Chapter 5

Introduction of Low-Carbon Community Energy Systems by Combining Information Networks and Cogeneration-Type District Heating and Cooling Systems

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Additional information is available at the end of the chapter

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Abstract

Achievement of a low-carbon society is becoming extremely important. In this report, we introduce an example of carbon dioxide (CO_2) emission reductions and energy savings, using a local energy-control system. Our research is focused on the town of Shinchi in the Fukushima Prefecture, Japan. Shinchi is pursuing initiatives to create a low-carbon, energy-efficient society and a disaster-resilient community. The National Institute for Environmental Studies provides academic support for the design and planning of low-carbon community energy systems by the local government of Shinchi, based on the Basic Cooperation Agreement. For the redevelopment of the Japan Railway (JR) Shinchi Station district that is being carried out, construction of a cogeneration-type district heating and cooling system is currently in progress. CO_2 reductions of about 20% can be expected by introducing this community energy system. To support these initiatives, we have developed an information and communication technology (ICT) system that shares a wide range of local information to support energy conservation. By analyzing electricity consumption data from the ICT, we evaluated the pattern of residential power consumption and confirmed that the project supports energy-saving behavior within the community. Additionally, the community energy project in the JR Shinchi Station district enables adjustment of the supply and demand balance.

Keywords: cogeneration, community energy management system, district heating and cooling, information and communication technology, waste heat recovery absorption chiller-heaters (genelink)

1. Introduction

As global warming becomes more serious, development of a low-carbon society has become an urgent task [1–3]. In particular, reduction of the energy used to cool and heat buildings, which is a large portion of energy usage during summer and winter, is an important issue [4, 5]. However, CO_2 emission due to heating and cooling-related energy consumption is still increasing. Thus, practical measures are needed to reduce CO_2 emissions.

As shown by recent examples, such as locally implemented plans to counteract global warming, formulation of new regional energy conservation visions, and proposals for environmental model/future cities, there are many opportunities for local governments to employ energy-efficient measures and CO_2 emission reduction plans [6]. Energy consumption for cooling and heating is strongly influenced by local factors such as climate, land use, and building-related aspects [7, 8]. The potential for energy and CO_2 reductions from both non-structural and structural measures is high [9], and there are proposals for such measures that incorporate various regional efforts.

In Japan, energy usage has changed greatly since the 2011 Great East Japan Earthquake [10–12]. Before the earthquake, during the period between the United Nations Framework Convention on Climate Change and the first commitment period prescribed by the Kyoto Protocol, reduction of CO_2 emissions was an important policy issue for mid-term to long-term global warming countermeasures. Since the earthquake, there have been many global warming countermeasures and energy policies such as government-imposed power-saving measures to mitigate power peak loading, various programs associated with nuclear power generation, a renewable energy feed-in tariff, and liberalization of power retailers.

There are three reasons that the Great East Japan Earthquake caused changes to energy-related matters. First, the vulnerability of Japan's large-scale energy supply network was exposed. The supply network for power and gas was disrupted during the earthquake, and the energy supply was discontinued over wide areas, even in areas that suffered only minor earthquake damage. In some cases, people survived the earthquake and tsunami but ultimately died due to the absence of power, which resulted in a lack of heating and a shortage of dry clothes. This situation led to a focus on renewable energy as an emergency power source during disasters. Through the introduction of a distributed power supply and construction of an autonomous energy network, energy supply and demand are becoming more efficient at the local scale [13].

Second, the earthquake-related accident at the Fukushima Daiichi Nuclear Power Plant increased the public's awareness of energy supply issues [14–16]. To mitigate peak power loading as the nuclear power plant ceased to function, rolling blackouts and legally binding power usage restrictions were implemented. Additionally, radioactive contamination led to a large-scale evacuation order for residents. During post-disaster reconstruction, many citizens cooperated with energy-saving measures during periods of peak energy demand in summer. As a result, a large number of citizens became aware of energy supply issues.

Third, the Great East Japan Earthquake intensified the problems of depopulation, declining birthrate and the aging population in Japan. For municipalities in disaster-affected areas, these issues are pressing. Population decline along with decentralization of residential areas

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leads to an increase in CO_2 emissions per capita. By making cities compact, travel becomes more efficient, and the air conditioning load of housing complexes is reduced, thus increasing energy efficiency [17]. The decrease in energy consumption related to cooling and heating results in reduced CO_2 emission. As such, during the reconstruction process following the earthquake, many disaster-affected municipalities aimed to build compact, energy-efficient cities, with improved energy supply and demand balance [18, 19].

This paper examines the advanced case of Shinchi, which is a town located on the northern edge of the Fukushima Prefecture. In Shinchi, after major damage from the Great East Japan Earthquake, a community heat supply system was introduced to link an information and communication technology (ICT) system with a cogeneration system (CGS). The National Institute for Environmental Studies provides academic support for the design and planning of such systems, as well as assessing the feasibility, energy conservation, and CO_2 emission reductions [20, 21]. As a social demonstration experiment, we introduced smart meters and tablet-type display terminals to sample households. Coupled with smart meters, the household display terminals show a variety of information such as real-time energy consumption, comparison with the previous day or year, and electricity-saving messages. Thus, Shinchi is not simply a case of disaster reconstruction but also successful realization of a low-carbon society to benefit future generations.

2. Case community

2.1. Outline of the town of Shinchi

Shinchi is a small municipality with a population of about 8000 and a total area of 46.53 km^2, located about 300 km north of Tokyo, near the border between the Miyagi and Fukushima Prefectures, in the northernmost part of the Fukushima Prefecture on the Pacific Ocean side of Japan (**Figure 1**). The population peaked in 1995 and has since declined, with an aging population and a diminished birthrate. The temperature of Shinchi is low compared to Tokyo, with especially cold winters (**Figure 2**). However, the summer temperatures tend to be high; thus, air conditioning is typically required on summer days.

In Shinchi, approximately 120 people died as a result of the Great East Japan Earthquake and subsequent tsunami that occurred on March 11, 2011. The tsunami inundated a large area of land 10 m above sea level, with flooding encompassing about 20% of the town. The tsunami destroyed 516 houses; including damage from the earthquake, 630 houses were totally or partially destroyed. The JR Joban Line Shinchi Station was destroyed, and 40% of agricultural land, 420 ha, was inundated. Furthermore, radioactive contamination due to the Fukushima Daiichi Nuclear Power Plant accident resulted in a mean air radiation dose of 0.2–0.6 μSv/h for the town in 2011, which has been declining ever since.

Before the earthquake, the main railway was the JR Joban Line, but it was closed immediately after the tsunami disaster. The JR Joban Line was reopened in December 2016, allowing access to Sendai, located north of Shinchi. Redevelopment of the district around the JR Shinchi Station, which was damaged by the tsunami, is currently being carried out.

