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Invited Review Paper

A Trend of Home and Consumer Appliances in Japan: The Past 50 Years and the Future

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Most of home appliances were put into practical use in the United Kingdom and the United States before early 20th century. However, in Japan, the production of the home appliances began in the 1950s. Home and consumer appliances market had been expanded and developed growing with high growth of Japan in 1950–1970. They are applied by power electronics for improvement of performance and energy saving in 1970s–1990s. After 2000, power generation equipment has been put in practical use. Distributed power systems like a smart house and a virtual power plant are spotlighted now. Internet of things (IoT) technology will make new generation of appliances. In this article, a trend of home and consumer appliances in Japan is explained and discussed viewing the past 50 years and the future. © 2021 Institute of Electrical Engineers of Japan. Published by Wiley Periodicals LLC.

Keywords: home; consumer; appliance; power electronics

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1. Introduction

Main household appliances except for a rice cooker were put to practical use before early 20th century in England and the United States. They were started to be produced in 1950s in Japan 50 years after in England and the United States. Home and consumer appliances market had been expanded and developed growing with high growth of Japan in 1950–1970. They are applied by power electronics for improvement of performance and energy saving in 1970s–1990s. After 2000, power generation equipment, such as PV system and energy storage apparatus has been put in practical use. Distributed power systems like a smart house, V2H (Vehicle to home), ZEH/ZEC (Net Zero Energy House, Net Zero Energy Community), and VPP (Virtual Power Plant) are spotlighted now. IoT technology will make new generation of appliances.

In this paper, a trend of home and consumer appliances in Japan is explained and discussed viewing the past 50 years and the future.

2. The Dawn Period for Power-Electronics Home Appliances

A basic construction of home appliance as electric power equipment is illustrated in Figure 1. A controller which has a role as a brain of the equipment had innovation of embedded microcomputers in 1980. An energy converter such as heater, motor, lamp *et cetera* converts electric power to heat, light, moment power *et al.* which give the convenience of a user. Power electronics improve the energy converter as indicated in Figure 1.

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Figure 2 shows a trend of home and consumer appliances in Japan. Many power electronics appliances are developed and commercialized in 1975–1995. We may be proud of that these all products are in practical use by Japanese engineers. These inverter appliances were grown up to large market under 'the high performance and quality boom' in 1970–1985 and 'the energy saving intention' in 1985–1995. Power devices which is the key technology of power electronics were developed in 1957 by GE in the United States then innovative wide band gap power devices which is made of new materials—*SiC*, GaN, etc.—are being commercialized now.

Power generation equipment such as PV and FC for home use are put into practical use in 2000s. FIT law spurred the spread of PV system in Japan from 2012, then grid instability caused by large amount of PV has been spotlighted. Power storage system has been produced in early 2010s. Distributed power systems such as smart house, V2H (Vehicle to Home), ZEH/ZEC (Net Zero Energy House, Net Zero Energy Community), and VPP(Virtual Power Plant) which use storage systems have appeared in 2010s and are expected to solve the problem of power system instability.

A high-frequency IH (Induction Heating) cooker shown in Figure 3 was commercialized in 1974. Eddy current induced in a cooking vessel is concentrated in bottom thin layer and heat the pan effectively by the skin effect under high-frequency operation. It is high efficiency, high power, high controllability, comfortable, clean, and safety. High-frequency power is supplied by a high-frequency inverter. A single-ended high-frequency inverter indicated in Figure 3 is used for IH cooking stoves, IH rice cookers and inverter microwave ovens. IH cooking heaters of mulch burner and high power are using bridge type inverters.

IH cooking heaters are miniaturized, lightened, and lowered price drastically in 15 years as depicted in Figure 4, because the power device for the apparatus evolved to high performance and make the system construction simple and low cost. An early

