carrier communication, RS485 bus mode, as well as some short-distance wireless communication methods are adopted in local communication network.

2.3 Development Platform Layer
Development platform layer of the information supportive system in Energy Internet, which is similar to the PaaS layer of industrial internet, provides an entrance to the platform basic functions for developers. Developers can access the basic service resources of the platform and build personalized industrial system applications through the interface provided by the development platform layer. There are three platform development modes, which are summarized as follows.

The first development mode is oriented to system application software developers. In this mode, the platform provides software developers with software development kits (SDKs) that support different development languages and application program interfaces (APIs) that comply with http or https specifications. The SDK packs the basic computing functions of the platform. Developers can build personalized applications locally through the SDK. The second mode is ordinary user-oriented. In this mode, the platform provides users with easy-to-use system development services, such as a drag-and-drop software development method. The drawback of this approach is that it cannot build a highly personalized system application for users, due to the limited basic services provided by the platform. The third mode is hybrid development mode. This mode is for the developers who have a basic software development technology reserve and expect to build personalized applications based on the platform deployment operation and maintenance environment.

2.4 System Application Layer
System application layer is concentrated on the interaction between system users and Energy Internet. In this paper, system users are divided into four major categories, including governments, energy consumers, energy operators, and energy producers. Energy Internet needs to provide functions or services such as energy monitoring, carbon measurement, energy management, energy operation and maintenance, energy optimization, transaction settlement. All the above-mentioned applications should be running throughout the whole process of energy industry services. In this layer, big data, artificial intelligence and other technical intelligent analysis are adopted to improve the efficiency of multi-energy management, reduce energy costs, and build a win-win energy ecosystem for Energy Internet.

3. STANDARDS ANALYSIS OF CONSTRUCTION FOR EACH LAYER OF INFORMATION SYSTEM
So far, there have already been some standards regarding communications and information technology in the field of industry internet. However, when it comes to the construction of information supportive system in Energy Internet, standards are still in a deficient state.

3.1 Data Collection Layer
In data collection layer, there have already been several national standards or industry standards, including basic general standards, sensor standards, measuring terminal standards, etc. [8,9]. Details are summarized in Tab. 1. However, the existing standards for data collection layer of Energy Internet are not yet complete, and some intelligent terminals still remain a low degree of standardization. For example, technical specifications for smart energy meter of Energy Internet, related standards for energy controllers, and technical specifications for energy routers have yet to be worked out.
TABLE 1. ANALYSIS OF STANDARDS FOR DATA COLLECTION LAYER

| Fields         | Standard Title                                                                 | Level                  | Standard Number          |
|----------------|--------------------------------------------------------------------------------|------------------------|--------------------------|
| Basic          | Basic environmental testing procedures for electric and electronic products    | National standard      | GB/T 2423                |
|                | Classifications and codes for sensors                                          | National standard      | GB/T 36378               |
|                | Technical guidelines for the perception layer of the Energy Internet           | /                      | To be formulated         |
|                | Layout Guidelines for Energy Internet Sensing Applications                     | /                      | To be formulated         |
| Sensor         | Specification for sensors information model of power internet of things         | Industry standard      | DL/T 1732—2017          |
|                | Requirements for smart sensor technology                                       | /                      | To be formulated         |
|                | Network access detection method for sensors                                    | /                      | To be formulated         |
|                | Value traceability method for partial discharge sensors (e.g. high frequency,  | /                      | To be formulated         |
|                | ultrahigh frequency, ultrasonic and transient ground wave)                    |                        |                          |
| Measuring      | Instrument transformers-Part 1: General requirements                            | National standard      | GB 20840.1—2010          |
| terminal       | Testing equipment for digital input electricity meters                          | National standard      | GB/T 37006—2018          |
|                | Technical specifications for smart energy meter of Energy Internet             | /                      | To be formulated         |
|                | Related standards for energy controllers                                       | /                      | To be formulated         |
|                | Technical specifications for energy routers                                     | /                      | To be formulated         |
| Local data     | Information technology-Sensor networks                                         | National standard      | GB/T 30269               |
| transmission   | Information security technology-Security technical requirements for            | National standard      | GB/T 36951—2018          |
|                | application of sensing terminals in internet of things                         |                        | DL/T 645—2007           |
|                | Multi-function watt-hour meter communication protocol                          | Industry standard      | DL/T 698                |
|                | Data acquisition and management system for electrical energy                   |                        |                          |
|                | Micropower wireless network communication protocol for power internet of things | /                      | To be formulated         |
|                | Wireless networking protocol for node devices in power internet of things       | /                      | To be formulated         |
|                | Security protection specification for edge IoT agent in power internet of things| /                      | To be formulated         |
|                | Safety certification technical requirements for perception layer devices       | /                      | To be formulated         |
|                | of power internet of things                                                    |                        |                          |
| Edge IoT       | Technical requirements for the internet of things at the edge of Energy Internet| /                      | To be formulated         |
| agent          | Technical specification for IoT agent terminal of power plant and stations      | /                      | To be formulated         |
|                | Interaction protocol specification for smart terminals and IoT management      | /                      | To be formulated         |