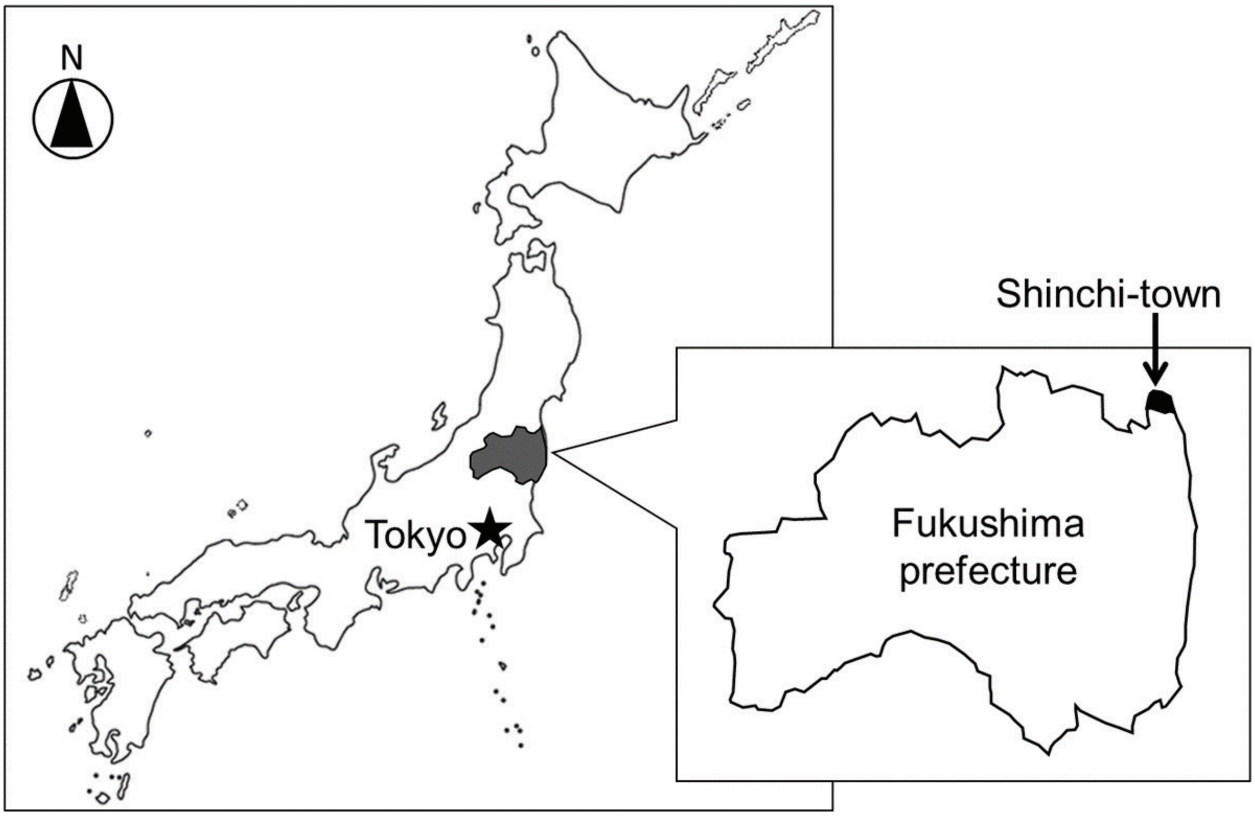

Figure 1. Location of Shinchi.

2.2. The smart hybrid town concept

In the process of disaster reconstruction, Shinchi proposed "the smart hybrid town" concept, which benefits the environment, economy, and society (**Figure 3**). The aim of this concept is to reconstruct the area by combining ICT with a social mechanism that supports the community. Specifically, community residents are linked with the municipality, research facilities, and businesses through a bidirectional information network. In this manner, a prototype for a new community information infrastructure, which shares information on the local environment and community lifestyle, is constructed. With this local information infrastructure, energy consumption monitoring systems are installed in homes, public facilities, and commercial facilities. The aim is to create a "community energy support network" that promotes energy conservation on the energy demand side, an "aging community support network" that accommodates an aging society, and a "community traffic support network" that improves the operation of public transportation, based on vehicle location information from global positioning systems (GPSs) and information supplied by users. With this concept, as a disaster-affected site, Shinchi was selected as a "future city" by Japan's Cabinet Office in December 2011.

Now the focus is on developing an energy management system based on a community energy support network to adjust supply/demand and to increase efficient use of renewable energy. On the supply side, the system forecasts electricity output and CO_2 emissions from the combination of thermal power generation, natural energy, and waste heat utilization and utilizes the forecast as control information. On the demand side, smart meters are provided to every household. These smart meters are not only display monitors but also interactive information

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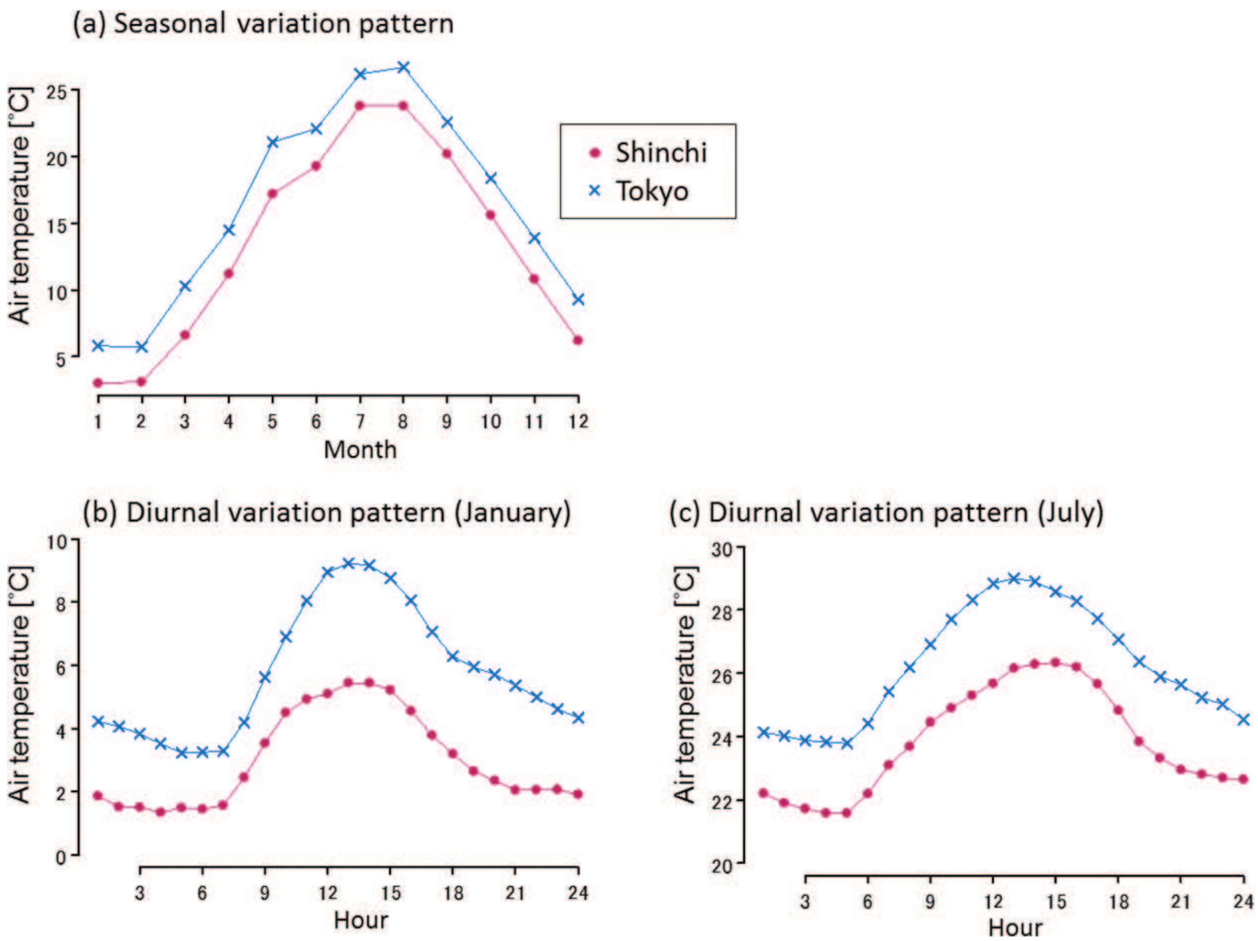

Figure 2. Air temperature variation pattern of Shinchi and Tokyo.

terminals. The information from both the supply and demand sides is gathered and managed at the smart hybrid center to improve energy efficiency. For example, messages are generated and sent to the demand side, asking for electricity savings based on the supply and demand situation. The system can "visualize" electricity-saving behavior and provide information such as energy-saving rankings within the community.

The next step will be the introduction of an automatic demand response control, which is realized by the combination of dynamic pricing and remote control of electrical appliances. Dynamic pricing continuously varies the price of electricity, which can provide economic benefits to consumers who proactively save electricity during power shortages and use electrical appliances such as washing machines when electricity is in surplus. By adjusting supply and demand with automatic dynamic pricing, it also becomes possible to introduce renewable energy sources on a large scale. For example, solar and wind power generation systems should be proactively introduced, as they have significant potential for reducing CO_2 emissions and can be used as emergency energy sources during natural disasters. However, renewable energy sources have drawbacks. For example, their output depends on factors such as the weather, and long-term energy storage is difficult. We are therefore developing a system to balance energy supply and demand by linking the supply and demand sides with the information network.

