Controversies and Developments in Centralized Meter Reading for Electricity, Water, Gas, and Heat

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Date: 2024-02-23T22:26:55+00:00

Abstract

The "Four-meter Centralized Collection" initiative rapidly gained momentum in August 2015 following a notice from the Marketing Department of State Grid. This notice promoted the unified collection of electricity, water, gas, and heat meter data, triggering widespread attention both within and outside the industry. With the rise of this initiative, divergent viewpoints and controversies emerged regarding whether to advance "Four-meter Integrated Collection" or develop separate industry-specific collection systems for water, gas, and heat. The development trajectory of this initiative began in early 2014, when the marketing department of State Grid first proposed a technical solution for four-meter integrated collection. Subsequently, in August 2015, pilot projects for four-meter integrated collection were successively launched in cities such as Yangzhou and Jining, yielding remarkable results. State Grid consequently convened a technical exchange meeting in Jining, Shandong, to disseminate the pilot experience. As the "Four-meter Centralized Collection" movement intensified, responses from both within and outside the industry grew increasingly vigorous. On one hand, organizations such as "Global Metering" convened specialized conferences to explore the technology and applications of four-meter centralized collection; on the other hand, various industries began competing to formulate technical standards for four-meter centralized collection to facilitate its application in their respective domains. However, perspectives on establishing unified standards diverged, with some arguing that due to the four meters belonging to different industries, developing unified national and industry standards presented certain challenges. Simultaneously, China Modern Power Grid Measurement Technology initiated top-level design research on four-meter centralized collection. These studies not only investigated the technical framework and architectural design of four-meter centralized collection but also conducted in-depth research on its relationship with the Energy Internet. Moreover, separate industry-specific collection for water, gas, and heat was also undergoing

quiet upgrades. For instance, Beijing Waterworks Group proposed a new concept of independent/zonal water supply metering, achieving precise monitoring and management of water supply through the installation of independent shutoff valves and flow meters. Concurrently, the gas industry was advancing intelligentization projects, enhancing the safety and efficiency of gas production and operation via intelligent monitoring and control systems. Despite controversies and disagreements, the preliminary effectiveness of "Four-meter Centralized Collection" had become evident. According to State Grid Corporation's 2015 Social Responsibility Report, the company achieved significant progress in accelerating the collection of electricity, water, gas, and heat data in 2015. This advancement not only improved data collection efficiency and accuracy but also facilitated the intelligentization and refinement of energy management. In summary, the emergence of the "Four-meter Centralized Collection" initiative marked a significant transformation in the energy management domain. Although differing viewpoints and controversies persisted throughout this process, continuous technological innovation and standard formulation are expected to establish "Four-meter Centralized Collection" as one of the mainstream trends in energy management. Meanwhile, with the ongoing development of the Energy Internet, "Four-meter Centralized Collection" will deeply integrate with it, promoting the intelligentization and sustainable development of energy management.

Full Text

Introduction

In August 2015, the State Grid Marketing Department issued the *Notice on Accelerating the Promotion and Application of "Four-in-One Collection"*, igniting intense interest in four-meter centralized collection. Simultaneously, divergent views emerged regarding whether to advance unified four-meter collection or develop separate industry-specific systems for water, gas, and heat. Consequently, how to guide this growing momentum has become a subject of considerable attention.

This paper will trace the development trajectory of the four-meter collection trend, accommodate controversies through new objectives and pathways, and examine the influence of the Energy Internet on its evolution, providing reference for formulating four-meter collection strategies and plans.

Development Process of Four-Meter Collection

1) Origins and Triggering Events

The development process began in early 2014 when the State Grid Marketing Department first proposed a technical solution for four-meter integration in Document No. [82]. Subsequently, in August 2015, pilot projects were launched in Yangzhou and Jining with notable success. Specifically, on August 11, 2015, the Yangzhou Second Power Plant Community pilot integrated 168 households'

electricity, water, and gas usage data, which could be transmitted to respective utility databases through a three-meter collection system. On August 13, 2015, the State Grid Marketing Department issued the formal notice and released the *Typical Technical Solution for Four-in-One Collection*. The following day, reports emerged that the Jining Jin Selanting Community pilot had achieved integrated collection of electricity, water, gas, and heat meters for 1,790 households. Later in August 2015, State Grid convened a technical exchange meeting in Jining, Shandong, to promote these pilot experiences.

2) The Wave of Enthusiasm

The surge of interest manifested in three primary ways. First, organizations such as *Global Metering* convened a trilogy of thematic conferences beginning in September 2015: the first session on September 24 in Hangzhou focused on developing technical solutions for four-meter integration; the second in Shenzhen in November 2015 addressed technical exploration; and the third on March 29, 2016, in Beijing provided practical case analysis and interactive discussion.

