HAN devices with ECHONET Lite for gas appliances

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1. Abstract

After 3.11, the Great East Japan Earthquake, power supply in Japan became tight due to the accident of a nuclear power plant. The concern over the demand-side management of energy has risen for balancing between supply and demand of energy. To control the energy demands for home appliances, the government promotes installing HEMS(Home Energy Management System) into each house. The problem seems to lie in the fact that each of the makers adopts different communication media and protocols. In Japan, the middle-ware called "ECHONET Lite" was adopted as the standardized HAN(Home Area Networks) interface to realize the universal-connection of home appliances made by different makers. The government, Ministry of Economy, Trade and Industry, designated the key devices for Smart Houses. They are Photovoltaic generations, storage batteries, air conditioners, smart meters, EV/PHVs, fuel cells, and water heaters.

Tokyo Gas Co. accelerates the spread of fuel cells named "ENE FARM" which can contribute to the reduction of the power demand. And also, we are testing the contents of HEMS, for example, visualization energy consumption, the advice for saving energy, ranking of consumers, and central control. There has been little study conducted concerning the effectiveness of cooperation between fuel cells and HEMS. We achieved the first release of devices to connect fuel cells "ENE FARM" to HEMS. In this paper, we introduce the activities of Tokyo Gas Co. on the development of HEMS and the devices with ECHONET Lite for gas appliances.

CONTENTS

2. Body of Paper

2.1 Introduction

After 3.11, the Great East Japan Earthquake, power supply in Japan became tight due to the accident of a nuclear power plant. Figure2-1 shows that the amount of power generation has decreased since the Earthquake in 2011. This summer, the power supply is still estimated to be insufficient especially in Western and Central Japan.

The concern over the demand-side management of energy has risen for balancing between supply and demand of energy. It has become a major issue to manage the energy consumption for household usage by the direct action of consumers, as well as by the installation of high efficient appliances. HEMS(Home Energy Management System) is expected to be one of the useful tools that induce the consumers to be concerned about energy consumption .
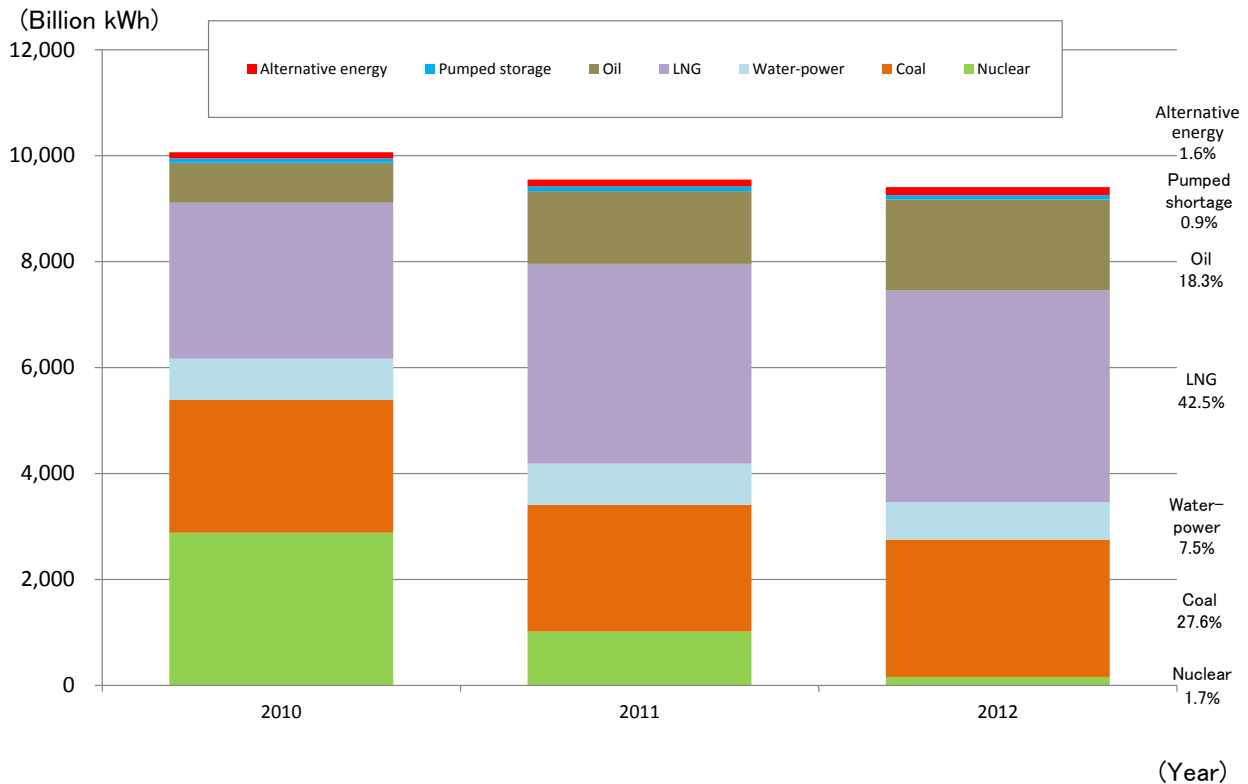