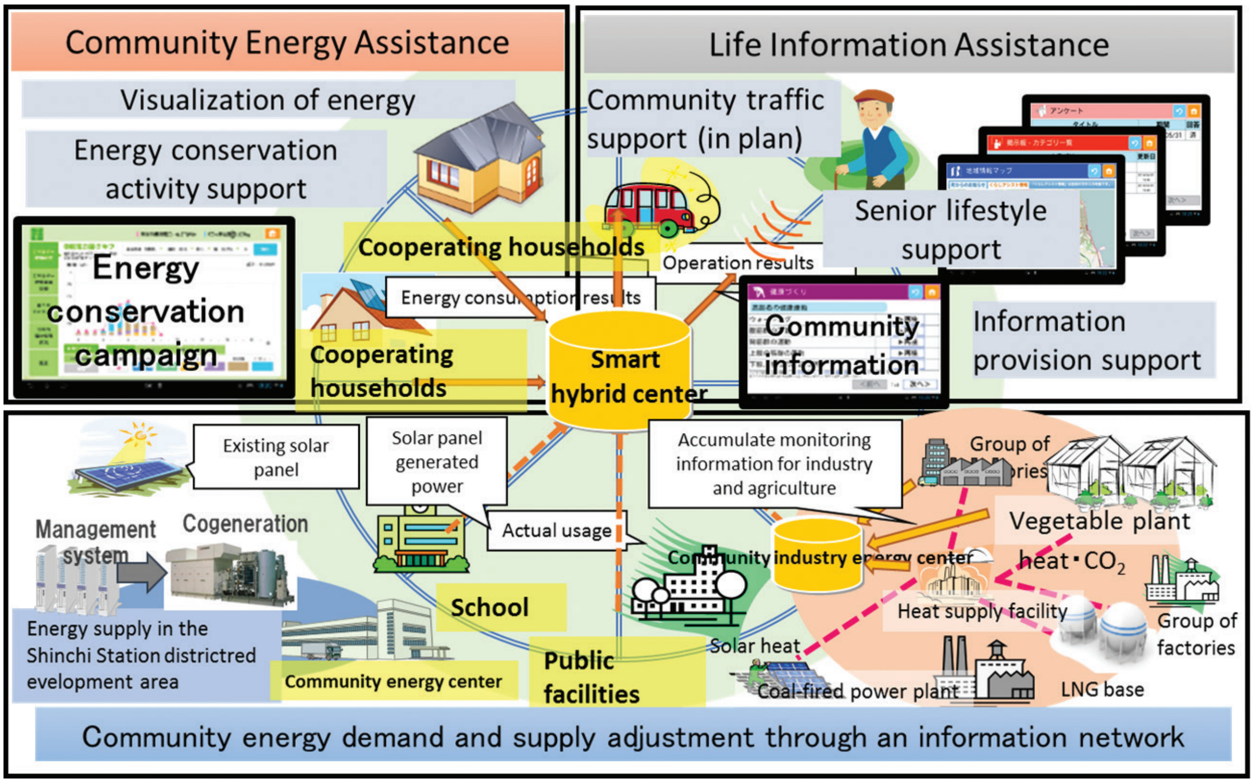

Figure 3. Schematic diagram of the smart hybrid town concept in Shinchi.

With Shinchi's selection as a "future city," discussion regarding reconstruction began, and in March 2013, a Basic Cooperation Agreement was drawn up between Shinchi and the National Institute for Environmental Studies. The National Institute for Environmental Studies has been supporting construction of future visions, maintenance of the ICT base, and comprehensive town reconstruction, based on academic knowledge such as social communication [20, 21].

3. Introduction of the JR Shinchi Station district community energy project system

3.1. Outline of the community energy project

In Shinchi, in addition to reconstruction of infrastructure, the aim is to implement a future city "smart hybrid town" concept, which promotes town reconstruction with a view to benefiting the environment and society. Thus, the reconstruction plan for the area around the JR Shinchi Station, where there was major damage from the tsunami, promotes the introduction of a community energy management system (CEMS) that utilizes natural gas and other clean sources (The Smart Community Project [22, 23]).

In the Smart Community Project, natural gas from a pipeline connected to the soma liquefied natural gas base (currently under construction) will be utilized, and combined heat and power will be supplied from the natural gas CGS to facilities around Shinchi Station. The Smart Community Project involves construction of a community energy center, local heat

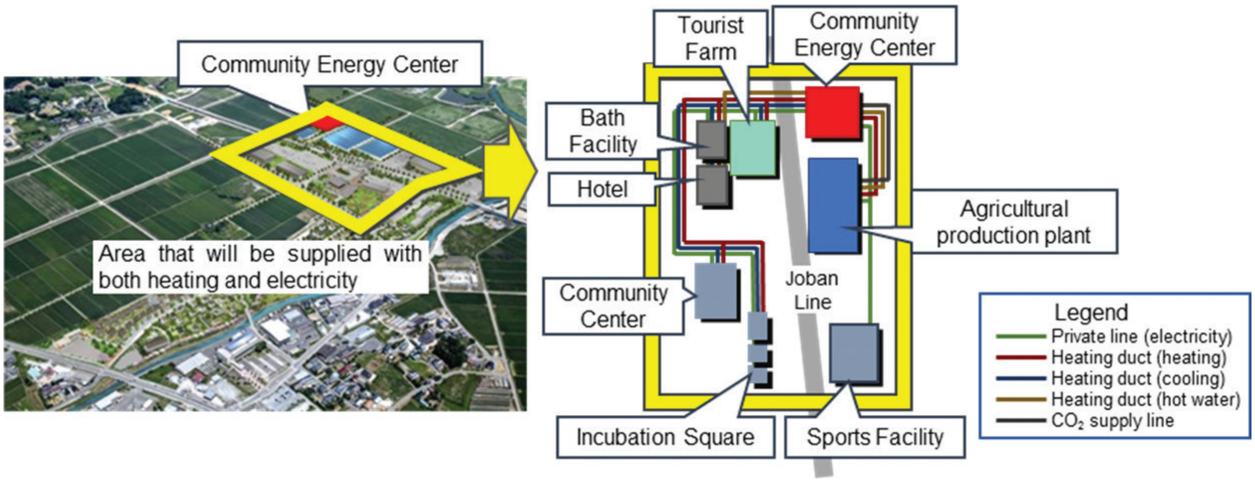

Figure 4. Locations of energy demand facilities in the area surrounding Shinchi Station (revised by authors based on reference [23]).

conduits, a community power grid, and CO_2 supply pipes. In addition, solar power facilities and batteries will be introduced to public facilities. To manage these facilities integrally, CEMS will be utilized.

3.2. Estimating facility energy demand

In this investigation, projections were made regarding the energy demands of facilities in the Shinchi Station area to be served by the distributed energy system. These estimates were based on two sources of data. The first source is an existing study, the 2016 smart community adoption promotion project titled "Master Plan Formulation Project for Revitalization Community Building Centered Around the Use of Energy Produced and Consumed in Shinchi City." The second source is responses obtained during a consultation with people in Shinchi's hotel industry regarding the progress of community reconstruction. These projections are shown in **Figure 4** and **Table 1**.

Facility	**Use**	**Total floor area [m²]**	**Supplied energy**
Agricultural production plant	Agricultural facility	9000	Electricity, heat (heating/hot water) (CO_2)
Tourist farm	Office	1200	Electricity, heat (cooling/heating)
Sports facility	Futsal court	3000	Electricity
Hotel	Hotel	4770	Electricity, heat (cooling/heating/hot water)
Bath facility	Welfare facility	1400	Electricity, heat (cooling/heating/hot water)
Community center	Cultural facility	1800	Electricity, heat (cooling/heating)
Incubation square	Office	610	Electricity, heat (cooling/heating)

Table 1. Demand facilities in the area surrounding Shinchi Station that are considered in this investigation.