Second, various industries rushed to organize the formulation of technical standards. On March 5-6, 2016, the second working meeting for revising the construction industry standard *Remote Meter Reading System for Residential Buildings (JG/T162-2009)* was held in Gaobeidian, Hebei, under the Ministry of Housing and Urban-Rural Development. This standard's core content addressed the generation and secure transmission of real-time consumption data for water, electricity, gas, and heat, proposing technical requirements for transmission methods and corresponding system testing approaches. In March 2016, the China Electricity Council issued a notice regarding the 2016 first batch of electric power industry standard formulation and revision plans, tasking the China Electric Power Research Institute with drafting industry standards for *Electricity, Water, Gas, and Heat Energy Measurement Management Systems* (Parts 1-4 covering general principles, system functions, equipment technical specifications, and communication protocols). However, opinions diverged on establishing unified standards. In March 2016, the Electromagnetic Measurement Information Processing Instruments Branch of the China Instrument and Control Society issued a notice on forming a working group for group standards on "Public Utility Energy (Measurement) Management Systems," noting that "due to the four meters belonging to different industries, establishing unified national and industry standards presents certain difficulties."

Third, the China Modern Power Grid Measurement Technology High-End Forum organized top-level design research for four-meter collection. On November 19, 2015, the forum released *Framework for Top-Level Design of Urban Four-Meter Collection Interconnection Networks* authored by Zhang Chunhui. On November 21, 2015, interactive discussions on the top-level design were organized via WeChat groups. On December 5, 2015, the forum held a technical lecture and discussion on "Energy Four-Meter Collection Network" architecture design at Zhengzhou Ruineng Company. On December 31, 2015, the forum

published *Further Exploration of "Energy Four-Meter Collection Network" Architecture Design (Second Edition)*, co-authored by Zhang Chunhui and Kai Zhaoqian.

3) Initial Results

According to the *State Grid Corporation 2015 Social Responsibility Report*, the company accelerated data collection construction for electricity, water, gas, and heat in 2015, collecting data from 93,273 water meters, 9,313 gas meters, and 11,229 heat meters, covering 108,000 households. State Grid proposed reaching 3 million households for four-in-one collection in 2016 and 30 million households by the end of the 13th Five-Year Plan period.

Meanwhile, separate industry collection systems for water, gas, and heat were quietly upgrading. The Beijing Waterworks Group introduced a new concept of independent/district metering areas (DMA) for water supply. By installing independent shutoff valves and flow meters in existing water pipe networks to form relatively enclosed zones, water volume at community entrances could be monitored every 15 minutes and compared with the sum of billing water meters within the zone, enabling timely detection and resolution of leakage issues. Each independent/district metering area covers approximately 5,000-10,000 households, with data transmitted every six hours to the DMA data management system. In the gas sector, intelligent engineering projects were advancing. A recently published *Technical Specification for Urban Intelligent Gas Network Engineering (Draft for Comments)*, drafted by the Beijing Gas Group and under the Ministry of Housing and Urban-Rural Development, addresses architecture design for urban intelligent gas networks, including basic requirements for data, information platforms, application infrastructure technology, and intelligent applications. The specification requires that data collection cover the full lifecycle of objects with time tags, information platforms achieve unified management of various resources in the information infrastructure, provide effective load balancing strategies, and meet big data analysis requirements. The monitoring and control system should collect and monitor urban gas production and operation data in real time, with field equipment having local and remote control functions when necessary. Intelligent measurement management employs smart metering devices to provide comprehensive and accurate measurement information, identify abnormal changes in measurement data, and support remote management of metering equipment.

Accommodating Controversy Through New Objectives and Pathways

State Grid's strong push for four-in-one collection has elicited strong reactions from water, gas, and heat industries, making the choice between unified collection and separate industry systems a focal point of controversy.

The authors contend that evaluating the merits of the four-meter collection

model should primarily consider four factors: practical system function expansion capability, capital investment direction, professional talent availability, and short-term versus long-term effects.

1) State Grid's "Four-in-One Collection" Approach

Promoting four-in-one collection is timely. As the electricity information collection system entered its later stages, State Grid sought to further leverage the value of this heavily invested system, comprehensively utilize social public resources, enhance public service levels, and address the "last kilometer" problem in serving the public. The company systematically arranged to advance four-in-one collection, with explicit deployment from provincial to county-level power supply departments in 2015, proposing typical technical solutions and standardized designs. This effort received explicit support from the National Development and Reform Commission, National Energy Administration, and Ministry of Industry and Information Technology through their joint *Guidance on Promoting "Internet Plus" Smart Energy Development*. Local governments and industry authorities should actively coordinate, placing four-in-one collection in a favorable policy environment.