Figure2-1. Changes in the volume of power generation in Japan

2.2 Function and Equipment configuration of HEMS

HEMS has typically two main functions. The first is to visualize detailed data about the energy consumption and power generation by solar power and fuel cells. Some of them have the services for consumers to give advices about saving energy.The second is to control home appliances, such as air conditioning and lighting. HEMS helps consumers to control home appliances easily from a tablet PC while they check the energy consumption.

As Figure2-2 indicates, HEMS is composed of two devices. The first device is the controller. The controller has three main functions.data storage,data analysis,and control. The second device is the multi measurement unit. The device measures detailed energy data with current sensors and the gas meter.
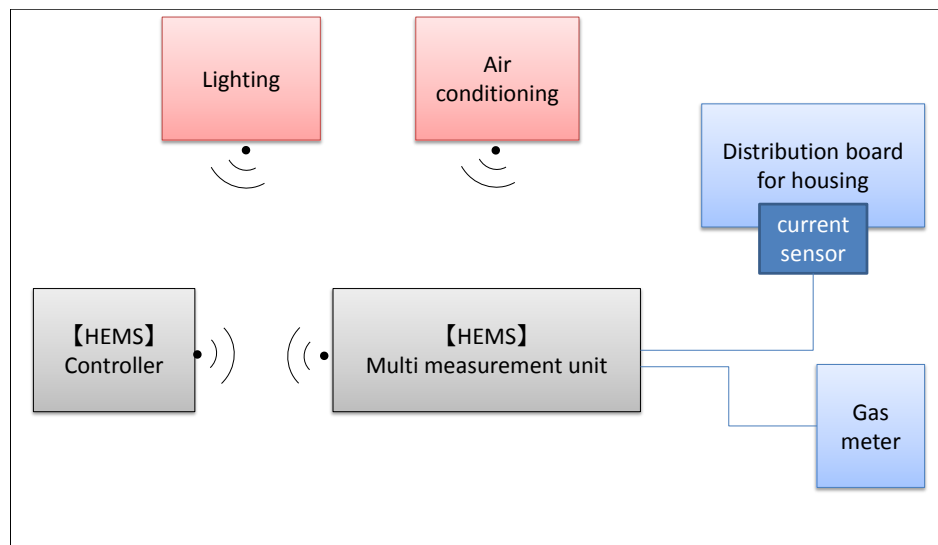

Figure2-2. Device configuration of HEMS

2.3 Tokyo Gas approaches to HEMS

Tokyo Gas is the largest supplier of city gas in Japan. Tokyo Gas serves more than 11 million customers, primarily in the Tokyo metropolitan area and surrounding Kanto region. We run a gas appliances sales business to accelerate the installation of high efficient appliances, such as condensing boilers and fuel cells. Besides, we carry out research and development about the appliances, the applications, and the related devices.

As for applications, we are trying field tests of HEMS connected to gas appliances. We are examining our original contents of HEMS including gas related information on tablet PC, for example, the advice for saving energy, ranking and central controller. As an interim result, we got the tendency of customers' accessing or tapping that historical energy consumption data were the most valuable information for them.

As representative products of the related devices, we develop adapters to connect gas appliances and HEMS with standardized communication protocol called "ECHONET Lite". We will describe the details below.