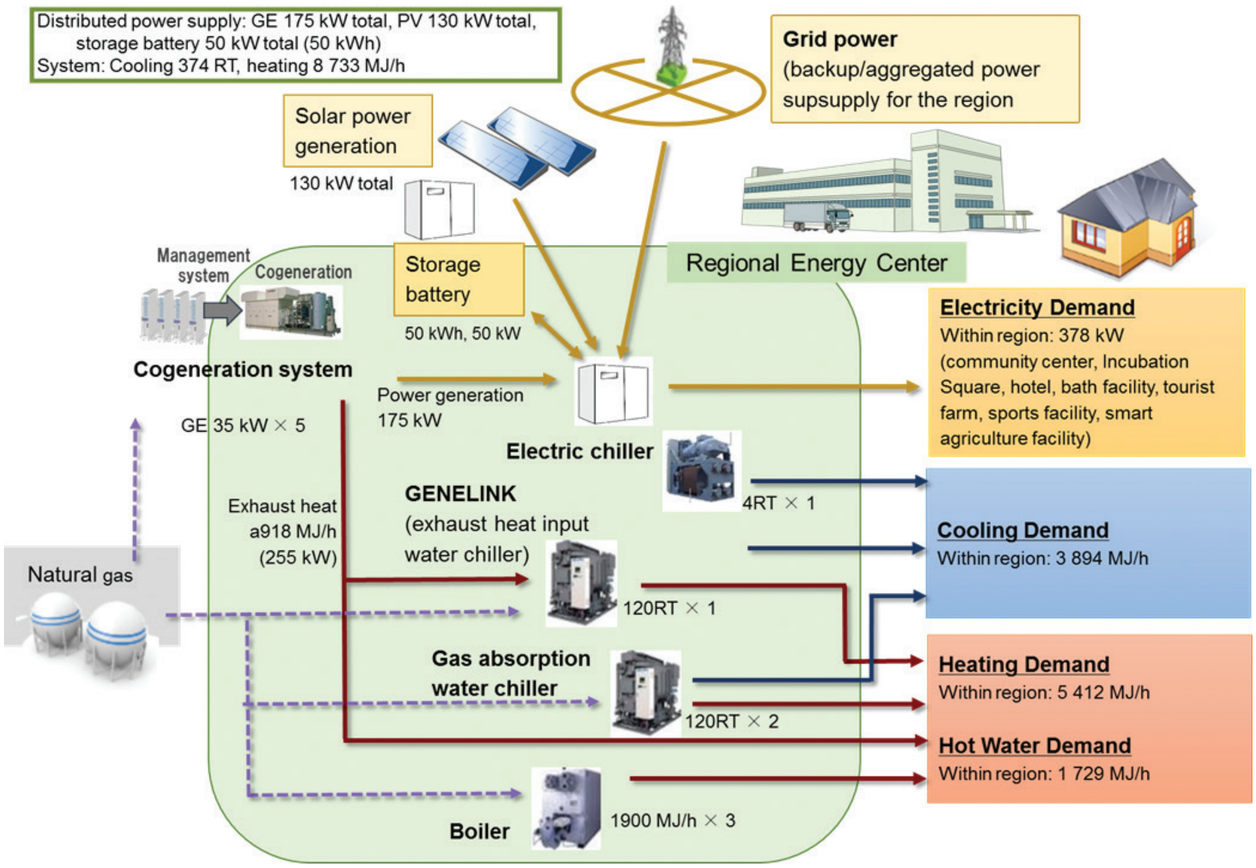

Figure 5. Components of the regional energy center equipment (revised by authors based on reference [23]).

3.3. Energy system overview

An overview of the energy system being planned for this project is shown in **Figure 5**. The system composition follows the plans that were developed during the design of the master plan. The capacity of the solar panels was changed to approximately 75 kW to address actual conditions.

4. Environmental features

4.1. Cogeneration facilities

In this project, we introduce a district heating and cooling system for the Shinchi Station area that utilizes natural gas supplied by pipelines. Additionally, the total energy efficiency is increased by introducing a CGS that utilizes waste heat from power generation.

This project involves cogeneration for cooling requirements during the summer. In Japan, power peaks occur during the summer when air conditioning is being used; thus, to reduce peak loads, the use of absorption chiller-heaters has become widespread. Absorption chiller-heaters produce cold and hot water using waste heat from power generation. These waste heat recovery absorption chiller-heaters are known as “genelink” systems in Japan. Some of

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these CGSs obtain steam using gas turbines. However, due to the small scale of this project, the CGSs in this case utilize gas engines, and the waste heat only provides hot water. In this project, cooling and heating requirements are satisfied using genelink systems to produce hot wastewater from power generation. Compared with conventional facilities, genelink systems provide a 10 to 15% increase in energy conservation. Therefore, genelink technology has the potential to be very useful, especially in Asia, where the climate is hot and humid.

4.2. Community energy management system

A CEMS is used to manage the energy consumption for the whole system and to increase the efficiency of energy use. Multiple autonomous power supplies are managed to conserve energy and to reduce CO_2 emissions.

One of the functions of the CEMS is to provide the necessary information for management of the community energy center. Cogeneration equipment is combined with multiple auxiliary heat sources and power purchased from existing power companies (grid power), thus reducing excess heat while avoiding production of unnecessary excess power. With this system, prediction of energy demands and power generation via renewable sources such as solar power becomes essential. Under such complex conditions, the information necessary for energy management personnel to make appropriate decisions is provided by the CEMS, which improves efficient operation of the community energy center.

The second function of the CEMS is demand response control during periods of insufficient power. Demand response control is performed in three steps. The first step is battery storage control at the community energy center. The CEMS controls the charge and discharge of batteries installed at the community energy center. Batteries are charged at night, and when the power procured from the grid exceeds a threshold, it is automatically released. The second step is automatic control of the lighting in public facilities. A control signal from the CEMS is sent to lighting control devices installed in the public facilities. These devices control lighting in areas with minimal impact to users. The third step is transmission of an energy-saving request to facility staff. Facility staff control power usage through predetermined energy-saving activities such as turning off lighting and air conditioning in unoccupied rooms.

4.3. The use of CO_2 by agricultural facilities

It is well known that increased CO_2 concentration improves crop production in greenhouses. Therefore, by sending gas engine exhaust with a high CO_2 concentration into greenhouses, crop growth can be promoted.

The city of Tomakomai in the Hokkaido Prefecture of Japan has been using a trigeneration system (a system involving heat, power, and CO_2) since 2015. Presently, the project is at the stage of recruiting companies that operate agricultural facilities and preparing these facilities so that a supply of CO_2 can be started immediately upon completion of the company recruitment process.

5. Residential interface for the community energy project

5.1. Outline of the community information system

In the Shinchi community energy project, heat is supplied to the Shinchi Station area through cogeneration, while power is supplied to surrounding residences. In addition, the plan includes construction of residences such as company dorms for community companies and permanent residence housing in the area around the station.

Based on this plan, the National Institute for Environmental Studies has developed an information system that will be used as the residential interface for the community energy project. This information system is presently in the social demonstration and implementation phase. It was developed as part of the future city "smart hybrid town" concept discussed above. With this information system, a central control server system "smart hybrid center" is constructed on the cloud server, and users utilize a tablet terminal called the "Shinchi Life Assist Tablet" to receive information. In this manner, a bilateral community ICT base is actualized.

Figure 6 shows a schematic of the energy in the system that is currently being developed. At its most basic, the supply is power procured from existing power companies, but in the future, it will be power supplied from the community energy project in Shinchi. At that time, cogeneration

