Toward IoT Smart Homes That Make People Happy

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1. Introduction

Kanagawa Institute of Technology Smart House Research Center is conducting research on "IoT smart homes that make people happy." There are two aspects regarding IoT smart homes as residences. The first is the "smart" aspect, i.e., using energy intelligently (energy savings and conserving electricity). The second is providing residences that promote prosperous lifestyles for people. Both aspects are advancing daily with Internet of Things (IoT) technology. IoT means the use of Internet technologies that connect various devices while creating new value.

This article describes how IoT smart homes will evolve in the future with respect to the latest government policies on residences.

2. New Basic Housing Plan (revised after five years) with "new normal" and "DX promotion" as key words

In March 2021, the Basic Housing Plan was revised after five years[1]. This plan is a basic policy on housing to achieve prosperous lives in homes based on a law called the Basic Act for Housing, which was enacted in 2006. It sets housing targets for the next ten years, and is revised every five years. It is referred to as a compass for housing policy for the near future. An outline of the new Basic Housing Plan is shown in Figure 1.

Several new notable themes are shown in Figure 1 regarding the current issues with housing, such as climate change, new lifestyles, and digital transformation (DX) promotion. The new Basic Housing Plan introduced three new goals to address these issues. From the viewpoint of the social-environmental change, goals 1 and 2 were set to indicate policy directions for handling "new normal" and disasters such as heavy rainstorms. From the viewpoint of housing stock and the housing industry, goal 6 was set to indicate policy directions for achieving carbon neutrality by 2050.

For goal 1, which denotes new daily life and DX, the following two directions were devised to achieve new lives in homes.

(1) Promote the diversification of residential styles to meet people's new thoughts on living and the flexibility for

■ Figure 1: Overview of new Basic Housing Plan
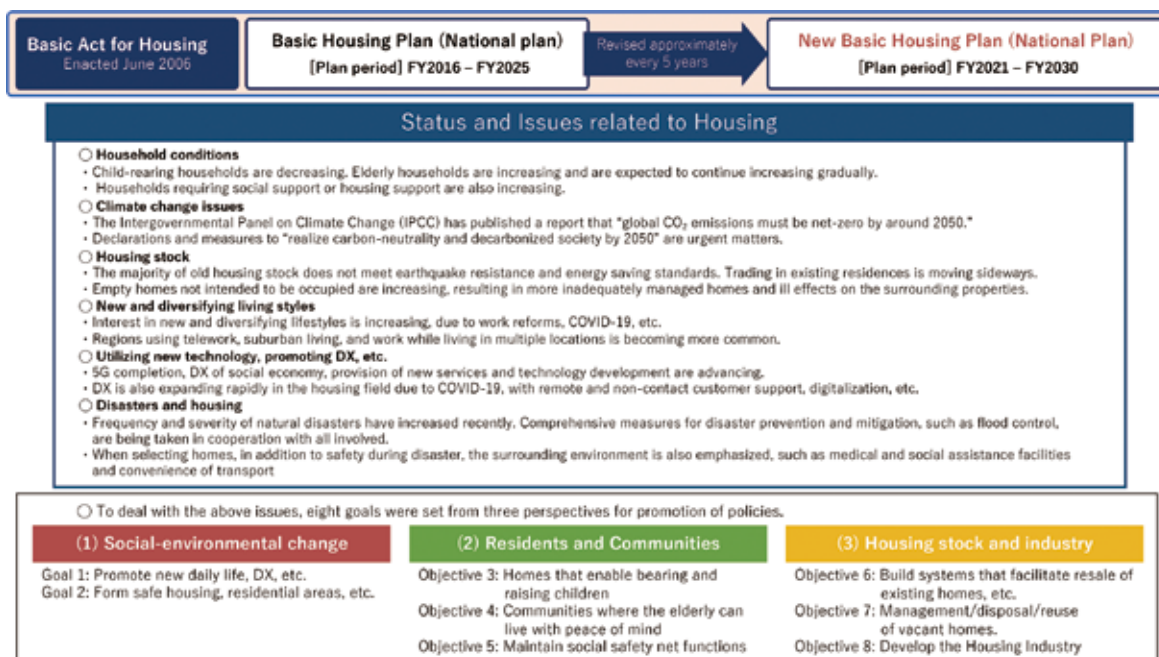
residential location choices according to people's living conditions.

(2) Promote DX of housing contracts and trade processes and of house construction and management processes using new technologies.

Regarding direction (1), the background on the issues with housing for "new normal" is the increasing interest in new and diversifying ways of living prompted by reforming of working practices and the aftermath of COVID-19. New residential situations, such as the increase in suburban and rural living owing to the increase of telework, or having multiple residences are becoming common. To adapt to these new situations, schemes, such as promoting environmental arrangements, have been set as basic policy to support telework and other new working practices.