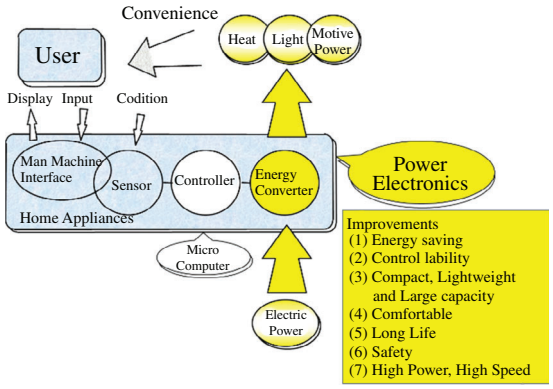


Fig. 1. A basic construction of home appliance

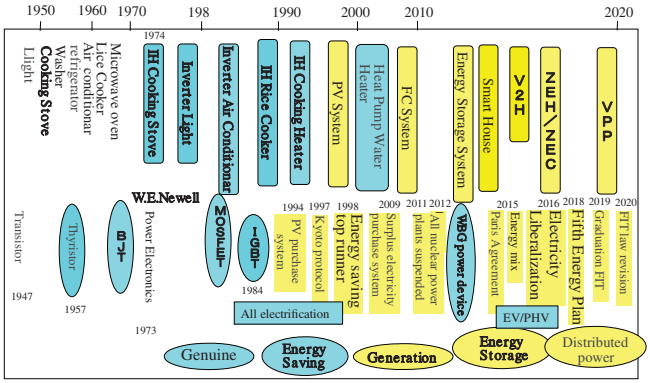


Fig. 2. A trend of home and consumer appliances in Japan

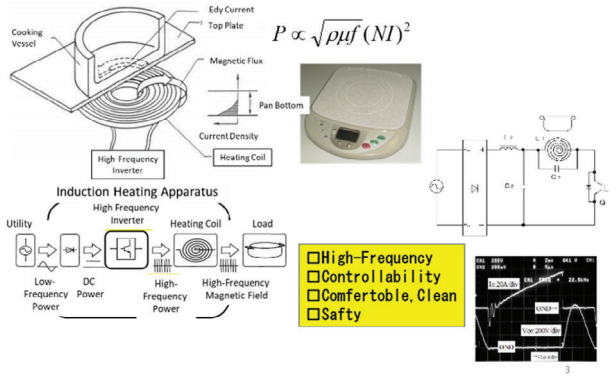


Fig. 3. An induction cooking heater

device is the thyristor which cannot self turn-off. Next, BJT (Bipolar Junction Transistor) which can do self turn-off operation is commercialized for home use in 1980. Then an IGBT (Insulated Gate Bipolar Transistor), which can be driven by very low power and an extremely small driver is developed in 1988.

High-frequency inverters for home appliances in Japan have variety of expansion as shown in Figure 5. They made their own evolution and form a technological base in Japan. Figure 6 indicates a single-ended high-frequency inverter family of 24 basic circuit topology which include all type of single-ended inverters in past and future [1].

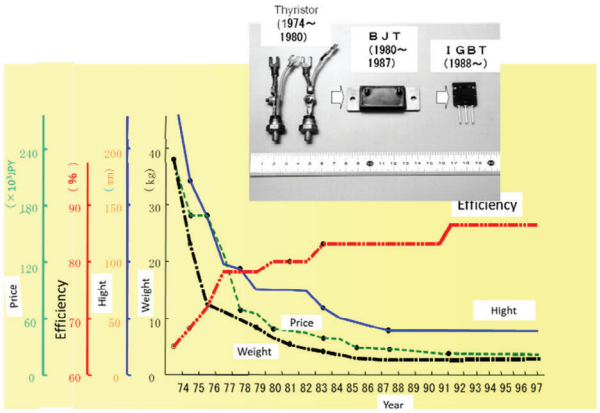


Fig. 4. A transition of size, weight, price of IH cooking heater

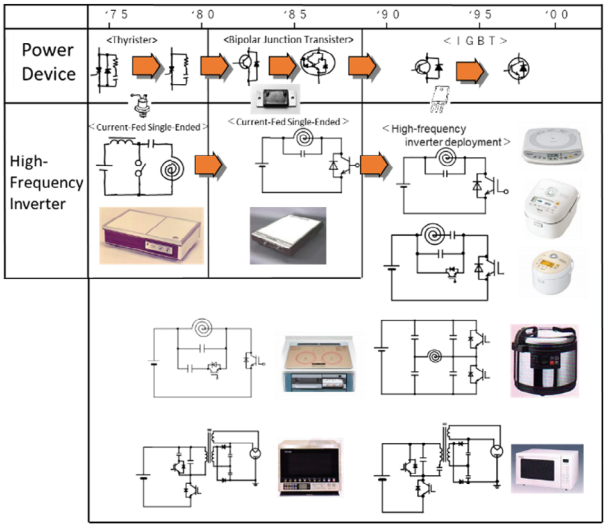


Fig. 5. An expansion of high-frequency inverters for home appliances

The power devices for home appliances is changing to wide bandgap power devices—*SiC* or GaN which can operate with extremely low loss. Recently, a novel type of *SiC* power device—*SiC* V-MOSFET—is developed as indicated in Figure 7. V groove trench gate construction realizes high breakdown voltage and very low ON-resistance. Ron of the new device VMOS is only 35 mΩ which is 1 of 3 compared with Ron 83 mΩ of conventional gate device DMOS [2,3].

Figure 8 depicts an inverter-driven air conditioner. Utility power is converted to various frequency power by an inverter indicated in Figure 8 and drive a compressor motor by variable speed. We get energy saving 40% by the inverter drive. This type of variable speed drive inverter is used for an inverter refrigerator and an inverter washer.

Inverter fluorescent lamps are shown in Figure 9. They get energy saving and brightness because high-frequency drive improves luminous efficiency. Recently, an LED lighting is paid attention for its high efficiency.