Figure2-3. The original contents of HEMS

2.4　Standardized communication protocol "ECHONET Lite"

For the sake of the spread of HEMS, the interfaces between HEMS and home appliances should be standardized. In 2012, the communication protocol called "ECHONET Lite" was adopted as standardized interface. And moreover, gas appliances like fuel cells and water heaters were defined as the key devices for Smart Houses, same as other home appliances such as solar power systems, storage batteries, EV/PHVs, lighting, air conditioning, and electricity meters.

As a result of easy connection among home appliances and HEMS made by different makers, the consumers will have various options when they purchase them. It is also expected that new services such as security and monitoring services for elderly people will be provided by using ECHONET Lite in the future.

2.5　Local network of fuel cells system in the house

Fuel cells system is composed of multiple units. Fuel cells unit, tank unit, back up boiler unit, bathroom heater and controllers for floor heating. As figure2-4 indicates, they are connected to each other by individual serial interfaces.

Fuel cells unit generates power and heat simultaneously. As figure2-5 indicates, back up boiler unit makes hot water and circulates it through floor heating mats and the bathroom heater under instructions from controllers.

Although the local network of fuel cells system has been built up to now, this conventional system has no interfaces to connect to HEMS.
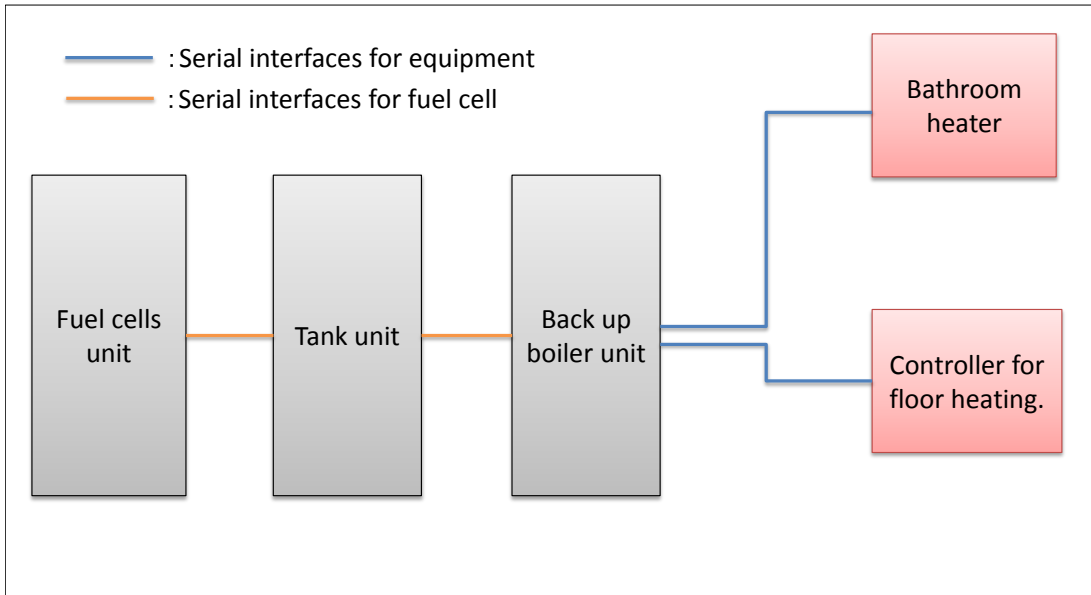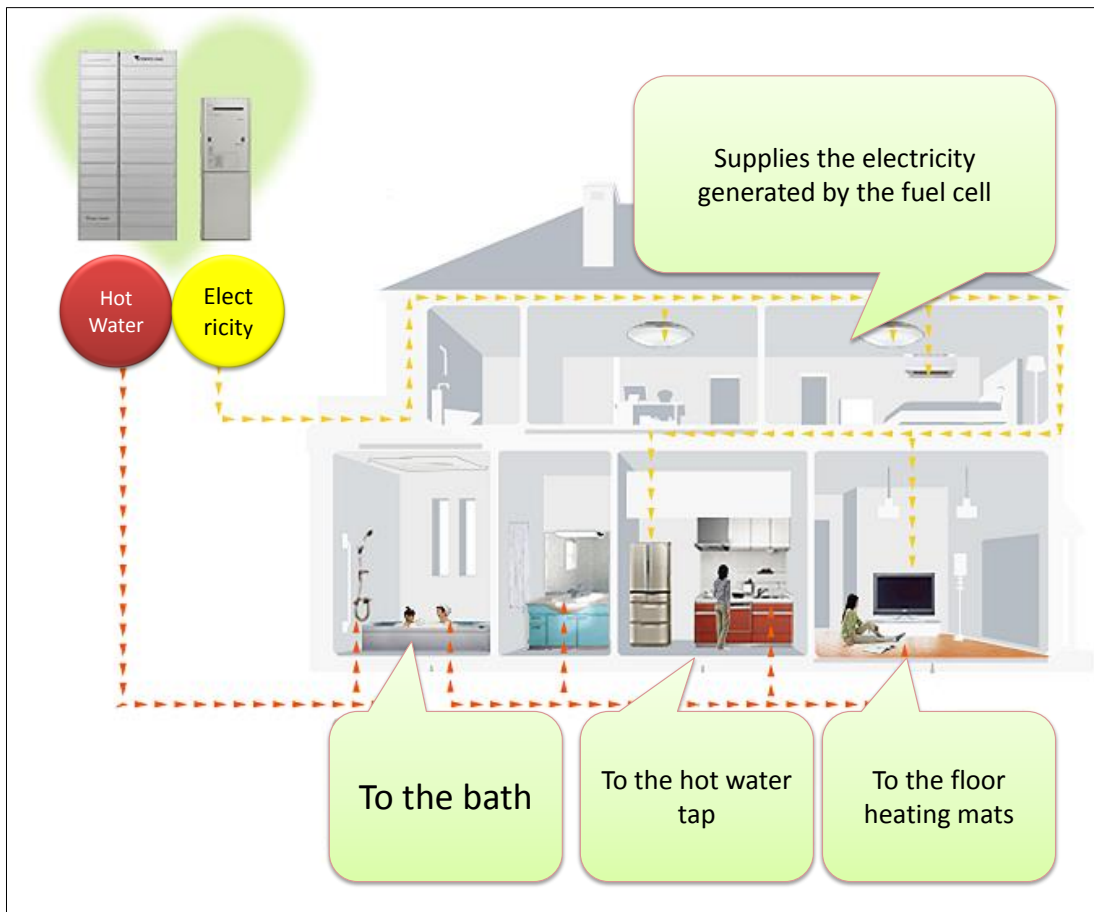
Figure2-4. The local network of fuel cells system

