Japan's First Large Scale Efforts on the Model Project of Smart Water Meter

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Abstract: Each water utility entity in Japan conducts demonstration tests for smart meters to examine communication methods and customer services and others. Tokyo Waterworks Bureau currently operates model projects to install smart meters in approximately 6,000 households, which are the largest number in the country in order to verify the results. In the model projects, suppliers of electricity and water collect data from their own meters they installed by using joint meter reading system. Tokyo Waterworks Bureau aims to collect hourly reading data, not only for the purpose of fee collection, but also for future provision of watching and visualization services. This paper presents future challenges and outlook of these projects.

Keywords: Smart water meter; visualization; watching services; demonstration test

1. Iintroduction

The Tokyo Metropolitan Government's Bureau of Waterworks has been working on automatic metering using electronic meters since the 1970s. Most prominently, the Bureau of Waterworks has implemented this technology in the Tama New Town and Tokyo Water Front City areas, where transmissions were passed through wires such as phone lines.

The Tama New Town area is a large residential development located in the southwest part of Tokyo. In 1976, there were initially approximately 49,000 installations of automatic metering systems in the area. The Tokyo Water Front City area is a waterfront development complex that combines employment, housing, schools, and recreation, and in 1995 it initially featured around 1,500 installations of automatic metering systems. However, in both locations aging equipment made it difficult to continue these services due to costs. In 2007, Tama New Town changed over completely to manual metering systems, followed by Tokyo Water Front City in 2016.

In this context, the Bureau of Waterworks decided to conduct demonstration tests of smart water meters aimed at the development of new waterworks services, based on the remarkable development of ICT technology in recent years. These tests were timed to coincide with urban development work in the Harumi 5-Chome district of Tokyo's Chuo Ward (hereinafter referred to as "the Harumi 5-Chome district"), which will serve as the Olympic village for the Tokyo 2020 Olympic and Paralympic Games (hereinafter "the Tokyo 2020 Olympics").

This paper provides an overview of the largest smart water meter model project (hereinafter "this model project") to be conducted in Japan, located in the Harumi 5-Chome district.

2. Expected role smart water meters in smart cities

In recent years, with the provision of services and the types of management of community infrastructure and energy that make use of ICT, IoT, Big Data, and other technology, smart city initiatives that aim to improve quality of life are underway in a variety of fields. In particular, there is varied potential for use with supply data for waterworks, electricity, and gas, where the smart meter would serve as a data-collecting sensor.

2.1 Precedent for smart meters for gas and electricity

Water meters have historically been installed for the purpose of accurately measuring and displaying water usage. At present, the Bureau of Waterworks has water contracts with approximately 7.6 million users in Tokyo. Around 1,500 meter readers visit these meters once every two months to collect data that forms the basis for water bill calculations.

Meanwhile, the TEPCO Power Grid Inc. electricity utility company (hereinafter “TEPCO”) is working to install smart meters for all of the 27 million users in its service area by 2020. These smart meters would measure electricity usage once every 30 minutes. Since April 2016, the retail market for electricity has been liberalized so that consumers are free to choose their electrical utility of choice. The adoption of smart meters enables electrical utilities to provide customers with a diverse range of rate plans suited to their lifestyles.

Gas utilities have also taken an active approach toward smart meter development. The Tokyo Gas Co. (hereinafter “Tokyo Gas”) plans to begin full-scale installation of wirelessly-transmitting smart meters in FY 2018.

2.2 Anticipated benefits of implementing smart water meters

Tokyo’s population is expected to peak in 2025 and begin to decline thereafter (Figure 1). Already the labor shortage in Tokyo has become an issue. One countermeasure to the labor shortage of the near future is the use of automatic metering systems to achieve more efficient operations.

