Power Feeding Interfaces between Household Direct Current Power Feeding System and Household Telecommunication Equipment

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Abstract

NTT Energy and Environment Systems Laboratories has been designing power feeding interfaces to establish direct current (DC) power feeding technology for homes in cooperation with the Green Grid Platform at Home Alliance (GGP@H). A lot of information and communications technology equipment as well as household electrical equipment operates by internally converting mains-supplied alternating current (AC) to DC, so feeding DC to houses from outside should bring various benefits.

1. Introduction

A major issue in discussions about global warming and energy savings has been how to use energy efficiently. The change in Japan's national greenhouse gas emissions over time is shown in **Fig. 1** [1]. Because global warming countermeasures as well as energy saving measures and policies have been addressed in various sectors, efforts to reduce the environmental load have been achieving positive results; for example, the CO_2 emissions in 2009 were less than or equal to those in 1990 for some sectors such as industries and transport. However, the environmental loads in the residential and commercial (commerce, services, offices, etc.) sectors showed an increase of nearly 30% compared with 1990. This might be due to an increase in power consumption in each household resulting from the onset of the information society and acceleration of the aging society [2]. Moreover, highly efficient use of energy has become a major issue in terms of saving power since the Great East Japan Earthquake of March 2011.

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2. Direct current power feeding technology with high efficiency

In ordinary homes, where the environmental load is increasing, many recent appliances have built-in control systems such as microprocessors for control and communications. Most control systems operate on direct current (DC), whereas the mains electricity supplied from power companies is alternating current (AC), so each DC-powered device converts AC to DC using an internal converter or an AC adapter.

Moreover, electrical equipment used for information and communications technology (ICT) services in telecommunication buildings and datacenters is, in most cases, operated in combination with batteries for backup and uninterruptible power supplies to ensure a stable power supply. Thus, the power that have been converted once from AC to DC in order to charge batteries is converted back to AC to feed power to electrical appliances where the AC is again converted back to DC [3].

Therefore, energy efficiency should be higher for electrical equipment whose internal devices operate on DC if the supplied power is initially converted from AC to DC in the power feeding system and electrical appliances are then fed with DC power.

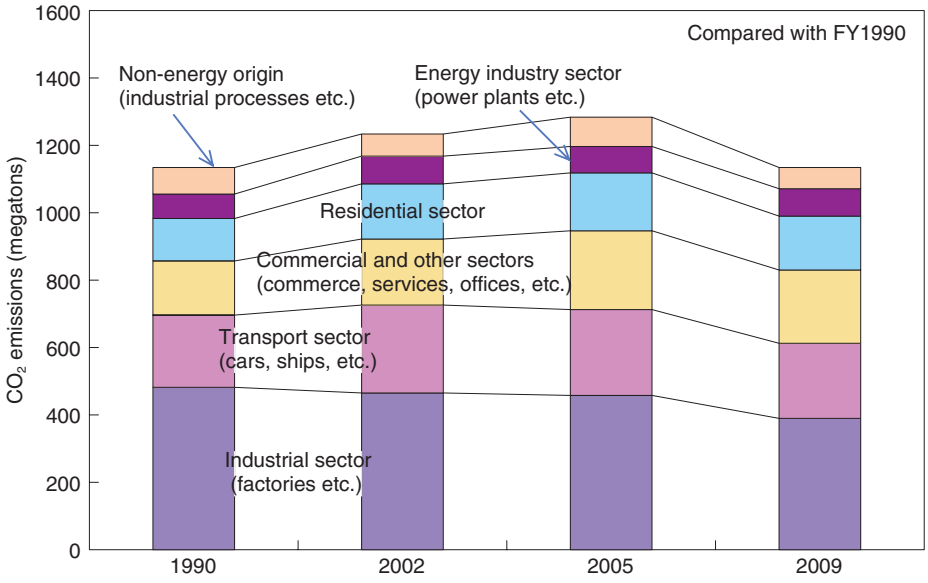

Fig. 1. Change in Japan's national greenhouse gas emissions.

Therefore, interest in DC power feeding systems has been growing.

3. Advantages of DC power feeding systems in homes

About 60% of CO_2 emissions in the residential sector comes from power consumption, which is thus a major component of the environmental load. Since households today tend to have many electrical appliances that convert AC to DC within the appliance, we expect DC power feeding to have a significant effect on reducing the environmental load and saving energy. In addition, generators such as solar panels and fuel cells, which have become more widely used recently in homes, output DC power, so they can be easily connected to a DC power feeding system [4]. Furthermore, in combination with storage batteries, they could act as emergency backup supplies available after a disaster. The many advantages of feeding DC power to homes are summarized in **Fig. 2**.