In a PV system indicated in Figure 10(a), PV electric power is connected to grid through a power conditioner, it is used for appliances in the home, and surplus power becomes reverse power

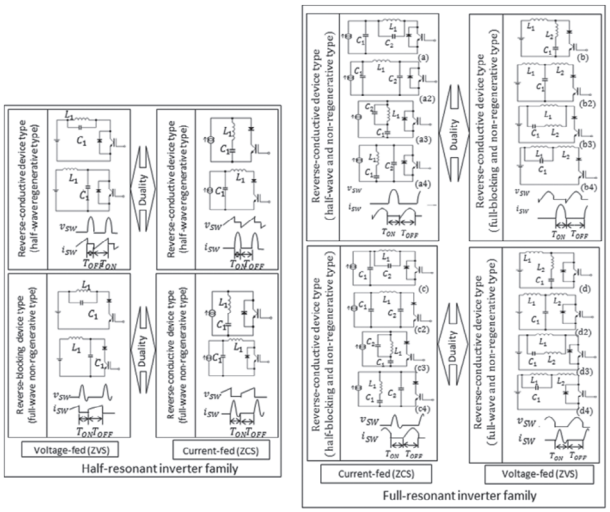


Fig. 6. A single-ended inverter family of 24 basic circuit topology

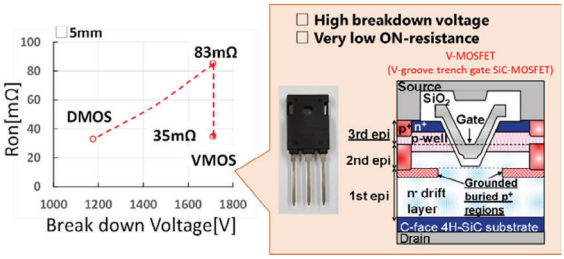


Fig. 7. *SiC* V-MOSFET

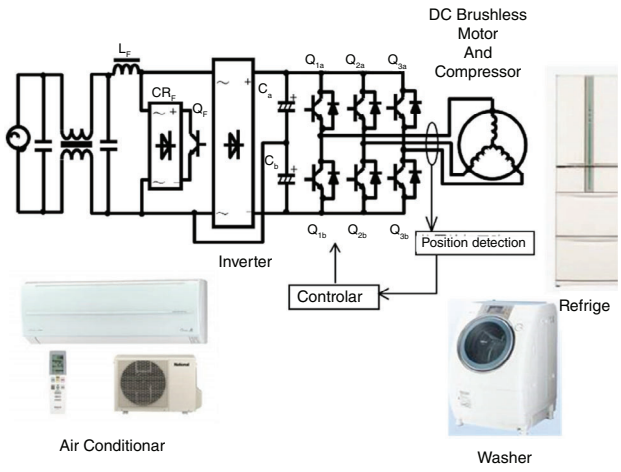


Fig. 8. An inverter air conditioner, refrigerator, and washer

flow to the grid. An FC system generates electric power from hydrogen which is made of gas and oxygen in atmosphere, it is consumed by home electricity apparatus, and surplus power is used for heating water in the hot water tank because reverse power flow is prohibited in the case of FC.

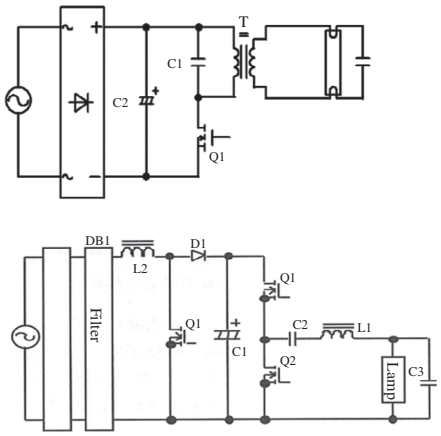
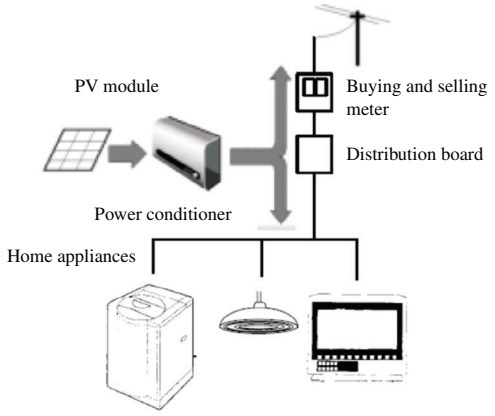
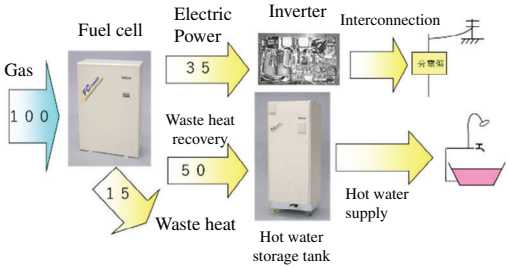


Fig. 9. Inverter fluorescent lamps



(a)



(b)

Fig. 10. Power generation appliances. (a) PV system and (b) FC system

3. Power Generation and Storage Appliances: Distributed Power Systems

Japan energy policy concentrates to energy saving, that is, reduction of power consumption before 2011 as shown in Table I. After the oil crisis, energy consumption has been suppressed in the industrial sector, on the other hand, power consumption in the civilian sector has consistently increased as shown in Figure 11. Then, the top runner standard in the revised Rationalization in Energy Use Law came into force in 1998, and realization of all product performance which is superior to the best energy-saving apparatus should be required after several years later. Energy