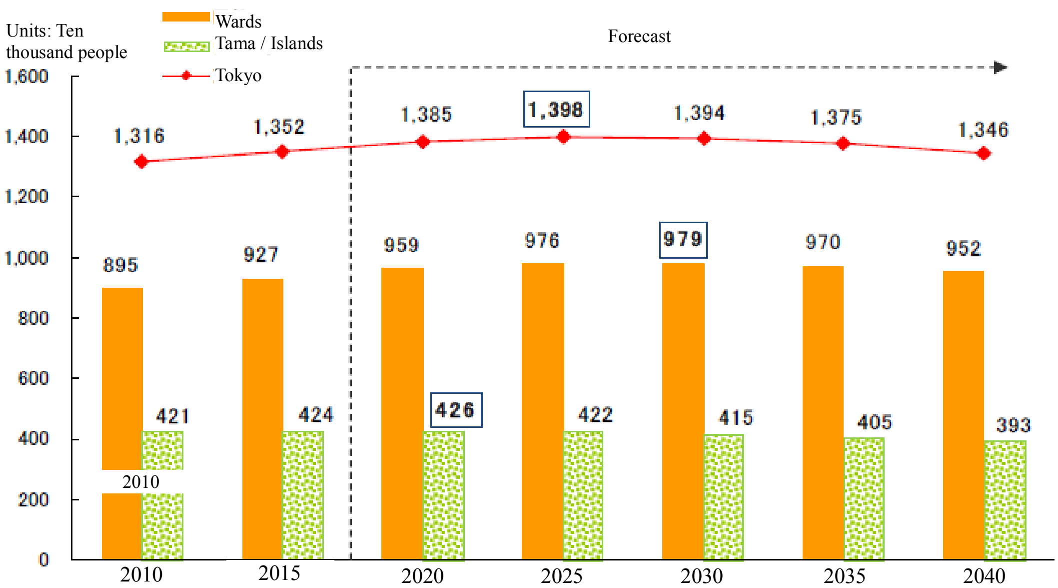

Figure 1: Population trends in Tokyo

It can also be expected that new services will be provided that contribute to improved quality-of-life for water utility users. For example, it is hypothesized that it will be possible to use kitchen and toilet usage information to check on elderly people living alone and confirm that children have returned home (Figure 2). Moreover, it can also be expected that such technology will increase awareness of water conservation and encourage early discovery of water leakage.

【data visualization service】【surveillance protection service】

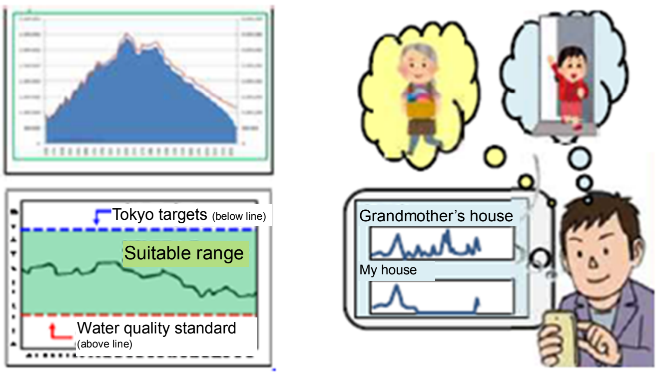

Figure 2: Conceptual image of data visualization and surveillance protection services

Moreover, if public trust in water meters can be increased through the provision of frequently-collected data to consumers, bill collection operations may be expected to become more efficient through the reduction of negotiations over metering results and billing initiated by distrustful consumers.

3. Model project initiatives

3.1 Overview of this model project

The Bureau of Waterworks started this model project in February 2016 to take advantage of the ideal opportunities provided by international events to promote the strengths and appeal of Tokyo's waterworks services. These events are those that draw large groups of people from Japan and around the world to Tokyo, such as the IWA World Water Congress & Exhibition and the Tokyo 2020 Olympics.

The Harumi 5-Chome district in which this model project is conducted is a redevelopment area in which around 6,000 residences will be constructed, beginning with the Olympic village for the Tokyo 2020 Olympics. With a construction area spanning approximately 18ha in area, the plan calls for the construction of 22 low-rise and 2 high-rise buildings (Figure 3).

Figure 3: Conceptual image of Harumi 5-Chome district development

This model project aims to implement automatic water metering at the largest scale yet in Japan, as well as to provide data visualization and surveillance protection services through the use of smart water meters, the first in Japan. The plan for this model project entails two phases.

First, during the Tokyo 2020 Olympics and other periods in which the Tokyo Organising Committee of the Olympic and Paralympic Games is responsible for the management of the entire area, we will conduct automatic metering via meter installations in individual buildings. Next, once ordinary residents begin to move in to the area in 2022, we will provide data visualization and surveillance protection services based on automatic metering via the meters in each building and changes in water usage.

For automatic metering, a joint metering system will be built and operated using communications infrastructure shared with TEPCO for data collection. Specifically, the system is built on the premise that it will utilize TEPCO communications infrastructure (Figure 4).