4. Importance of unified standards for DC power feeding interfaces

Smart houses compatible with DC power feeding have been introduced on the market recently [5]. To promote DC power feeding widely in homes, many power feeding characteristics (voltage, safety, connectors, electrical noise, etc.) for all or many of the electrical appliances need to be compatible with DC power feeding systems. At present, however, a lot of ICT equipment and many household appliances are incompatible with DC power feeding systems. Two major reasons are that some technical issues still remain in the DC power feeding systems and that the price of compatible appliances is still high, but another contributing factor is thought to be the lack of unification of DC power feeding interfaces. A unified standard for DC power feeding is essential to ensure user-friendliness. We think that opportunities for discussion are necessary in order to work on standardization such as the conditions for power feeding interfaces.

5. Activities toward standardization and popularization

The Green Grid Platform at Home Alliance (GGP@H, hereinafter the alliance) [6] is an organization that NTT Energy and Environment Systems Laboratories has been actively involved in since taking on the role of its secretariat. The alliance was established in November 2009 and has 48 members (as of October 2011). The members are listed in **Fig. 3**.

In the alliance, there are two working groups (WGs) for detailed discussions, and many companies joining the discussions come from a variety of business

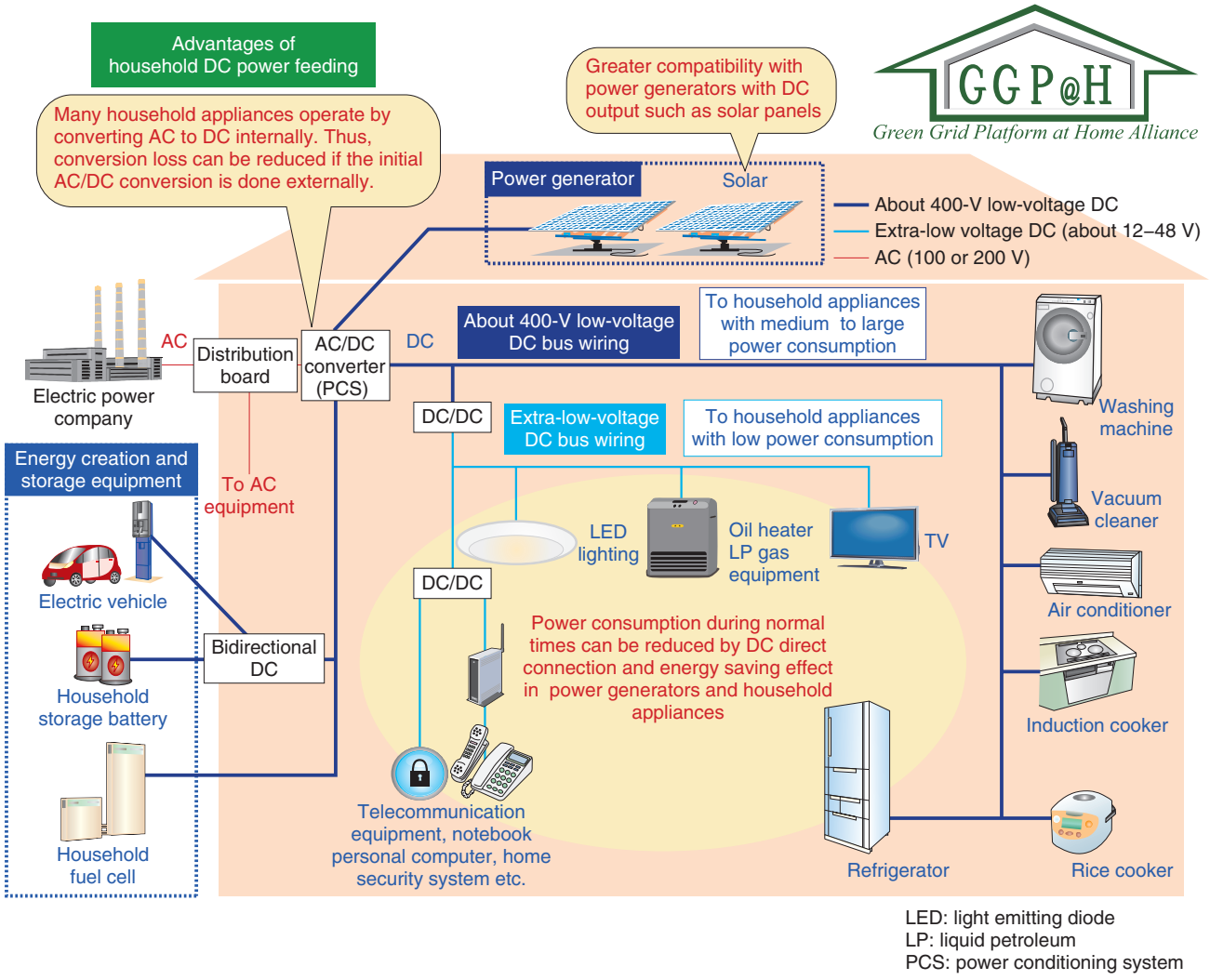

Fig. 2. Advantages of household DC power feeding.

categories such as ICT devices, security, household equipment, and appliances.

These two WGs discuss technical requirements and issues for power feeding in their areas of responsibility and coordinate with each other. WG1 is responsible for equipment with relatively low power consumption and low voltages such as ICT devices, security devices, and lighting equipment and WG2 is responsible for appliances with high power consumption and high voltages as well as power generators and power storage equipment such as solar panels, fuel cells, and power storage devices.

Since low-power telecommunication equipment, such as modems and routers, is commonly used in NTT's telecommunication services for homes, we are paying more attention to such equipment to make it compatible with DC power feeding first; thus, we have been focusing on WG1.