Figure2-5. Network of power and heat

2.6   The development of ECHONETLite adapter for gas appliances

2.6.1 The structure of ECHONETLite adapter

Tokyo Gas has developed the ECHONETLite adapter that enables gas appliances such as fuel cells and water heaters to communicate by ECHONETLite in collaboration with the gas equipment makers and other gas companies. The adapter works as a converter from original communication protocols to standardized protocols, ECHONETLite. It allows gas appliances to connect HEMS directly by Ethernet cable. It is unnecessary to put the adapter on each controller because the fuel cells system has a local network as we mentioned before. We only have to install the adapter near the distribution board.
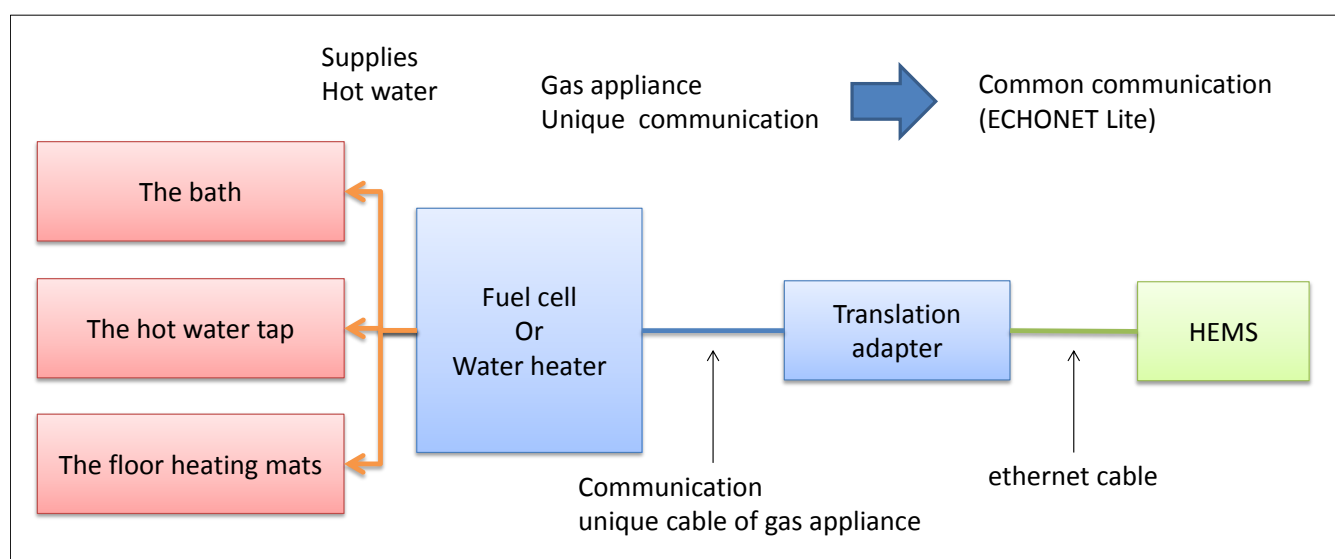