Regarding direction (2), the background includes advances in new services and technology on the basis of 5G installation and expanding social and economic DX. It also includes the rapidly expanding DX in the field of housing, such as remote and non-contact customer handling and digitalization prompted due to the aftermath of COVID-19. Schemes, such as AI-assisted designing and all-stage DX, i.e., design, construction, maintenance, management, and disposal, are listed as the basic policy to promote the use of new technologies in housing-contract, trade, construction, and management processes.

Note that in the Basic Housing Plan, DX promotion is described from the perspective of housing suppliers or enterprises. We describe our thoughts on housing DX in later sections.

For goal 2, which denotes establishing safe housing and residential areas and securing houses to people afflicted by increasingly frequent and intense disasters, installation of facilities such as renewable-energy equipment and storage batteries is being promoted by government projects to support energy-saving residences such as net-zero energy houses (ZEHs)[2], which contributes to increasing resilience in housing. Note that the standard equipment for a ZEH is the home energy management system (HEMS), which is the infrastructure for managing energy consumption and controlling home devices, such as appliances. It can also contribute to goal 6 discussed below, with respect to saving energy in the home.

For goal 6 which denotes building house recirculation systems for a decarbonized society and forming good-quality housing stock, the spread of energy-conserving houses such as ZEHs is an important initiative toward achieving carbon-neutrality by 2050.

IoT smart homes will of course be equipped with HEMSs; therefore, we believe that its expansion will contribute to achieving these goals.

3. What is housing DX?

What is meant by DX? In Japan, the Ministry of Economy, Trade and Industry (METI) has published Digital Governance Code[3], which defines the DX as, "by use of data and digital technology by enterprises in response to intensifying change in business environments, reforming products, services and business models based on the needs of customers and society, and also reforming the business itself: organization, processes, and corporate culture and climate; to establish competitive superiority," indicating that enterprises should take initiatives. However, the historically first definition is attributed to Prof. Erik Stolterman of Umeå University in Sweden, who in 2004 proposed it to mean "improvement in all aspects of people's lives through the permeation of IT[4]". Perhaps housing DX fits this latter definition better. Thus, we assume that promoting housing DX means "'fertilizing' people's lives." We also expect that the use of digital technologies for communication between residents and housing suppliers or providers of residential services on the corporate side will also contribute greatly to DX on the corporate side.

4. ECHONET Lite: key technology for promoting housing DX

A ZEH, as described in the previous section, is equipped with a HEMS. The first objective of introducing HEMSs is to provide visualization of the energy consumption of connected devices to encourage users to actively conserve energy. Therefore, a HEMS requires more devices to be connected to it, so the communication technology used for the interface (language) between devices is a key issue. In November 2011, METI formed the "Smart House Standardization Study Group" to study measures promoting energy saving and conservation of electricity in homes, and this study group recommended ECHONET Lite as the standard communication interface between devices connected to a HEMS in the home and smart meters (Figure 2)[5].

■ **Figure 2: ECHONET Lite: HEMS communication interface**

http://www.meti.go.jp/committee/summary/0004668/011_04_02.pdf
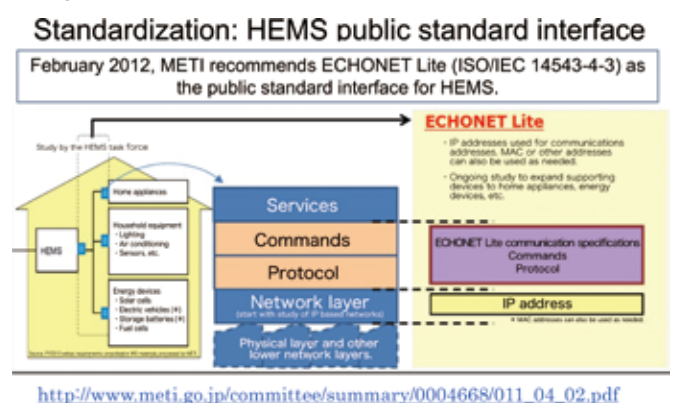
Homes have various appliances and other household equipment, and in the past, most manufacturers used different rules for communicating with their products, which resulted in problems such as the inability to manage them centrally and services no longer able to be used if a device was replaced with a product from a different manufacturer. A decision was made to unify and standardize communication rules to resolve such issues. This was a significant decision and became the rationale

for ECHONET Lite as the base communication technology for smart homes and HEMSs. The features of ECHONET Lite are as follows.

1) It is a communication technology based on the Internet Protocol (IP).
2) It is a non-vendor-specific communication technology.
3) It defines detailed control commands at the level of handy remote controllers (defining more than 100 types of devices)
4) It can use various standard transmission media (wired LAN (Ethernet), wireless LAN (Wi-Fi), etc.).
5) It is an international standard (ISO/IEC 14543-4-3).
6) The specifications are open to the public (in Japanese and English).

As stated in 1), ECHONET Lite is based on IP, so connectivity to the Internet is assumed; thus, all ECHONET Lite devices can be called IoT devices. With the ECHONET Lite recommendation as the communication technology for HEMS in Japan, the infrastructure for conversion to IoT has already been built.