6. Discussions toward standards for various appliances

The power consumption of appliances found in homes ranges from a few watts to several kilowatts. If we were to apply a single power feeding interface to appliances with such widely differing power consumptions, the number of convertible appliances might end up being small. Thus, appliances need to be classified.

The alliance has defined three power feeding

☆Japan Advanced Institute of Science and Technology (Prof. Yasuo Tan)
• I-O DATA DEVICE, INC.
• AICHI INSTITUTE OF TECHNOLOGY
• ALPS ELECTRIC CO., LTD.
• Ishikawa Optics and Design Institute Ltd.
• IWATSU ELECTRIC CO., LTD.
• SMK CORPORATION
• NEC Magnus Communications, Ltd.
• Osaka Gas Co., Ltd.
• Osaki Electric Co., Ltd.
• Oki Electric Industry Co., Ltd.
• Otowa Electric Co., Ltd.
• Origin Electric Co., Ltd.
• Kawamura Electric Inc.
• Kandenko Co. Ltd.
• Sharp Corporation
• Shindengen Electric Manufacturing Co., Ltd.
• Sumitomo Electric Industries, Ltd.
• JX Nippon Oil & Energy Corporation
• SOHGO SECURITY SERVICES CO., LTD.
• Daiko Advertising Inc.
• TDK Corporation
• TDK-Lambda Corporation
• The Telecommunications Carriers Association
• DENSO CORPORATION
• The University of Tokyo
• Toshiba Corporation
• TOMITA ELECTRIC MFG. CO., LTD.
• Nihon University
• NEC Corporation
• HASEGAWA ELECTRIC CO., LTD.
• Haseko Corporation
• BUFFALO INC.
• FUJITSU TELECOM NETWORKS LIMITED
• Panasonic Electric Works Co., Ltd.
• Hitachi, Ltd.
• France Telecom
• Mitsubishi Electric Corporation
• Ricoh Company, Ltd.
• Ruby Investment Research Co., Ltd.
• Renesas Electronics Corporation
• Yazaki Corporation
• NTT Advanced Technology Corporation
• NTT FACILITIES, INC.
• NTT FACILITIES RESEARCH INSTITUTE Inc.
• NTT EAST CORPORATION
• NTT WEST CORPORATION
★NIPPON TELEGRAPH AND TELEPHONE CORPORATION (NTT)

☆: Chairperson
★: Secretariat

Fig. 3. Organizations participating in the Green Grid Platform at Home Alliance.

interfaces (IFs) according to power consumption and device characteristics; namely, IF1 (ICT equipment and security equipment), IF2 (lighting equipment, TVs, etc.), and IF3 (appliances with medium to large power consumption, power generators, and power storage equipment). WG1 is discussing the technical requirements for IF1 and IF2, while WG2 is discussing those for IF2 and IF3. The classification of DC power feeding interfaces by appliances is shown in **Fig. 4**.