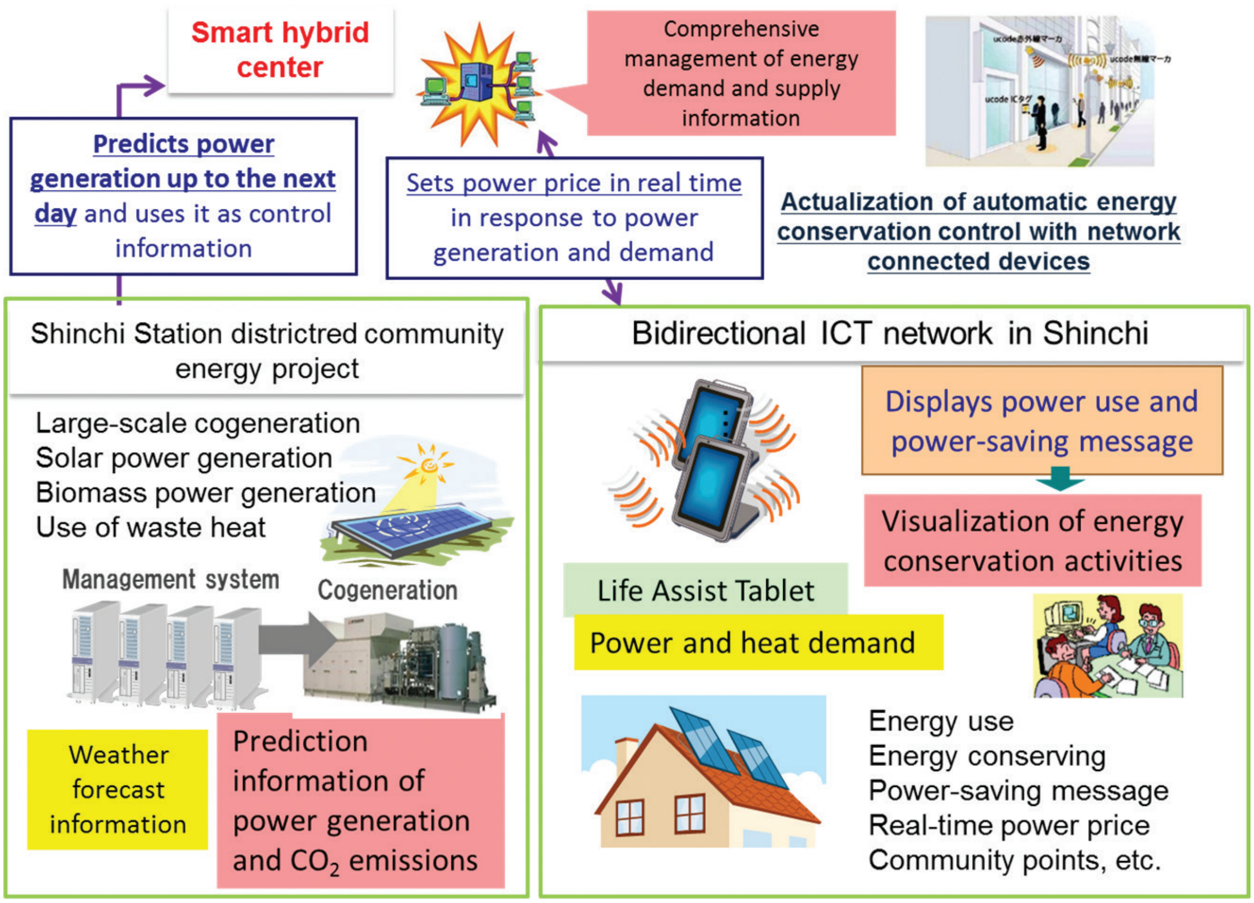

Figure 6. A control flow chart of the community information system.

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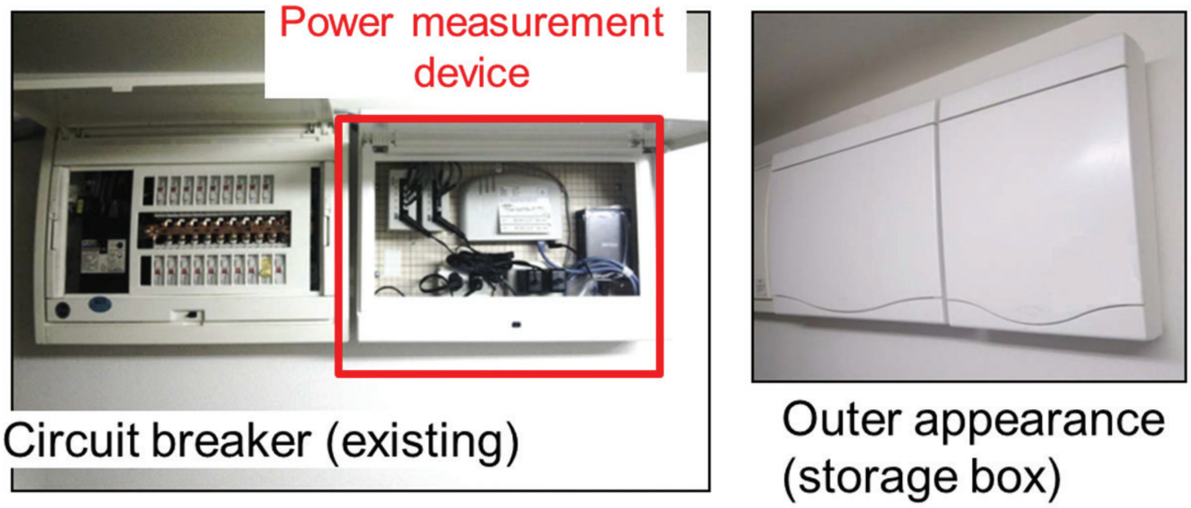
and renewable energy will be combined to predict power generation and CO_2 emissions, and this prediction information will be used as the control information. On the demand side, a power measurement device was installed at each home with the system introduced (**Figure 7**), and each home will use a "Shinchi Life Assist Tablet" as the display terminal.

The power measurement device analyzes the main power line and the branch lines using a current transformer (CT). This device measures the purchased power from the electric power system at the distribution board. The purchasing and selling of power are also measured by a CT for photovoltaic (PV) power generation systems.

A connection with the CEMS that comprehensively manages supplier information in the Shinchi Station area still needs to be developed, but various other functions of the system, such as visualization of energy use on the demand side, are already available. At the present phase of social demonstration and implementation, tablet terminals have been distributed to 75 households in Shinchi. Briefing sessions, individual visits, seminars, and opinion exchange meetings are often held. Operation is stable and communication with residents is maintained. The electricity consumption data obtained by this system have been already utilized for energy consumption modeling in Shinchi [24]. In 2016, the system was opened to allow for use with typical personal computers and smartphones in addition to the distributed tablet terminal. In this manner, information can be remotely obtained and viewed in real time.

Figure 8 shows the display on a tablet terminal. Power consumption can be viewed in real time with the "Shinchi Life Assist Tablet," which displays a comparison with the previous day or year, the energy conservation ranking compared to other households, power uses within the community, and power-saving messages. Through this process, the system encourages



Composition **product specification**

Power measurement device main unit model number: NT-A5EZ NAVI-Community
Power measurement device adapter model number: NT-AZB5 NAVI-Community
Wireless LAN model number: WLAE-AG300N/V2 Buffalo
Storage box model number: HJ-4632 Nitto Kogyo Corporation

Figure 7. Power measurement device installed in each home.

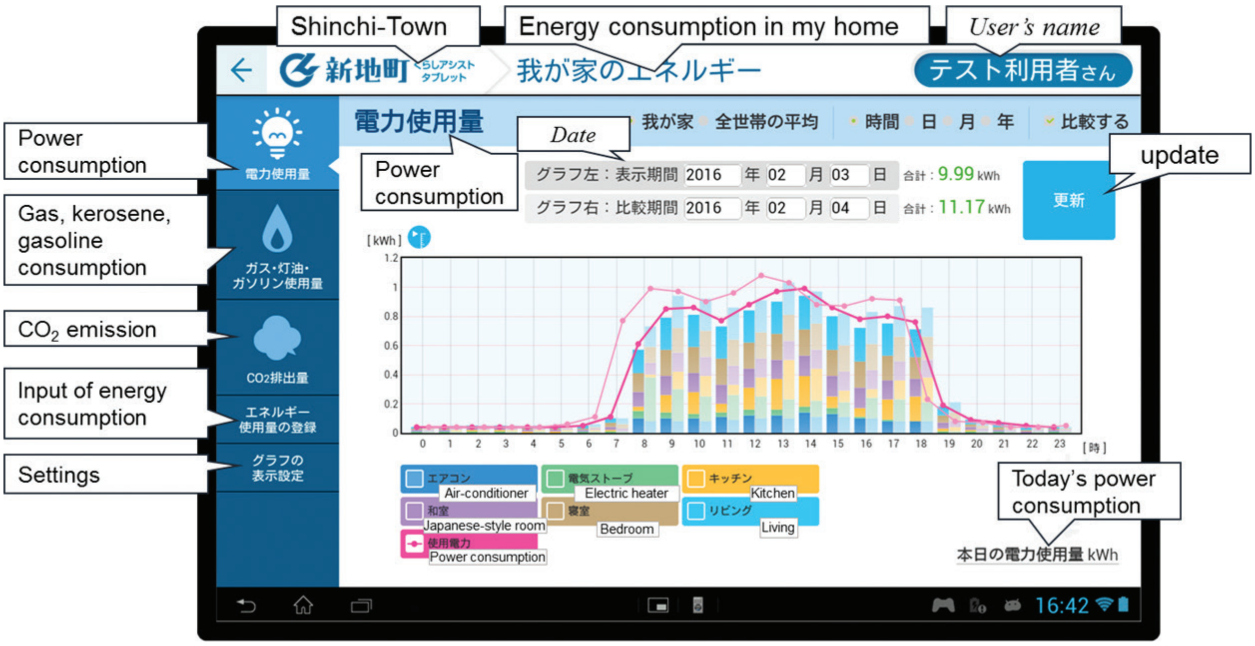


Figure 8. Example of the energy display on a Shinchi Life Assist Tablet.

people to save electricity proactively during power shortages, thereby voluntarily adjusting the supply and demand balance and reducing or shifting power peaks. Furthermore, through incentives such as community energy conservation campaigns and provision of information regarding power usage for each household, community energy supply and demand can be improved, and actual energy conservation activity can be measured.