Table I. Energy policy of Japan

[Energy Saving] (1990–2011.3.11)
☐ Revised energy saving law **(1998) Top runner** Energy Saving product
☐ Kyoto Protocol **(1997 COP3)** Energy saving system/life
Large-scale introduction of renewable energy
: System stability Generation leveling Energy storage
Increased nuclear power generation
☐ All nuclear power plants shut down (2011)
Distributed power generation and leveling by power generation and energy storage **(2011.3.11∼)**
☐ **FIT Law (2012)**: Fixed-price purchase of renewable energy
☐ Paris Agreement **(2015 COP21)**
Japan—2030Δ 26% 2050Δ80% (compared with 2013)
☐ Long-term energy supply and demand outlook**(2015)**
2030 Energy mix Renewable energy **22–24%(PV 7%)**
☐ Fifth Energy Plan **(2018)**
Expansion of zero emission power supply
Decentralized energy system (DR, VPP, Energy Storage, EV, V2X)
☐ Graduation FIT **(2019)** End of FIT purchase period
Self-consumption / Free contract sales
☐ Revised FIT law **(2020)**
Post-FIT Renewable Energy Policy Reduction of national burden
Long-term stability Imbalance responsibility

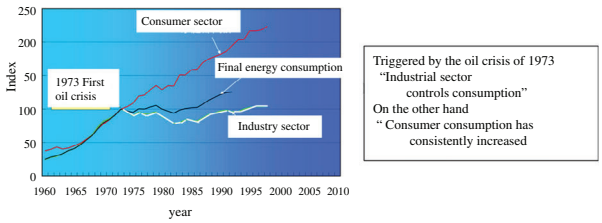


Fig. 11. The energy consumption trend and the top runner standard

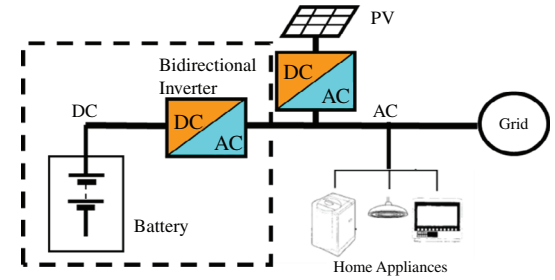


Fig. 12. An energy storage system

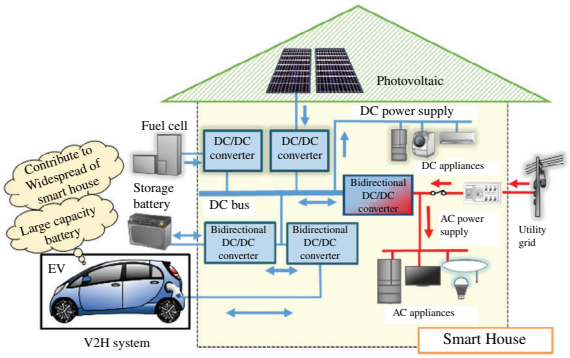


Fig. 13. An advanced smart house with V2

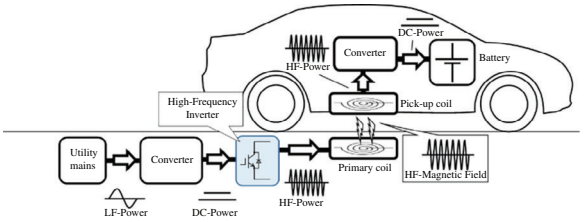


Fig. 14. A wireless power transfer apparatus for EV charging

efficiency of air conditioners, refrigerators and lighting equipment increased 36–68%. Although equipment's efficiency is greatly improved, total energy consumption in the sector continued to deteriorate because power and number of power apparatus have been increasing in an affluent society.

After 2011, power consumption/generating leveling is emphasized for power system stability, and distributed power systems consist of power generation and storage equipment are paid attention. End of FIT law in 2019 and revised FIT law indicate that effective utilization way of surplus power in a large amount of PV system is required from now on. The government 'Fifth energy plan' shows that Paris Agreement—greenhouse gas reduction 26% in 2030 and 80% in 2050 and the energy mix in 2030—renewable energy 22–24%—should be followed. It is expected to make up the main power source of renewable energy. The decentralized energy systems with energy storage apparatus should be constructed for mass introduction of renewable energy since Japan do not have any international interconnection which is useful for leveling.

Figure 12 illustrates an energy storage system. When PV generation power is higher than power consumption of appliances, surplus power is stored to a battery in the storage system. On the other hand, when PV power is smaller than appliances power, the system supplies stored energy to appliances. Then, power consumption and generation are leveled successfully.

An important obstacle to wide diffusion of a smart house that has the energy storage apparatus for load/generation leveling is that the storage battery cost is too high. A V2H system indicated in Figure 13 is expected as the solution of this problem. By using a Large battery in EV for the energy storage system in the smart house, the system cost can be kept low [4].

A WPT (wireless power transfer) apparatus is noticed as a next power connection method for home appliances. Figure 14 depicted a WPT EV charger which is very convenience and safe as compared with a wired type of EV charger. By modifying the apparatus to a bidirectional WPT system, V2H system can be connected wirelessly.

An EV is connected to a smart house even in the case of short-time parking such as several minutes, then, an EV battery is used effectively. Wireless V2H system technology can be expanded to V2B (Building), V2G (Grid), V2C (Community), etc. [4].