It should be noted that not only power consumption but also other requirements need to be considered for the power feeding interfaces. It is necessary to take account of the fact that some appliances with the same power consumption still differ in the electrical characteristics of their internal components. The requirements for power supply equipment (AC adapter and power supply unit etc.) may differ to match the characteristics of each appliance; for example, many personal computers are switched on only when they need to be used, whereas ICT equipment such as modems and routers usually operates in an always-on manner.

Furthermore, there are many cases of AC power being converted to DC at about 300 V for use inside electrical equipment such as air conditioners. When voltage exceeding 300 V is supplied, stricter restrictions are imposed on electrical facilities by law. The alliance has purposely discussed IF3 as the standard corresponding to equipment with voltage exceeding 300 V in order to clarify the problems, and it is aiming to consider any required legal amendments in the future.

Moreover, DC power feeding will not be widely used until both efficiency and safety have been ensured. Thus, we are currently discussing a mechanism for protection coordination that is considered to be necessary to minimize the impact of trouble and to prevent interference with other equipment and the distribution system in the event of failures.

7. Study on power feeding interfaces for ICT equipment

WG1 is working on IF1 and developing the requirements for the power feeding interfaces, in particular, for household ICT equipment such as home gateways (HGWs) and optical network units (ONUs). The maximum power consumption of household ICT equipment is roughly 30 W, and equipment of such a class operates in conjunction with AC adapters that output DC at a voltage ranging from 12 V to 24 V. Considering other factors such as efficiency, many WG1 members are currently discussing whether power at a DC voltage of 24 V or less is adequate, and WG1 is close to reaching agreement to include this as a requirement for the IF1 power feeding interfaces. There are some other suggestions for additional power feeding interface requirements besides voltages: some people think that it is necessary to study technical items such as electromagnetic compatibility (EMC) corresponding to the characteristics of each appliance as well as the required conditions for the protection coordination of appliances and AC adapters.