A community energy conservation campaign has already been implemented using this information system, contributing to improved awareness of energy conservation and a more engaged community. This energy conservation campaign also demonstrates implementation of energy conservation activities; effective results were obtained regarding the provision of energy conservation information and added economic incentives for residents [25].

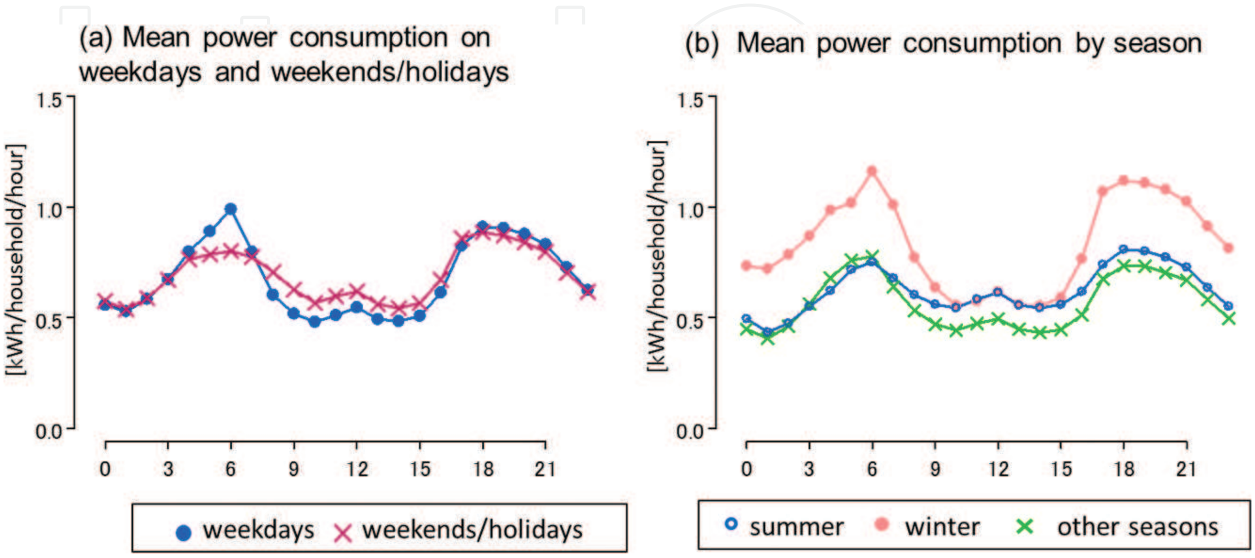


Figure 9. Example of power monitoring results.

5.2. An example of power monitoring results

Figure 9 shows an example of a data summary obtained from power monitoring. Because there is a large variation among individual data, we have presented diurnal patterns averaged for weekdays, weekends/holidays, and seasons. Results show a diurnal pattern of typical domestic energy consumption, with peaks in the morning and evening. When weekdays and weekends/holidays were compared in **Figure 9(a)**, a large peak was observed around 6 a.m. on weekdays, which rapidly decreased by around 9 a.m. In contrast, this trend was much weaker on weekends/holidays, and power usage was higher during the day on weekends/holidays. Seasonal comparison based on **Figure 9(b)** shows a large peak in the morning during winter, but summer usage is similar to spring and fall usage, indicating that a large heating load occurs as people turn their heaters on upon waking. Subsequently, power usage during the day before bedtime was higher for summer and winter than the other seasons, showing that increased cooling and heating loads occur in the summer and winter months.

5.3. Connection with the Shinchi Station district CEMS and future outlook

Introduction of automatic demand response control is being evaluated for the community energy project in the JR Shinchi Station district redevelopment area. Automatic demand response control involves a bidirectional information network that connects the demand and supply sides and automatic control of cooling, heating, and lighting based on the demand. In this manner, reductions can be made to peak loads and excess power at existing power plants, the heat and power balance at cogeneration plants can be adjusted, and the demand and supply balance can be controlled when introducing unstable power, such as natural energy.

6. Energy simulations

Energy simulations were used to calculate electricity and gas consumption, which is the core component of fuel costs in energy service businesses. The input conditions for the energy simulation are summarized below.

6.1. Simulation model and energy demand data

In this simulation, input data were provided, and we calculated the load allotment of various heat sources based on input data and the setting of the driving order. Next, we calculated city gas and electricity consumption based on the coefficient of performance (COP) of the heat source equipment, efficiency data, and so on. Based on this result, we calculated the energy savings, CO_2 reductions, and running costs for this system. The calculation for the flow of energy simulation is shown in **Figure 10**.

The estimate for energy demand was based on the consumption rates that were selected during the master plan investigation (**Tables 2** and **3**). In turn, these calculated consumption rates were based on reference materials from past studies, hearings, and estimates made for existing similar facilities (please refer to the master plan report for details).

6.2. Estimation of energy demand

The energy demand in each period is different because the expected opening date for each facility varies. The energy demand for each operating period is summarized below.

6.2.1. Standard: after all facilities are in operation

Values shown below are estimates of the demand in the standard scenario. The construction of the energy system and evaluation of the net profit are based on these values (**Table 4**).