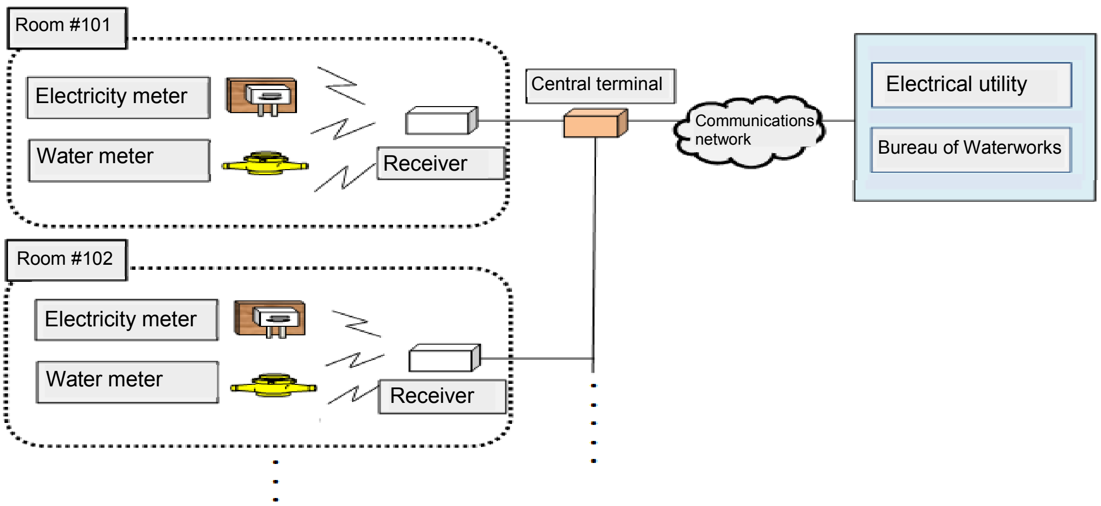

Figure 4: Conceptual image of the joint metering system

3.2 Challenges facing this model project

3.2.1 Smart meter function setup

The Report from the Smart Meter System Planning Conference is a report issued by the Ministry of Economy, Trade and Industry in February 2011 on the topic of electricity and gas meters. This report describes two “smart meters” concepts. The first is the narrow definition that a smart meter is an electrical meter with has the bidirectional communication and remote opening/closing functionality required for metering and bill-collection operations. The second is a broader definition that includes, in addition to the narrow definition, functionality such as energy consumption visualization and home energy management functionality.

One major issue in smart meter function setup is the price of such meters. Smart meters are several times more expensive than existing analog meters, and this is thought to be one of the reasons that the meters have not been used more in Japan. This also created a vicious cycle in which the meters’ lack of popularity precludes any drop in prices. Moreover, if too many functions are incorporated into the device, it leads to new meter development, and this presents the problem of not only price but also necessary development time.

Based on this, it was necessary to consider what functions to include on smart meters to be used in this model project, with the further consideration of price and time restrictions.

3.2.2 Meter-reading frequency

If only the data required for bill calculation were collected, it would be sufficient to collect data once every one or two months. However, to provide data visualization and surveillance protection services, metering data must be collected several times per day.

Transmitting meter values at a high frequency requires an appropriate amount of battery capacity. It was feared that battery replacements would be necessary within the 8-year period of validity specified for meters in the Measurement Law. While the meters were needed to contribute to the provision of certain services, there was a need to strike a balance with battery costs, replacement labor, and other concerns.

3.2.3 Transmission method

It was assumed that automatic metering data would be gathered via the joint metering system on TEPCO transmission infrastructure. However, in grasping the details of Harumi 5-Chome district development, it was discovered that TEPCO’s transmissions infrastructure was physically unusable for some of the approximately 6,000 residences and the general meters for individual buildings.

For this reason, there was a need to find another transmission method, and we engaged in a search for the most appropriate method in terms of cost, transmission stability, operational stability of the telecommunications provider, and other factors.

3.3 Challenge analysis: Background and conclusions

3.3.1 Smart meter function setup

It was not feasible to choose to develop a new meter system or to use a high-cost system from among existing products. This is because it would not be possible to lower meter prices through mass-production at a scale of around 6,000 buildings, and although this was a demonstration test we could not expend an excessive amount on investment.

Therefore, for the smart meter used in this model project, we elected to use a simple electric meter already in use by the Bureau of Waterworks, affixing to it an external transmitter to add only the capability to transmit meter values back (Figure 5). The data visualization and surveillance protection services would be handled by a separate system that can process the data.

This electric meter also has other functionality including backflow detection capabilities, and it is expected to also help with the early detection of misconnections in water wells, sewer pipes, etc.