Furthermore, it is considered to be unrealistic to

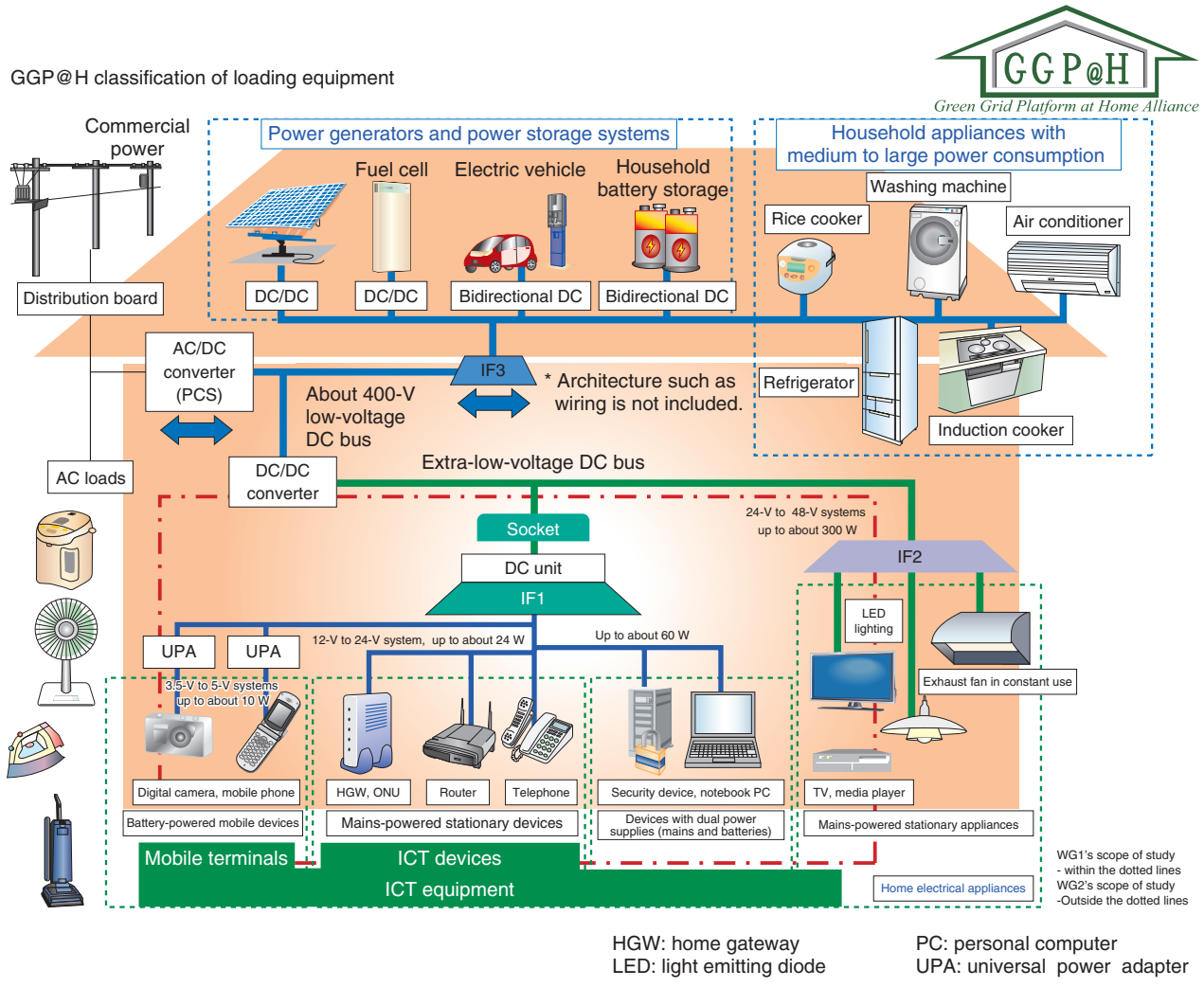

Fig. 4. Classification of DC power feeding interfaces by appliances.

change the power feeding system from AC to DC while most households use AC power supplies at present. Thus, as an intermediate phase between AC and DC power feeding, we have been investigating power feeding interfaces (AC adapters) that convert currents from AC to DC, and we have been studying their requirements.

When the requirements of AC-to-DC conversion power feeding interfaces are determined in the future, the DC power feeding interfaces for appliances will be determined. Therefore, we expect that it will be possible to implement DC power feeding directly in appliances by just removing the AC adapters once the power feeding system to homes is changed from AC to DC.

WG1 is currently working on the power feeding interfaces for adapters that can be used in common among the home ICT equipment that has relatively low power consumption.

8. Widely promoting the advantages of household DC power feeding as a disaster countermeasure

People's interest in a stable supply of electricity as well as energy conservation and power saving has increased greatly since the Great East Japan Earthquake. The alliance has been vividly aware of disaster countermeasure aspects since its establishment. As mentioned above, if DC power feeding to homes is put into practice, it will enable power to be fed from solar panel systems and electric vehicles to household

appliances if the commercial power supply is cut off by events such as disasters. IF2 and IF3 are being discussed in WG2 to achieve this function.

Moreover, the alliance has always clearly recognized since its establishment that fiber to the home (FTTH), which has become widely used in recent years, cannot supply electric power through its communication wires, so optical-based telecommunication equipment will fail to operate when the commercial power supply is lost. For this reason, the initial aims of the alliance included the idea of the DC power feeding system for houses providing an emergency power supply function for telecommunication equipment.

Having seen a rise in social awareness of disaster countermeasures, the alliance intends to disseminate information more actively in order to gain a wider understanding of these advantages. The GGP@H website [6] explains these ideas in an easy-to-follow manner for the public.

9. Future prospects for the alliance

The standardization being undertaken by the alliance is also progressing globally. We have proposed the requirements for IF1 to ITU-T (International Telecommunication Union, Telecommunication Standardization Sector) and have been advancing our activities toward standardization with the goal of contributing to energy savings in supplying power to household communication equipment and to resource savings by reducing the use of AC adapters. The international community has already standardized battery chargers for mobile phones from a waste reduction viewpoint and the alliance's efforts have been attracting more attention. Our proposal includes ideas related to waste reduction, so it has been favorably received and discussed.

IF2 and IF3, by contrast, still face many difficulties such as legal restrictions and protection coordination since their standardization must deal with voltages over 300 V, so they are both still being discussed. We intend to prepare power feeding requirements that are applicable in practice and aim at eventually proposing them as international standards in the same way as for IF1.

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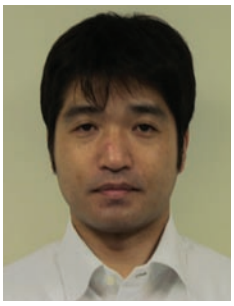

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