To what extent have ECHONET Lite devices spread throughout the world? The ECHONET Consortium, which created the ECHONET Lite specifications, has been publishing statistics for shipped devices classified in the major product categories since FY2013 on its web site[6] (Figure 3). In FY2013, there was approximately 4.7 million units shipped, while in FY2022 there was approximately 140 million units shipped. The residential smart meters, that accounts a good portion of the statistics, have been installed in basically all homes in Japan. The consortium has voiced the direction to expand healthcare-related products and will contribute to IoT transformation of homes.

5. State of housing DX expansion

Next we examine the expansion of ZEHs, which are homes

■ **Figure 3: Cumulative numbers of shipped or scheduled ECHONET-Lite-compliant devices**

Figure 1: Cumulative number of shipped or scheduled ECHONET Lite compliant devices

https://echonet.jp/shipments-en/
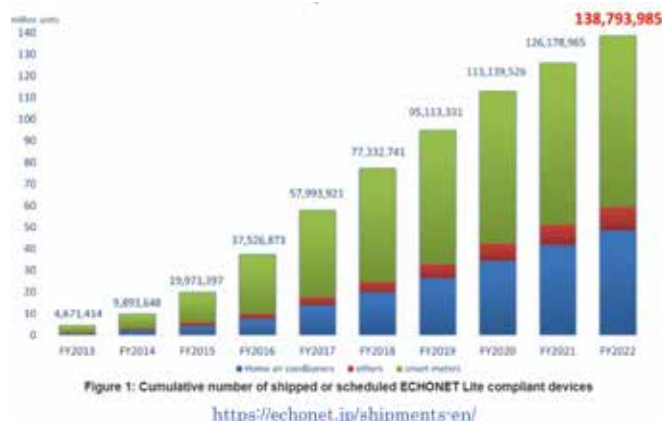
equipped with HEMS and ECHONET Lite devices. Figure 4 shows the year-to-year progress in the percentages of ZEHs among newly built and scheduled homes up to FY2021. The government target for FY2020 for the spread of ZEHs was that 50% or more of newly built or scheduled houses by home builders should be ZEHs, and, as shown in this figure, this target was achieved in FY2020 (56.3%). However, it should be noted that a ZEH is not the same as housing DX. A ZEH only means that a platform for housing DX has been installed, and 70–80% of homes in Japan are still built by local contractors, so the spread of ZEHs is just beginning. However, the government's declaration for carbon neutrality by 2050 is expected to strengthen policy for residential energy saving, and we expect this to promote the spread of ZEHs. COVID-19 has also resulted in trends such as increased telework, so the number of residences with good Internet environments has been increasing steadily, and we expect this will also result in the advance of housing DX.

■ **Figure 4: Percentages of ZEHs as newly built and scheduled homes**

https://sii.or.jp/opendata/#prj6

6. Housing also entering "Software First" era

There is a manufacturing approach called "Software First", in which products are manufactured with the assumption that they will be updated. Familiar examples of devices manufactured with this approach are PCs and smartphones. Both hardware and software (services) had been basically developed together, but by updating software, improvements can be made such as updating the user interface or providing new services, even if using the same hardware. With the development of Internet technologies, the speed of software advances has exceeded that of hardware, which is a major driving factor for the approach. Of course, hardware also needs to be updated periodically, so it still provides value that cannot be improved through software, but the important role software plays in improving the utilization of that hardware is undeniable.

Actually, it seems that this "Software First" concept is gradually entering development in the automobile industry, so perhaps this approach will also become more important in housing in the future (Figure 5). Also in housing policy, themes such as promoting long-term high-quality housing, increasing activity in the used/older/resale housing markets, building long-lasting housing, and utilizing existing housing are becoming important. Considering such conditions, it seems that software development can play an important role in housing, supporting changes in the social environment and lifestyles. Of course, it is important to have ease-of-use so that those not proficient in information technology will not be left behind. Key points include user-friendly design and low-cost, so that anyone can use features easily. For Japan, with its aging population, it is even more important to prepare environments so that all, including both the child-rearing generation and the elderly, can enjoy the benefits.

7. Conclusion

With the aftermath of COVID-19, advancing DX has become a target of housing policy, and we expect various residential services to emerge through the Internet in the future. We also expect this to become a design assumption for the "hardware" of housing. Through the promotion of energy-saving housing, many household appliances and residential equipment and devices have become IoT compliant. Houses are used over many years and change gradually over long periods, but the environment for building "Software First" housing seems to be falling into place. In the future, enterprises supplying housing and residential service providers are expected to promote housing DX. We hope to also be able to contribute to this effort through collaborative research with enterprises. We hope that housing DX will lead to home-building initiatives that bring happiness to everyone.

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■ **Figure 5: Updatable homes**

To the "Software First" era

<Updatable homes will create homes that can make people happy>

Sold with the assumption of being updated.

Design with the assumption of updates

Now

To homes that can be updated!

Next