All EVs in a community work as if they were one huge battery by WPT connecting with the community. Large PV systems and

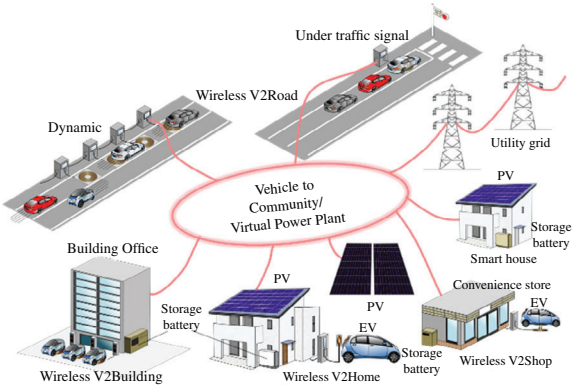


Fig. 15. A smart community with V2C

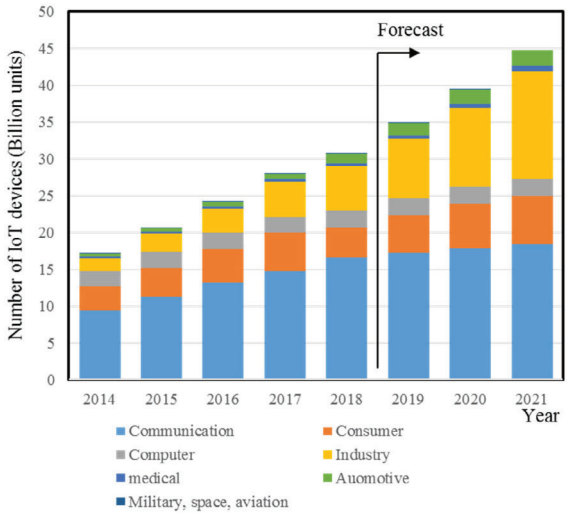


Fig. 16. Numbers of IoT device connection forecast in the world for different industry sectors

huge energy storage systems by wireless V2C can operate as virtual power plants shown in Figure 15. This system is expected as a solution to the mass introduction of unstable renewable energy and EVs which causes high peak power of generation and consumption.

4. New Trends in Consumer Electronics

4.1. Changes in social environment It is necessary to respond to the following major changes in the social environment and consumer electronics equipment sector, as the future is expected to undergo a new evolution.

4.1.1. Informatization The smartphone ownership rate (individuals) has increased to 64.7% in 2018, and since then it has become widespread [5]. It became very convenient for people to connect to the internet and exchange large amounts of information without restrictions on time or place. In the future, as the communication environment shifts toward 5G technology and the Internet of Things expands, a new era will come when most of the devices will be connected to the internet eventually [5].

4.1.2. Low-birth rate and aging population The birth rate has continued to decline in Japan, and the population has been declining since 2008. Hence, a lower birthrate and aging population will accelerate in the future. The proportion of the total population over the age of 65 (aging rate) in 2019 has risen to 28.4%. It is estimated that it will reach 31.2% in 2030 and 37.7% in 2050 [6].

4.1.3. Global warming Since the industrial revolution, global climate change due to rapid greenhouse gas emissions has become a problem. There are concerns about increase in the sea level, melting of permafrost, acidification of the sea, frequent occurrence of heavy rain, floods, and strong winds due to rising sea water temperature in the short term, and increased in heat stroke due to the temperature rise. There is a concern that the deterioration of the environment, which was not in the past, will become more serious [7]. As measures against this, various efforts have been made such as promotion of introduction of renewable energy and electrification of power.

4.1.4. COVID-19 Due to this pandemic of new coronavirus infection that was spread from China to the other countries of the world in the beginning of 2020, all countries need to change its behavior toward many situations. Such as, restriction on outdoor activities, increase in teleworking, and reducing or canceling the scale of socio-economic activities. These sudden major unexpected changes have hit the world economy severely and the situation is still evolving. As infectious diseases are still on the rise, and it is thought that even if they end soon, the socioeconomic structure of our society would never be the same as it happens to be earlier. Hence more and more discussions are being held toward industrial revival [8].

4.2. IoT for consumer electronics This subsection describes the evolution of IoT-based home appliances (connected home appliances). When home appliances are connected to the internet, remote operations are possible, and remote home appliances can be used in cooperation with each other devices as well. The logs can be easily collected and can be used for other purposes as needed. To improve the safety features for the remote control of home appliances in May 2013, a part of the Ministerial Ordinance that sets the technical standards for electrical appliances was revised. Based on the new design standards the installation of remote-control functions using communication lines was approved for non-hazardous devices [9].

Figure 16 shows the transition and forecast of the number of IoT devices in the world [5]. The number of IoT devices has been increasing remarkably in the communications and industrial applications sectors steadily for past couple of years. Moreover, consumer sector has also seen a remarkable increase with 6.15 billion units in 2020. There is an increase of 1.58 times over the past 5 years.

Figure 17 shows two different forms of IoT connections for home appliances. Figure 17(a) is an example of using dedicated smart home appliances, like lighting, air conditioner, TV, refrigerator, air purifiers, washer/dryers, robot cleaner, bath water heater, and various other devices. In all these appliances IoT devices are compatible with wireless LAN (Wi-Fi), Bluetooth, or wired LAN, and are connected to the home network. The user can connect to the home network directly while at home. Alternatively, via a mobile phone line or Internet via Wi-Fi when user is outside home and can easily check the status of each IoT home appliance status, like power ON/OFF, and operation mode. It is also possible to perform operations such as switching.