3.2. Communication Network Layer

In communication network layer, there have already been several international standards, industry standards, and enterprise standard. Details are summarized in Tab. 2. However, the existing standards for access network communication layer of Energy Internet are not yet complete. For example, technology standards for ultra-wideband short-range wireless communication, standards for ubiquitous network interconnection, technology standards for visible light communication, technology standards for low-power wide area network have yet to be formulated.
### TABLE 2. ANALYSIS OF STANDARDS FOR COMMUNICATION NETWORK LAYER

| Fields | Standard Title                                                                 | Level                      | Standard Number |
|--------|--------------------------------------------------------------------------------|-----------------------------|-----------------|
|        | Types and characteristics of SDH network protection architectures               | International standard     | ITU-T G.841      |
|        | Characteristics of a single-mode optical fiber and cable                        | International standard     | ITU-T G.652:2009 |
|        | Interfaces for the optical transport network (OTN)                              | International standard     | ITU-T G.709/Y.1331 |
|        | Technical specification of integrated intradyne coherent receiver               | Industry standard          | YD/T 2799       |
|        | Code for engineering design of wavelength division multiplexing (WDM) optical fiber transmission systems | Industry standard          | YD 5092-2014    |
| Access network communication | Technical Requirements for Access Network-Multi-service Delivery over EPON/GPON Systems | Industry standard          | YD/T 1953-2009  |
|        | Power ethernet passive optical network system part 3:                           | Enterprise standard        | Q/GDW1553.3-2014 |
|        | Technical requirements and testing methods for interoperability                  | Enterprise standard        | Q/GDW 11664-2017 |
|        | Technical guidelines for conception planning of electric wireless private network | /                           | To be formulated |
|        | Technology standards for ultra-wideband short-range wireless communication       | /                           | To be formulated |
|        | Standards for ubiquitous network interconnection                                | /                           | To be formulated |
|        | Technology standards for visible light communication                            | /                           | To be formulated |
|        | Technology standards for low-power wide area network                            | /                           | To be formulated |

### 3.3. Development Platform Layer

In development platform layer, there are already been several international standards and national standards, which are summarized in Tab. 3. The existing standards for this layer are concentrated on two fields, one is data sharing and management, the other is cloud computing and analysis platform. As for data sharing and management, standards for data governance and analysis algorithm, and standards for management and analysis based on digital technology have yet to be formulated. When it comes to standards for cloud computing and analysis platform, standards for cloud computing network, and standards for cloud computing services are still in need.