State Grid possesses substantial financial resources and has requested that "government resources be actively secured, striving to incorporate four-in-one collection into smart city construction frameworks, include related construction costs in new residential area power supply project supporting fee policies, and incorporate installation positions and collection wiring requirements for electricity, water, gas, and heat meters into relevant design and construction standards for new communities." However, State Grid Marketing Department regulations stipulate that "the procurement and installation of smart water, gas, and heat meters shall be separately handled by relevant enterprises according to their respective needs," effectively sidestepping a major challenge.

The application of four-in-one collection "focuses on newly built urban residential communities, targeting key areas where governments attach importance, enterprises are proactive, and smart city construction is underway." This indicates that the short-term or localized effects are evident, but no proposal has been made for collecting data from the large number of early-installed meters in water, gas, and heat industries.

Functionally, four-in-one collection remains remote meter reading. The State Grid Marketing Department document states: "Promote the application of four-in-one collection, then develop agency meter reading and collection services, and continuously innovate commercial cooperation models." However, power supply departments do not engage with water, gas, and heat industries' needs for online production and operation monitoring systems.

Several technical issues require resolution for promoting four-in-one collection, including equivalent confidentiality measures for water, gas, and heat industry data, as well as interfaces and communication protocols for obtaining data from

the State Grid electricity information collection system.

These observations reveal that while State Grid's promotion of four-in-one collection has certain positive driving effects, it exhibits significant limitations in application scope, capital investment direction, and promotion target design, providing insufficient impetus for the overall development of water, gas, and heat industry collection systems.

2) Separate Industry Collection for Water, Gas, and Heat

Early-stage water, gas, and heat industry collection infrastructure was relatively poor, with main issues including low digital/intelligent application levels for meters, varying collection and local communication methods with technical bottlenecks, non-unified design specifications and communication application protocols, smaller user bases within urban administrative divisions, and particularly difficult funding sources for meter updates, with no unified coordinating authority for local energy industries.

However, separate industry collection construction shows promising prospects with strong late-stage momentum. As previously described, the Beijing Waterworks Group and Beijing Gas Group provide new development experiences for industry-specific collection, with key points being the expansion from remote meter reading to employing new meter types, installing energy control components, achieving online energy consumption monitoring, real-time collection and monitoring of energy production system operation parameters, establishing unified management platforms for various resources, and conducting intelligent measurement management.

Regarding funding, as digital/intelligent meter coverage grows rapidly and local governments have not yet issued investment policies, industries are estimated to compress pipeline network project funds and self-fund the purchase of new meter equipment.

These narratives indicate that under the influence of the four-meter collection trend, Beijing's water, gas, and heat industries are leading in new collection system construction. Some gas meter companies in Zhengzhou also report that 2016 gas meter orders are estimated to increase by 120% year-over-year. While these represent regional developments, separate industry collection systems for water, gas, and heat are being propelled onto development tracks nationwide, though development remains uneven and requires comprehensive evaluation.

3) New Objectives and Pathways to Accommodate Controversy

Based on the preceding evaluation of the two models—unified four-in-one collection and separate industry collection—it becomes clear that neither model can be dismissed at present, and each should develop according to its own momentum. Both models constitute bottom-level design for four-meter collection

networks, primarily focused on remote meter reading with simple system functions that struggle to influence local governments' investment policies.

Therefore, the authors propose that to promote comprehensive and balanced development of collection systems across electricity, water, gas, and heat industries, new objectives oriented toward smart cities/intelligent energy and new pathways involving the establishment of a "Four-Meter Collection Network" must be adopted to accommodate both unified and separate industry collection models.

The fundamental task of the "Four-Meter Collection Network" remains remote meter reading, but with a key shift toward meeting smart city/intelligent energy development needs through expanded network functions: - Urban energy 总量 control and planning - Online monitoring of energy production and operation - Energy balance and online energy consumption monitoring - Development of intelligent energy use plans for users and energy-saving statistical analysis

Regarding top-level (hardware) architecture design for the four-meter collection network: the basic concept employs "Internet Plus" technologies along with gateways/routers, firewalls, and advanced password authentication through dual internet networks (remote wireless public networks and twisted-pair Ethernet) to connect electricity, water, gas, and heat industry master stations (including State Grid's four-in-one collection), public energy network management platforms, and local government and multi-industry authority websites, constructing an interconnected networking solution with multiple master stations and interfaces.