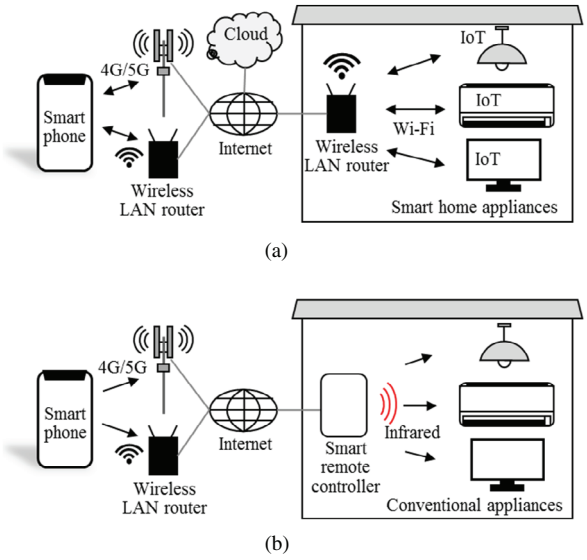


Fig. 17. IoT and smart remote controller-based home solution. (a) Configuration of IoT home appliances and (b) configuration of smart remote controller

For an example in refrigerator, notifications of door kept open, ice making, temperature control, food expiration date management, instruction manual support, etc. are possible with smartphones. This will help to contribute in the overall energy saving and increased food life span. On the other hand, the new generation of washing machines are coming with additional implementation of a laundry course that can be used only with a dedicated application from a smartphone.

The usage data of the smart home appliances are then sent to the cloud and used for services related to the consumables and for the operating condition improvement. For an example, in drum-type and vertical washer/dryers that have an automatic loading function for liquid detergents and softeners, a service has been implemented to automatically reorder the liquid detergents and softeners from service provider when the remaining quantity falls under certain threshold limit [10]. In addition, for microwave ovens, it is possible to download cooking recipes from the cloud to smartphones, etc. by IoT and send the cooking methods to the oven controller to control the heating automatically. In addition, cooking appliances such as microwave are also linked with foodstuff delivery services [11]. The operating status of the various home appliances can also be monitored by other family members, which is an indirect way to understand the health of elderly person living alone.

Figure 17(b) shows the method proposed to make the conventional home appliances compatible with the remote control or monitoring. A smart remote control is a communication device that is connected to the internet via a home network. It has an infrared interface with home appliances and can be used in place of conventional remote controllers. With the smart remote control, even conventional home appliances can be operated remotely from a smart phone. However, as there is no direct feedback from the appliances to know about their status (ON/OFF), it may be necessary to check the power meter reading directly using smart meter, to get an idea of the home overall electrical load or use webcam to visually verify the status.

Figure 18 shows the operation of smart speaker and home appliances through voice control. A smart speaker is also called

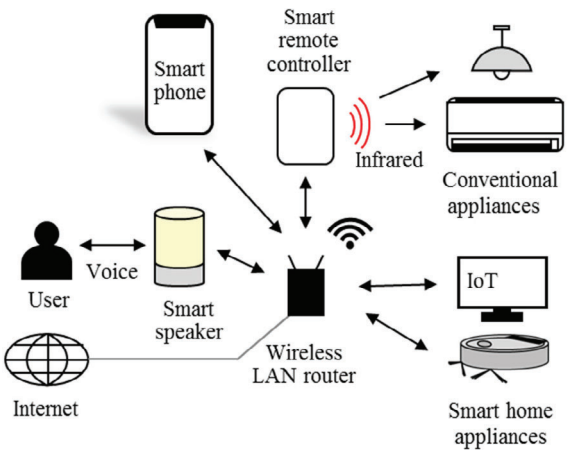


Fig. 18. Operation of home appliances by voice

an AI speaker, and it responds when asked a question by someone. The smart speaker connects to the wireless LAN and sets the operation contents from the smartphone. The smart home appliances are connected to wireless LAN. On the other hand, conventional home appliances are connected by infrared rays via the smart remote controller as described above, and the smart remote controller is connected to the smart speaker via the wireless LAN. With this configuration, the user can operate the home electric appliance by voice. Home appliances that operate directly by voice without using a smart speaker is already available for use. As an example, in a robot vacuum cleaner, it is possible to give instruction on the selection of cleaning location, charging state, and the amount of dusts that need to be collected.

The operation of home appliances by voice is an important trend to the improve usability not only for general users but also for the elderly and people with disabilities. Therefore, it is expected that in the future, 5G will increase the communication speed and increase the number of IoT home appliances, which will leads to the further development of smart home appliances.

4.3. Future trend toward net zero energy house (ZEH) In this section, we will focus on the electrical energy consumption by home and related equipment. ZEH has been proposed as an initiative in the household sector with the final goal to prevent global warming. In the fifth basic energy plan, which was approved by the cabinet in July 2018, more than half of the custom-built houses newly built by house makers will be ZEH by 2020, and generation system is mostly used for residential applications can be sold over 10 years at a unit price determined by the contract start year and the 'surplus purchase system'. However, over the years the selling price has gone down.