Figure 5: Electric meter

3.3.2 Meter-reading frequency

Due to the problems related to battery capacity, a variety of matters were studied pertaining to the issue of the number of times that meter data would be transmitted per day. TEPCO checks meter data once every 30 minutes, but this would be difficult for water meters that rely on battery power. However, we did decide to use hourly meter checks, as data visualization and surveillance protection services require hourly measurements and, moreover, technological advances will likely enable the use of batteries that can read meter data and transmit it 24 times per day for a span of 8 years.

3.3.3 Transmission method

We have conducted an especially careful study of transmission methods before selecting one for use. Because bill calculations are based on smart meter reading values, it would be acceptable to suffer data loss or for the telecommunications carrier to be rendered unable to continue performing their role.

At just this timing, with advances in technology toward the IoT society, a new transmission technology called “LPWA” (Low-Power Wide-Area) is entering the commercialization stage that enables transmission at low energy consumption and low cost. This gives a bright future to the propagation of smart water meters, which faced major hurdles in finding ways to improve costs and transmission environments (Figure 6).

3.3.3.1 Studies; demonstration test implementation and considerations

From July to September 2017, we conducted a study on transmission technologies that were applicable to meter-reading work. This study included interviews with telecommunications carriers and smart water meter manufacturers, examination of implementation trends and past experiences of other cities, uncertainties involved in each potential transmission method, summaries of sources of risk, and simulations and field tests of transmission circumstances. Based on this information, we considered transmission methods and frequency bands that could be used with smart water meters, as well as the compatibility of these candidates.

As a result of this investigation, we decided to move towards using the LTE communications method at a licensed spectrum for this model program. The primary reasons for this included the unlikeliness of network congestion in a licensed spectrum and the fact that future commercialization by major telecommunications carriers can be expected to result in stable, competitive service. Another deciding factor was the fact that data could be sent all at once, without the need to break up a single reading's values across multiple transmissions. Thus transmissions could be made for lower battery consumption. Moreover, transmission would be possible anywhere mobile phones can be used, and this was judged to be useful in considering future development (Figure 6).

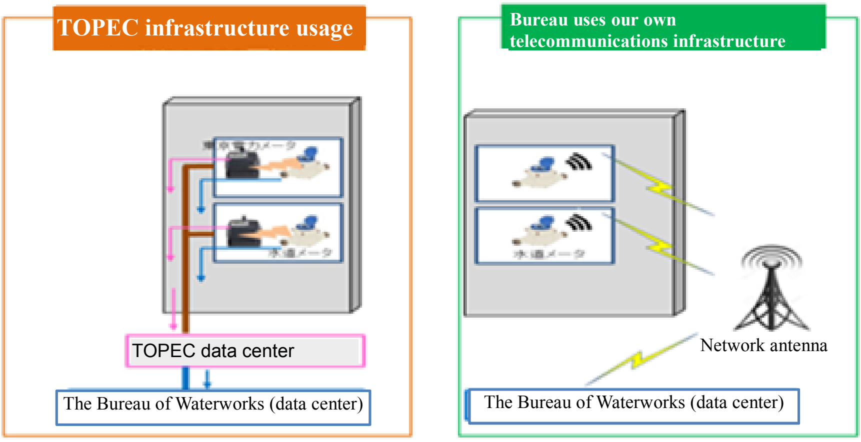

Figure 6: Transmission methods

3.3.3.2 Transmission tests in Harumi 5-Chome district

In March 2018 in Harumi 5-Chome district, in collaboration with major telecommunications company SoftBank Corp., we conducted transmission tests using the LTE method that we intended to use with water meters. Each general meter at each building was installed within a large-caliber meter box and covered by an iron cover around 2cm thick, and therefore we used an existing a meter box in the same circumstances for the test.

Our results showed that, although the iron cover dampened transmission somewhat, transmission from within the meter box was adequate. Nevertheless, transmission from areas with poor reception was less than 100% successful, and we determined it was necessary to consider whether to add functionality such that the transmitter would re-send transmissions in the event of failure, or otherwise use a method whereby the transmitter would be installed on the exterior of the meter box.

4. Conclusion

This model project is the Bureau of Waterworks' first step toward full-scale implementation of smart water meters.

The cost-benefit of smart water meters is certainly hard to see at present, and for that reason they have yet to become widespread in Japan. However, if effective methods can be established of using the data obtained by smart meters, it is expected that implementation will proceed at a rapid pace. Smart meters present many possibilities that could lead to cost reductions from a business perspective, including a billing system that reduces peak demand, optimal investment plans for water distribution facilities, and more efficient water purification plant operation and management.

The Bureau of Waterworks must not only steadily implement this model project, but also analyze and verify the process by which the project was implemented, the data gathered post-implementation, user opinions, and other information as we actively study ways of utilizing smart water meters.

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