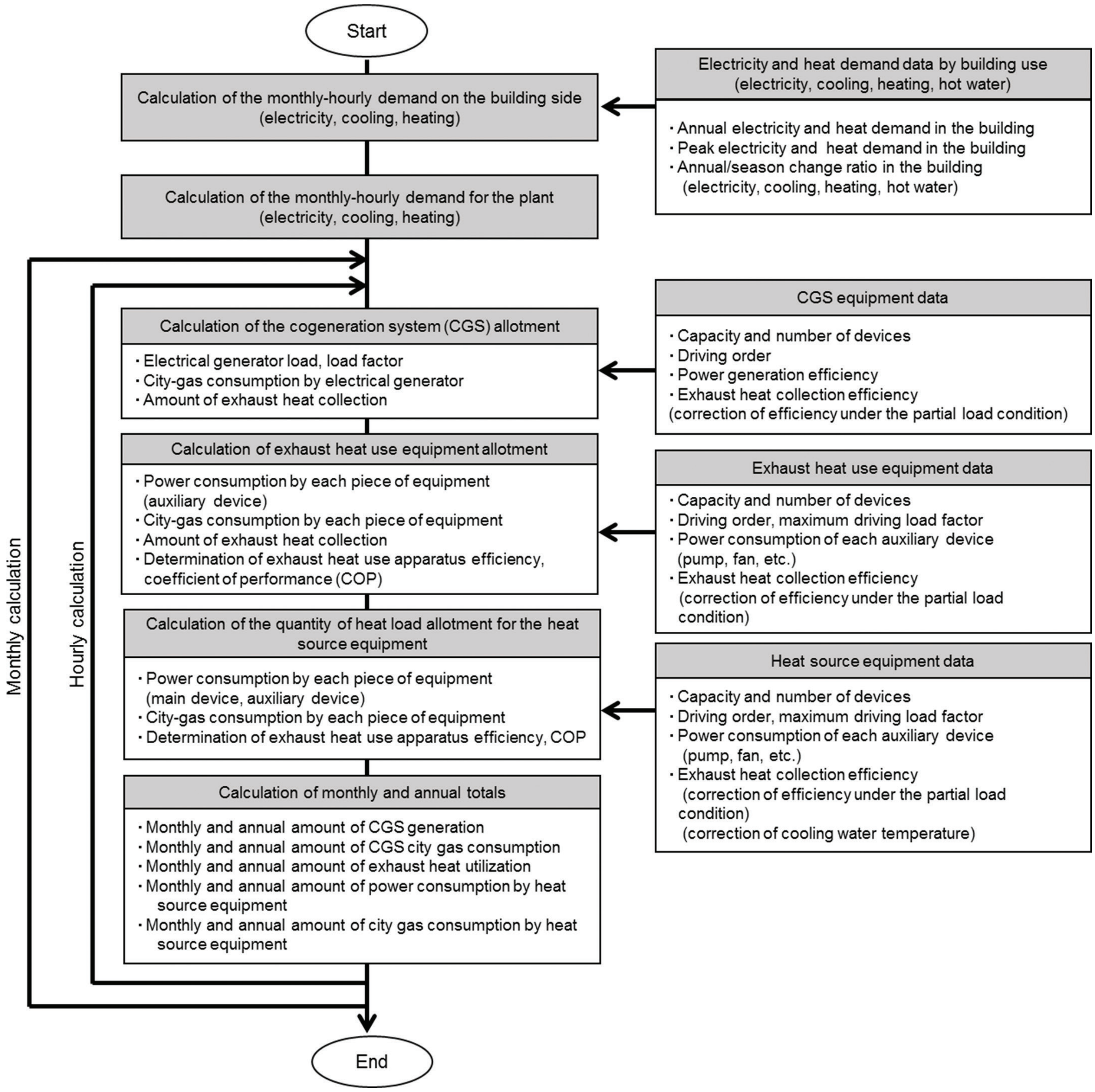


Figure 10. Calculation for the flow of energy simulation.

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Facility	Electricity	Cooling	Heating	Hot water
	[W/m²]	[kJ/m²·h]		
Agricultural plant	5	—	249	—
Tourist farm	37	357	268	—
Sports facility	11	—	—	—
Hotel	31	472	369	300
Hot bath facility	35	174	247	213
Community center	20	418	322	—
Incubation square	37	357	268	—

Table 2. Maximum energy demand consumption rate.

6.2.2. Early phase 1: early phase of project start

The energy demand in the early phases of the project, when only the hotel and bath facility are in operation, was calculated as shown in **Table 5**.

6.2.3. Early phase 2: public facilities open

The energy demand, when the public facilities (community center, incubation square, and sports facility) were open, 3 months after the beginning of the project, was estimated and tabulated (**Table 6**).

6.3. Estimation of energy consumption and CO_2 emissions

The energy consumption (including electricity, natural gas, and water and sewage requirements) of the system was calculated through an energy simulation for each of the operation periods described above.

Facility	Electricity	Cooling	Heating	Hot water
	[kWh/m²]	[MJ/m²·year]		
Agricultural plant	9	—	320	—
Tourist farm	115	295	56	—
Sports facility	26.5	—	—	—
Hotel	183	366	200	420
Hot bath facility	120	232	238	638
Community center	63	385	260	—
Incubation square	115	295	56	—

Table 3. Annual energy demand consumption rate.

Facility	Total floor area [m²]	Electricity	Cooling	Heating	Hot water
		[MWh/year]	[GJ/year]		
Agricultural plant	9000	81	—	2880	—
Tourist farm	1200	138	354	67	—
Sports facility	3000	80	—	—	—
Hotel	4770	873	1746	954	2003
Hot bath facility	1400	168	325	333	893
Community center	1800	113	693	468	—
Incubation square	610	70	180	34	—
Total	21,780	1523	3298	4737	2896

Table 4. Annual energy demand (standard).

The calculated results are shown in **Figure 11**.

CO_2 emissions were calculated based on the simulated energy consumption under standard conditions after all facilities are operational. For comparison, CO_2 emissions were calculated for a case in which conventional systems were introduced in the individual buildings. The results show that a CO_2 reduction of about 20% can be expected by introducing the community energy system (**Figure 12**).

6.4. Project cost calculations and investigation of the business plan

Various quantities, such as expenses and revenues related to the commercialization of this system, were included in the calculations. Because most of the initial costs were covered by a subsidy, the investigation focused on the operational costs. The two scenarios that were considered in the calculation of business income and expenditures are as shown in **Figure 13**.

Facility	Total floor area [m²]	Electricity	Cooling	Heating	Hot water
		[MWh/year]	[GJ/year]		
Agricultural plant					
Tourist farm					
Sports facility					
Hotel	4770	873	1746	954	2003
Hot bath facility	1400	168	325	333	893
Community center					
Incubation square					
Total	6170	1041	2071	1287	2896

Table 5. Annual energy demand (early phase 1).

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Facility	Total floor area [m²]	Electricity	Cooling	Heating	Hot water
		[MWh/year]	[GJ/year]		
Agricultural plant					
Tourist farm					
Sports facility	3000	80	—	—	—
Hotel	4770	873	1746	954	2003
Hot bath facility	1400	168	325	333	893
Community center	1800	113	693	468	—
Incubation square	610	70	180	34	—
Total	11,580	1304	2944	1789	2896

Table 6. Annual energy demand (early phase 2).

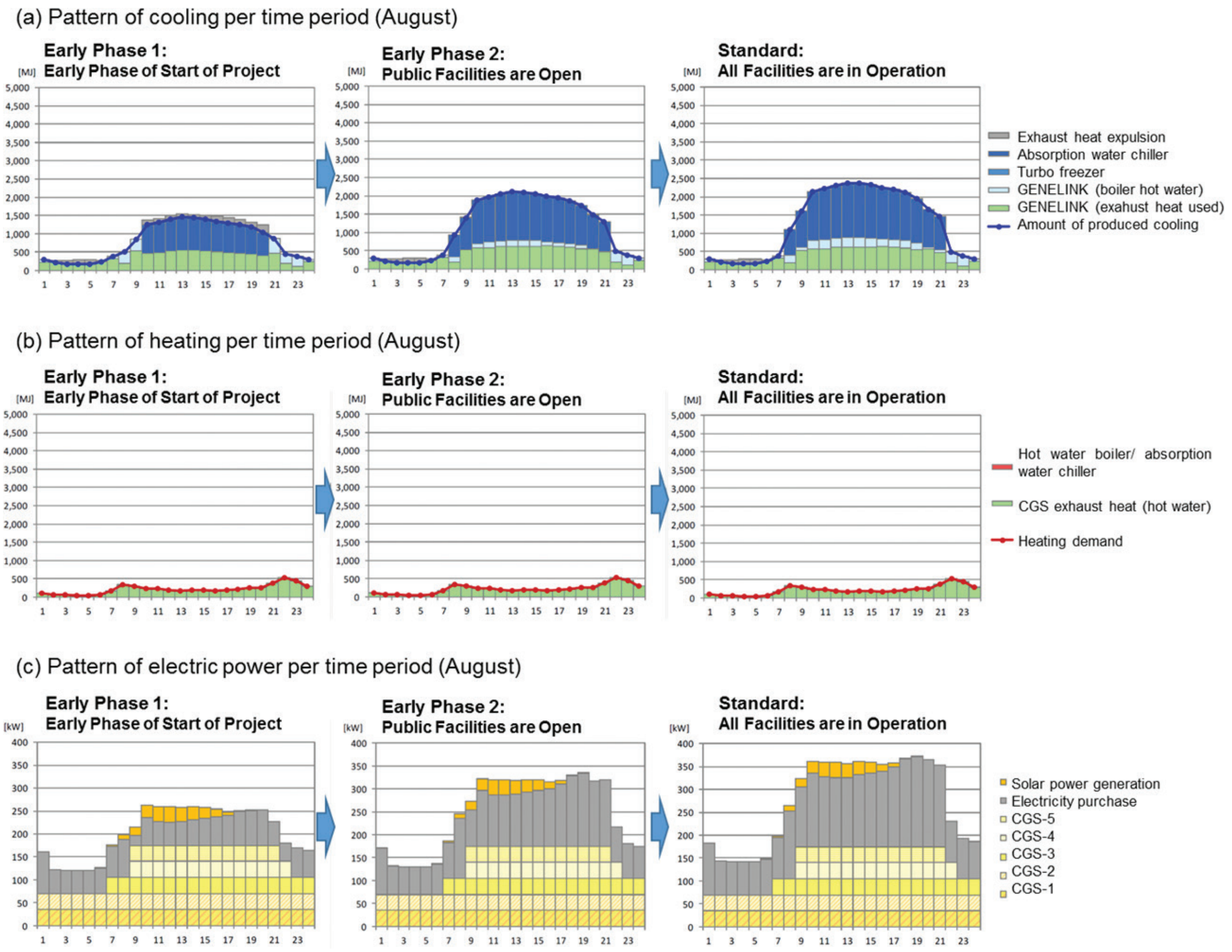

Figure 11. Results of the energy simulation (operation status in the summer season for each standard scenario).