For solar power generation of 10 kW or more, either the 'surplus purchase system' or the 'total purchase system' could be selected in the past, but from FY 2020 onwards only the 'surplus purchase system' is available. In addition, from the perspective of resilience by 2030 all the average newly constructed housing will be ZEH [12].

Figure 19 shows an example of ZEH configuration. ZEH uses energy-saving technologies such as photovoltaic power generation, high heat insulation, air tightness of building materials and windows, high-efficient air conditioners, total heat exchangers, LED lighting with human sensor, etc., to achieve zero net energy

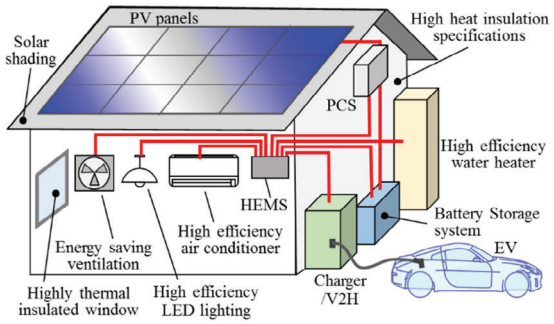


Fig. 19. Image of ZEH configuration

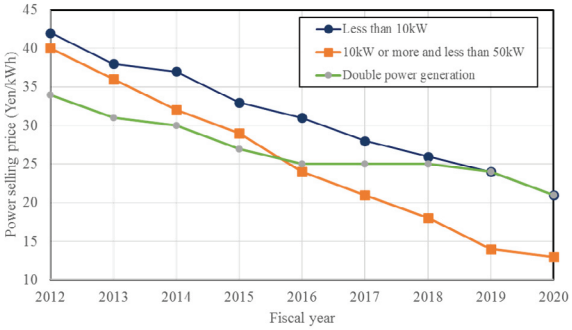


Fig. 20. Change in solar power generation price over the years

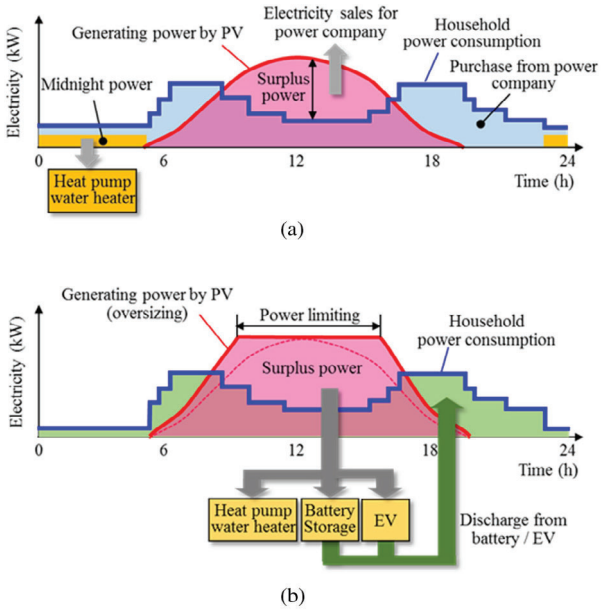


Fig. 21. Comparison of FIT (feed-in tariff) type and self-consumption type power consumption patterns. (a) Power usage pattern for selling PV surplius power and (b) power usage pattern for self-consumption

used at home. In addition, a heat pump-based water heater, a storage system, and an EV charger with V2H function controlled by HEMS can also be included in the ZEH system.

Figure 20 shows the change in solar power generation selling price over the years for three different types [13]. The 10 kW or less power (utilization in the event of a disaster), local production and consumption of energy, it has become necessary to have a certain ratio of private consumption. Due to continuous downwards trend in the solar power selling price, it can be understood that the solar power generation should shift to the self-consumption type of usage, from the conventional idea of making a profit by selling power.

Figure 21 shows a comparison of the power flow from conventional power sales-based configuration and the difference between the self-consumption pattern that will become the mainstream in the future as shown in Figure 19 type configuration.

Figure 21(a) shows the conventional power-sale pattern, in which surplus power, which exceeds the power consumed by home, is sold to the power company through the distribution system. The heat pump water heater stores the heat as warm water using inexpensive late-night power.

Figure 21(b) shows the self-consumption pattern. In this configuration, the solar plate is overrated than the conventional configuration due to the declining trend in cost and the installed PCS power rating kept the same. Hence, during sunny day condition, the maximum output power will be limited by the available PCS power ratting. However, the available power during early morning hours and evening will increase as compared to conventional configuration. Moreover, the power fluctuation during daytime will reduce.

The heat pump water heater is set to boil hot water using surplus power generated by solar power in the daytime. Similarly, the storage system and EV are charged during this daytime period. At night, electric energy stored in a storage system or EV is discharged and consumed by the home appliances. These home energy devices are centrally controlled by HEMS, and it is possible to minimize the power purchased from the power company. At present, household storage batteries are relatively expensive, so V2H which uses EVs instead of storage batteries may become more popular. It should be noted that a fuel cell-based power source might be added as an energy source in the future.

By operating the EV in cooperation with the home as described above, the running cost can be reduced as compared to a gasoline vehicle as the fuel ratio of the vehicle. The renewable energy (RE) rate of EVs will also improve.