Figure2-6. Configuration of HEMS and gas appliances with the translation adapter

2.6.2 The outline of the function of ECHONETLite adapter

The adapter has mainly 2 functions. First is to send "Set commands" such as ON/OFF command from HEMS to gas appliances. Second is to send data from gas appliances to HEMS in response to "Get commands" such as taking the operating state, gas consumption data and power generation date.

Table 2-1 shows the standardized functions of the water heaters. Table 2-2 shows the standardized functions of the fuel cells.

Table2-1. Water heater functions in ECHONET Lite

Property name	EPC	Contents of property / Value range (decimal notation)	Data type	Data size	Unit	Access rule	Man-datory	Announce-ment at status change	Remark
Operation status	0x80	This property indicates the ON/OFF status.	unsigned char	1 byte	—	Set		O	
		ON=0x30, OFF=0x31				Get	O		
Hot water heating status	0xD0	This property indicates the hot water heating status.	unsigned char	1 byte	–	Get	O		
		Hot water heating status found = 0x41 Hot water heating status not found = 0x42							
Set value of hot water temperature	0xD1	This property indicates the set value of the hot water temperature in °C.	unsigned char	1 byte	°C	Get/Set			
		0x00–0x64 (0–100)							
Hot water warmer setting	0xD2	Hot water warmer setting	unsigned char	1 byte	–	Get/Set			
		Hot water warmer operation = 0x41 Hot water warmer operation resetting = 0x42							
Bath auto mode setting	0xE3	Bath auto mode ON/OFF	unsigned char	1 byte	–	Set/Get	Ⓜ		
		Auto ON = 0x41 Auto OFF = 0x42							
Bath hot water volume setting 2	0xE8	This property indicates the bath hot water volume (in 8 steps).	unsigned char	1 byte	–	Set/Get			
		0x31–0x38							

Table2-2. Fuel cells functions in ECHONET Lite

Property name	EPC	Contents of property / Value range (decimal notation)	Data type	Data size	Unit	Access rule	Man-datory	Announce-ment at status change	Rem ark
Operation status	0x80	This property indicates the ON/OFF status.	unsigned char	1 byte	–	Set		O	
		ON=0x30, OFF=0x31				Get	O		
Measured instantaneous power generation output	0xC4	This property indicates the instantaneous power generation output in watts.	unsigned short	2 bytes	W	Get	O		
		0x0000–0xFFFD (0–65,533W)							
Measured cumulative power generation output	0xC5	This property indicates the cumulative power generation output in units of 0.001kWh.	unsigned long	4 bytes	0.001 kWh	Get	O		
		0x00000000–0x3B9AC9FF (0–999.999.999kWh)							
Power generation status	0xCB	This property indicates the power generation status.	unsigned char	1 byte	—	Get			
		generating =0x41, stopped=0x42, starting=0x43, stopping=0x44, idling=0x45							
Measured remaining hot water amount	0xE1	This property indicates the measured amount of remaining hot water in liters.	unsigned short	2 bytes	liter	Get			
		0x0000–0xFFFD (0–65,533 liters)							
Tank capacity	0xE2	This property indicates the tank capacity in liters.	unsigned short	2 bytes	liter	Get			
		0x0000–0xFFFD (0–65,533 liters)							

2.6.3 The HEMS functions expanded by ECHONETLite adapter

The ECHONETLite adapter will give the consumers new HEMS functions by using the two-way communication between HEMS and gas appliances. Table2-3 shows additional contents. Figure2-7 shows the image of HEMS application on a tablet PC. The adapter makes the gas appliances convenient, moreover It will allow the consumers to easily take advantage of energy-savings.