Various four-meter collection systems serve as bottom-level design for the "Four-Meter Collection Network," accommodating both State Grid's four-in-one collection and existing separate industry collection systems. In principle, no major modifications are required from industry master stations downward.

Comprehensive solutions for the four-meter collection network, including top-level (hardware) architecture design, software system content, and industrialization processes, are detailed in *Toward Smart City/Smart Energy Systems Engineering: Promoting Top-Level Design and Industrialization Research for Energy "Four-Meter Collection Networks"* co-authored by Zhang Chunhui and Kai Zhaoqian.

Impact of Energy Internet on Four-Meter Collection Development

On February 24, 2016, the National Development and Reform Commission, National Energy Administration, and Ministry of Industry and Information Technology jointly issued the *Guidance on Promoting "Internet Plus" Smart Energy Development (Document No. [2016]392)*. Item (3) of its key tasks, "Promoting Deep Integration of Energy and Information Communication Infrastructure," explicitly requires: "Promote remote automatic collection and centralized reading

of water, gas, heat, and electricity to achieve multi-meter integration." However, examining the full text of item (3) reveals that Energy Internet requirements for information communication infrastructure (including four-meter collection) are innovative and forward-looking:

1) "Develop intelligent terminal advanced measurement systems and supporting equipment for the Energy Internet to achieve real-time metering, information interaction, and active control of energy consumption such as electricity, heating, and cooling. Enrich the implementation functions of intelligent terminal advanced measurement systems, promote remote automatic collection and centralized reading of water, gas, heat, and electricity to achieve multi-meter integration. Standardize the networking structure and information interfaces of intelligent terminal advanced measurement systems to achieve secure, reliable, and rapid two-way communication with users."

Interpretation and reference: Advanced measurement systems, as described in Tsinghua University's *Smart Grid Fundamentals*, "are designed to complete two-way interactive communication and control between user-side and grid dispatching sides. Generally, AMI consists of user home networks, smart meters, measurement data management systems within power companies, and communication systems connecting them."

In advanced measurement systems, the role of electricity, water, gas, and heat meters changes significantly: First, their status shifts from terminals in collection systems to intermediate nodes between the Energy Internet and users, adding support for two-way interactive functions. Second, communication changes from one-way to two-way. Third, electricity meters require two-way metering, while water and gas meters generally need only one-way metering, with heat meter metering direction requiring further study.

Intelligent terminals feature autonomous decision-making and response capabilities, primarily configured with two-way high-speed remote communication modules, large-capacity memory, advanced application programs, remote software upgrades, and provision of multiple data exchange formats to accommodate expanded functional requirements.

2) "Optimize the layout of sensors, information, communication, and control elements in energy networks to achieve efficient coordination with various facilities in energy networks. Promote power fiber-to-the-home projects to improve the communication system of the Energy Internet."

Interpretation and reference: In the Energy Internet, active control represents a key function. Research on new four-meter collection system output control information technology is recommended. Attention should be paid to re-proposing power fiber-to-the-home projects to solve the "last kilometer" communication challenge in residential community energy projects.

3) "Strengthen security infrastructure for energy communication systems, sci-

> entifically configure security strategies according to different information security levels, communication methods, and service objects. Relying on advanced cryptography, identity authentication, encryption communication, and other technologies, establish an information security assurance system for information transmission, storage, and distribution among users, data, devices, and networks under the Energy Internet."

Interpretation and reference: New four-meter collection systems require construction of information security assurance systems, comprehensively introducing advanced cryptography, identity authentication, and encryption communication technologies. As previously mentioned, equivalent confidentiality measures for water, gas, and heat industry measurement data in the four-in-one collection system need improvement.

In summary, Energy Internet requirements for new four-meter collection system construction primarily involve transforming meters from collection system terminals to intermediate nodes supporting two-way interactive functions, changing communication to two-way modes, researching collection system output Energy Internet control information technology, and constructing information security assurance systems.

Given that State Grid's electricity information collection system coverage has not yet reached 100% and the timeline for implementing two-way interactive functions remains unclear, with water, gas, and heat industry collection standards even less developed, new four-meter collection system construction remains a longer-term objective that will advance alongside Energy Internet development.

References

[1] *Guidance on Promoting "Internet Plus" Smart Energy Development*, Urban Gas, 2016-04-15
[2] Zhang Chunhui, Zhang Zhen. The Controversy and Development of Electricity, Water, Gas, and Heat Four-Meter Collection

Note: Figure translations are in progress. See original paper for figures.