In addition, the system shown in Figure 19 allows PV, power storage system, and V2H to operate independently, so that home appliances can be used stably even during a power outage due to a disaster. In particular V2H is also attracting attention as a regional support power source in the event of a disaster.

4.4. With/after COVID-19 Table II summarizes the main household appliances and additional services that will attract attention in the future in relation to COVID-19.

No. 1 is related to the countermeasure for infection risk in a closed space and is related to a 24-h ventilation system and a static total heat exchanger. Ventilation equipment has already been installed in the rooms built after July 2003, according to the Building Standards Law to improve living standard and air quality [14]. The 24-h ventilation system can be expected to improve its effect by adjusting and operating at a larger air volume [15].

Nos. 2 and 3 are related to virus removal. No. 2 is related to a filter type air purifier. It is effective as an auxiliary facility, but

Table II. Main household appliances and services related to COVID-19

No.	Purpose	Household appliances, related services	Remarks
1	Reduced infection risk in enclosed spaces	• 24-h ventilation system	Living rooms created after July 2003 have already been installed as sick house measures [14]
		• Total heat exchanger	Adjust to operate with a larger air volume [15]
2	Virus removal	Filter air purifier	Effective as an auxiliary equipment, but the effect of reducing virus concentration by ventilation is greater [15]
3		Virus vacuum cleaner	Installed at the entrance to discharge pollen and viruses from clothing [16]
4	Suppresses deterioration of infection defense function due to dry oral mucosa	Humidifier	Temperature: 17–28°C, relative humidity: 40–70% RH strict adherence is required [15]
5	Virus inactivation, sterilization	•Sterilization deodorizer	Some use ozone, UV, and hypochlorous acid.
		• Sterilization lamp	Many of them have a deodorizing effect by removing bacteria
		• Virus killer air system	
6		Antibacterial coat for home appliances	Suppressing viruses by coating coatings, sheets, stickers, etc.[17]
7	Preventing infection by contact	• Voice control of equipment	See Section 4.2
		• Smart speaker	
8		Device touchless operation	Operate by touching the image floating in the air [18]
9		Automatic door	No need to touch the doorknob [16]
10		Delivery box with wireless LAN function	It is possible to receive luggage securely without face-to-face [16]

since the effect of reducing the virus concentration by ventilation is greater, it is necessary to use it in combination with other methods. No. 3 is a virus cleaner installed at the entrance, and it can be used to remove pollen and viruses attached with clothes after returning home from outside activities [16].

No. 4 is the suppression of the deterioration of infection defense function due to the drying of the oral mucosa. Humidifier could be useful for this purpose. For a room temperature of 17–28°C relative humidity of 40–70% RH is expected [15].

Nos. 5 and 6 are related to the virus inactivation and sterilization. No. 5 has a sterilization deodorizer, a sterilization lamp, and a virus killer air system. These are roughly classified into those that use ozone, UV (ultraviolet light), or hypochlorous acid. It has also been proposed to install a sterilization lamp at the entrance to sterilize shoes and outer wear as well [16]. Many of them also have a deodorizing effect by removing bacteria.

No. 6 is an antibacterial coat for home appliances, which inactivates attached viruses by coating the surface of the appliances. The anti-virus performance standard is evaluated by the test method according to JIS 21702 in a comparative test with unprocessed products. Traditionally, the industry association of antibacterial product technology council used to mainly deal with antibacterial and antifungal, but since July 2019 the antivirus processed SIAA mark has also been put into operation [17]. The anti-virus products that have acquired the SIAA mark include anti-virus sheets, films, glass coatings, decorative boards, stickers, labels, and coatings. They are expected to be applied to various home appliances and homes in the future.

Nos. 7–10 are intended to prevent contact infection. No. 7 relates to the voice operation of equipment, as explained in Section 4.2.

No. 8 relates to the touchless operation of equipment. An imaging optical element parity mirror that raises the image in the air is developed, and become possible to apply it to a non-contact sensor that responds by touching an image floating on the air [18].

It is expected that it will be put into practical use in public facilities in the future, such as opening and closing elevators, doors and operating equipment.

No. 9 is an example of automatic door, like in the house, the door between the entrance and bathroom can be operated without touching the doorknob [16].

No. 10 is a home delivery box equipped with a wireless LAN function. It is said to be effective as a method of reliably receiving luggage in a non-face-to-face manner [16].

In addition, as a response to the demand for a new lifestyles, it has been reported that the demand for the food delivery services linked to the cooking appliances by IoT mentioned earlier has increased in response during the state of emergency period [18].

Since COVID-19 is facing major challenges in modern society, it is expected that various changes will appear in the home appliance sector and consumer field in next 1–2 years.

5. Conclusion

A detailed study to understand the trend in home appliances sector considering new challenges over the years is presented. Home appliances have evolved their functions to provide a comfortable and enjoyable life. However, now we need to emphasize on the

energy conservation and refine the performance further. In recent years, energy generation and storage related products that are conscious of global environment and disaster prevention have been introduced in the homes. On the other hand, the progress of IoT technology has been remarkable, and now individual home appliances are connected to the Internet, and it has become easy to operate from smartphones in remote areas. In the future, home appliances are expected to evolve to create a better living environment while supporting COVID-19.

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