### TABLE 3. ANALYSIS OF STANDARDS FOR DEVELOPMENT PLATFORM LAYER

| Fields | Standard Title                                                                 | Level                      | Standard Number |
|--------|--------------------------------------------------------------------------------|-----------------------------|-----------------|
| Data sharing and management | International technology-metadata registries standard | International standard     | ISO/IEC 11179   |
|        | Information technology-procedures for achieving metadata registry               | International standard     | ISO/IEC TR 20943 |
|        | Standard series for data quality                                               | International standard     | ISO TS 8000     |
|        | Information technology-database languages                                     | International standard     | ISO/IEC 9075-1:2008 |
|        | Technical requirements of relational database management system                | International standard     | GB/T 28821-2012 |
|        | Information technology-reference model of data management                      | International standard     | GB/Z 18219-2008 |
|        | Standards for data governance and analysis algorithm                           | /                           | To be formulated |
|        | Standards for management and analysis based on digital technology              | /                           | To be formulated |
| Cloud computing and analysis platform | Information technology-cloud computing-reference architecture | International standard     | ISO/IEC 17789: 2014 |
|        | Information technology-open virtualization format specification                | International standard     | ISO/IEC 17203:2011 |
|        | Information technology-cloud data management interface                          | International standard     | ISO/IEC 17826:2012 |
|        | Graphic technology-extensible metadata platform specification                  | International standard     | ISO 16684-1:2012 |
|        | Information technology-Elastic computing application interface                  | National standard          | GB/T 31915-2015 |
|        | Information technology-cloud data storage and management                        | National standard          | GB/T 31916.2-2015 |
|        | Information security technology-security capability requirements of cloud computing services | National standard          | GB/T 31168-2014 |
|        | Standards for cloud computing network                                          | /                           | To be formulated |
|        | Standards for cloud computing service                                          | /                           | To be formulated |
3.4. System Application Layer

In system application layer, there have already been several national standards and industry standards, which are summarized in Tab. 4. The existing standards for this layer are concentrated on mobile internet and human-computer interaction. Similarly, standards for this layer of Energy Internet are not yet complete. For example, technology standards for mobile application development and evaluation, third-party service interaction standards for mobile internet applications, Security protection standards for mobile applications, and New type of human-computer interaction instant communication technology, three-dimensional space human interaction system standards are relatively lacking.

| Fields                        | Standard Title                                                                 | Level           | Standard Number          |
|-------------------------------|------------------------------------------------------------------------------|-----------------|--------------------------|
| Mobile internet and human-computer interaction | Technical requirements of security for operating system in smart mobile terminal | National standard | GB/T 30284-2013         |
|                               | Technical requirements of authorization framework for mobile internet API     | Industry standard | YD/T 2912-2015          |
|                               | Security protection requirements for networked application over mobile internet | Industry standard | YD/T 2694-2014          |
|                               | Technical requirement of internet-based service deployment and operation platform | Industry standard | YD/T 3016-2016          |
|                               | Technology standards for mobile application development and evaluation applications | /              | To be formulated         |
|                               | Security protection standards for mobile applications                        | /              | To be formulated         |
|                               | New type of human-computer interaction instant communication technology, three-dimensional space human interaction system standards | /              | To be formulated         |

4. Conclusion

This paper focuses on the construction standards of information supportive system in district Energy Internet. First, the overall structure of the information supportive system is put forward, and the functional characteristics of each layer of information system are analyzed as well. Then, the existing standards are summarized, and standards that need to be formulated in the future are proposed. Last but not least, suggestions for standard establishment are given for the construction of information system in the Energy Internet.

In data collection layer, standards like technical specifications for smart energy meter of Energy Internet, related standards for energy controllers, and technical specifications for energy routers have yet to be worked out. In communication network layer, technology standards for ultra-wideband short-range wireless communication, standards for ubiquitous network interconnection, technology standards for visible light communication, technology standards for low-power wide area network are in need of establishment. In development platform layer, standards for data governance and analysis algorithm, standards for management and analysis based on digital technology, standards for cloud computing network, and standards for cloud computing services are still in need. In system application layer, technology standards for mobile application development and evaluation, third-party service interaction standards for mobile internet applications, Security protection standards for mobile applications, and New type of human-computer interaction instant communication technology, three-dimensional space human interaction system standards are relatively lacking.

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