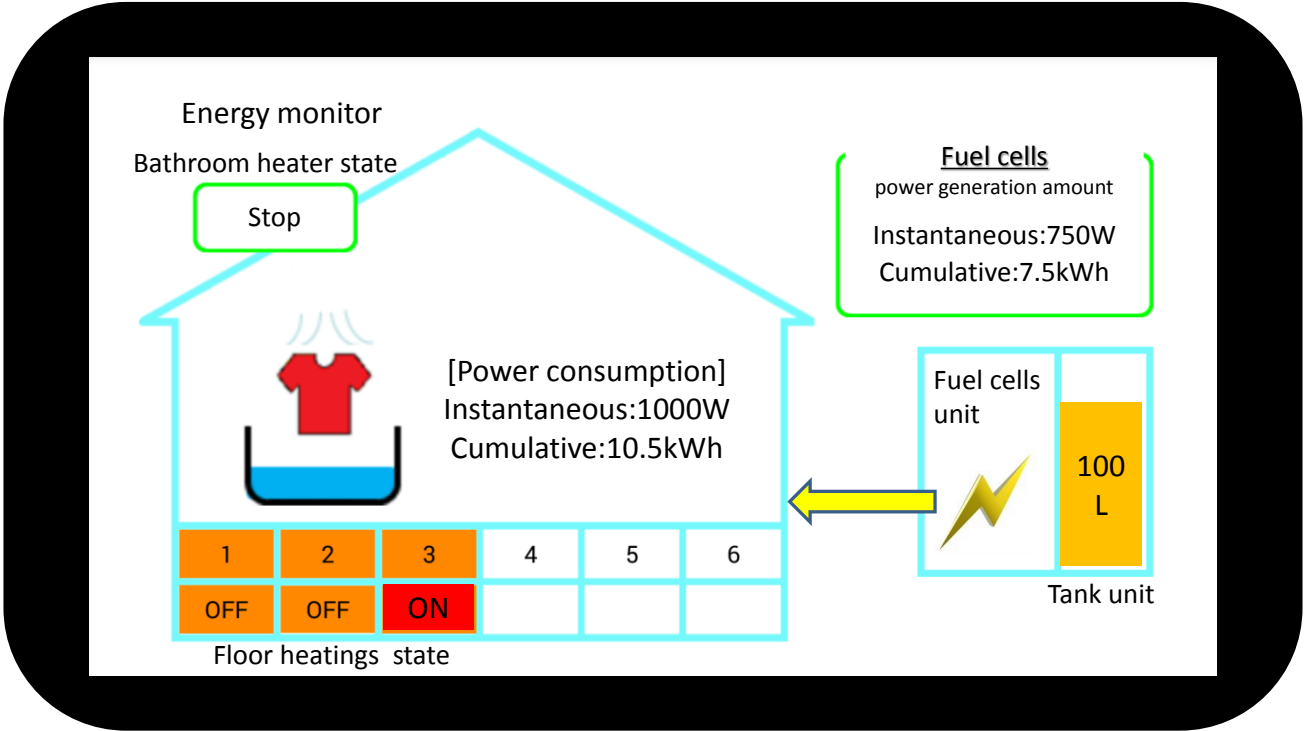| HEMS can control that:	Bath auto mode setting(Auto ON/OFF)
	Floor heating mat operation(ON/OFF)
	Floor heating mat temperature(9steps)
HEMS can show that:	gas consumption of gas appliances
	power generation amount of fuel cells
	power generation state of fuel cells
	remaining hot water amount of fuel cells

Table2-3. Contents of HEMS

Figure2-7. The image of HEMS application

2.7   Conclusion

We developed the adapter to connect gas appliances and HEMS with standardized communication protocol "ECHONETLite". We expect that the adapter will contribute to the wide spread use of HEMS, and in the long run, that most of the consumers using gas appliances connected to HEMS can manage energy consumption easily.

3. References

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