We have performed a detailed cost evaluation to support the local government. However, as an energy company is now going to be established, the business income and expenditure are not openly available as official information from the local government. Therefore, the quantitative evaluation result shown here is not official information but is our individual research result. In this evaluation, although the costs are set realistically, the introduction scenario is given hypothetically. The costs of sales, such as electricity costs, natural gas costs, water and sewage

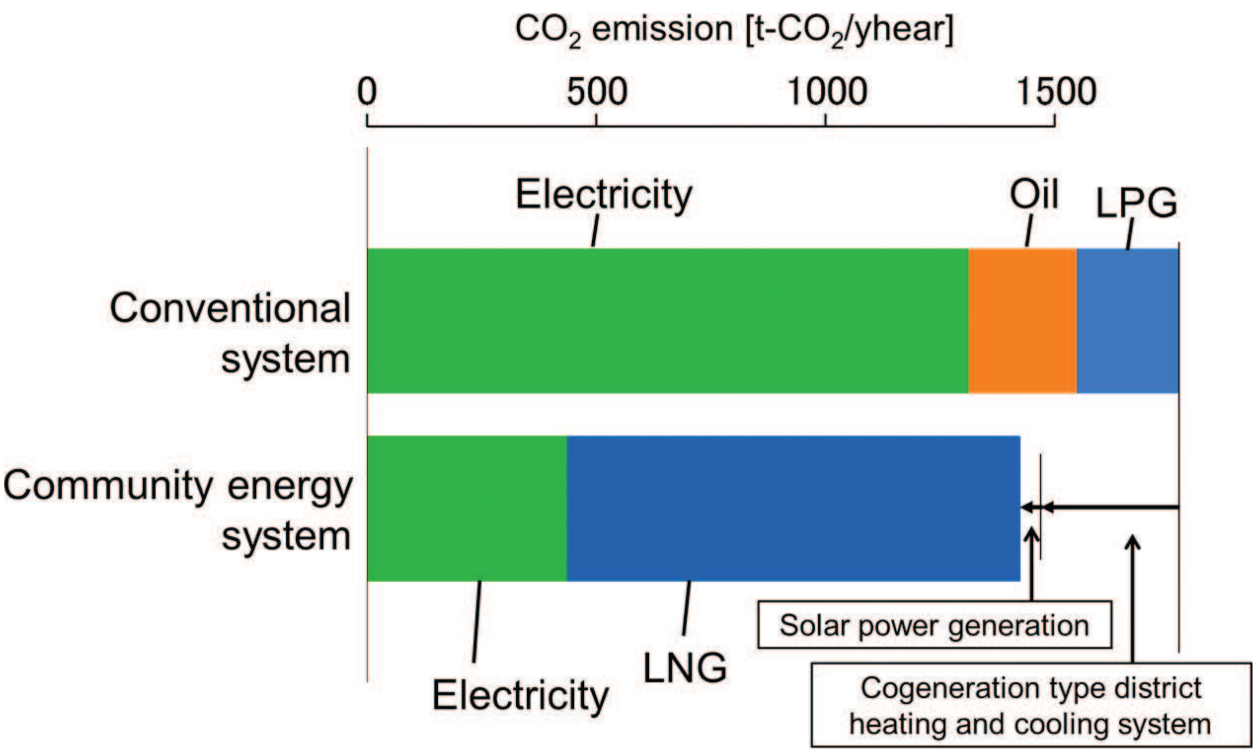

Figure 12. Estimation of the CO_2 emissions for each system.

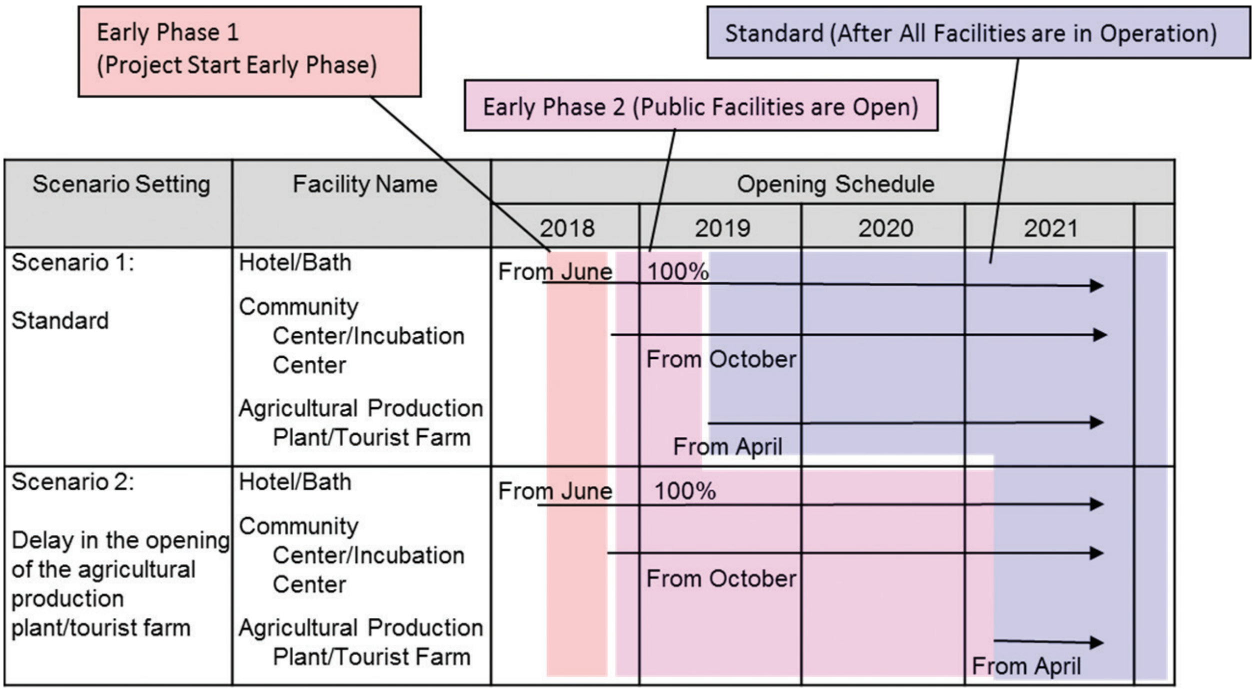

Figure 13. Investigated scenario settings and considerations regarding estimations of operation periods.

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costs, CGS/heat source maintenance costs, consumable part costs, equipment repair costs, CEMS/home energy management system (HEMS) operation costs, personnel costs, and business operation costs, were calculated based on the scenarios.

The result of the evaluation is shown in **Figure 14**. Based on the above scenarios, it can be concluded that the viability of this business depends on whether the opening of the agricultural production facility/tourist farm is delayed or not. In addition, since around 60% of the sales revenue comes from the hotel/bath facilities, it can be deduced that stable operation of these facilities is crucial. At this stage, it is essential to hold meetings with the managers of the hotel and bath facilities to examine their demands and obtain appropriate estimates of future requirements.

As shown by the results, in the standard scenario (Scenario 1), the business is expected to yield an operating profit after the second year, and the business is stable and performing well. In the scenario in which the opening of the agricultural production facility and tourist farm is delayed (Scenario 2), the business will post a loss for the first several years but will yield a profit after the agricultural production facilities open. The business is expected to recover the losses in the seventh year, in 2024. Therefore, it is necessary to obtain additional information from the city regarding the opening of the agricultural facility and tourist farm, including business details and the energy demand of the hotel and bath facility. The impact of such information on

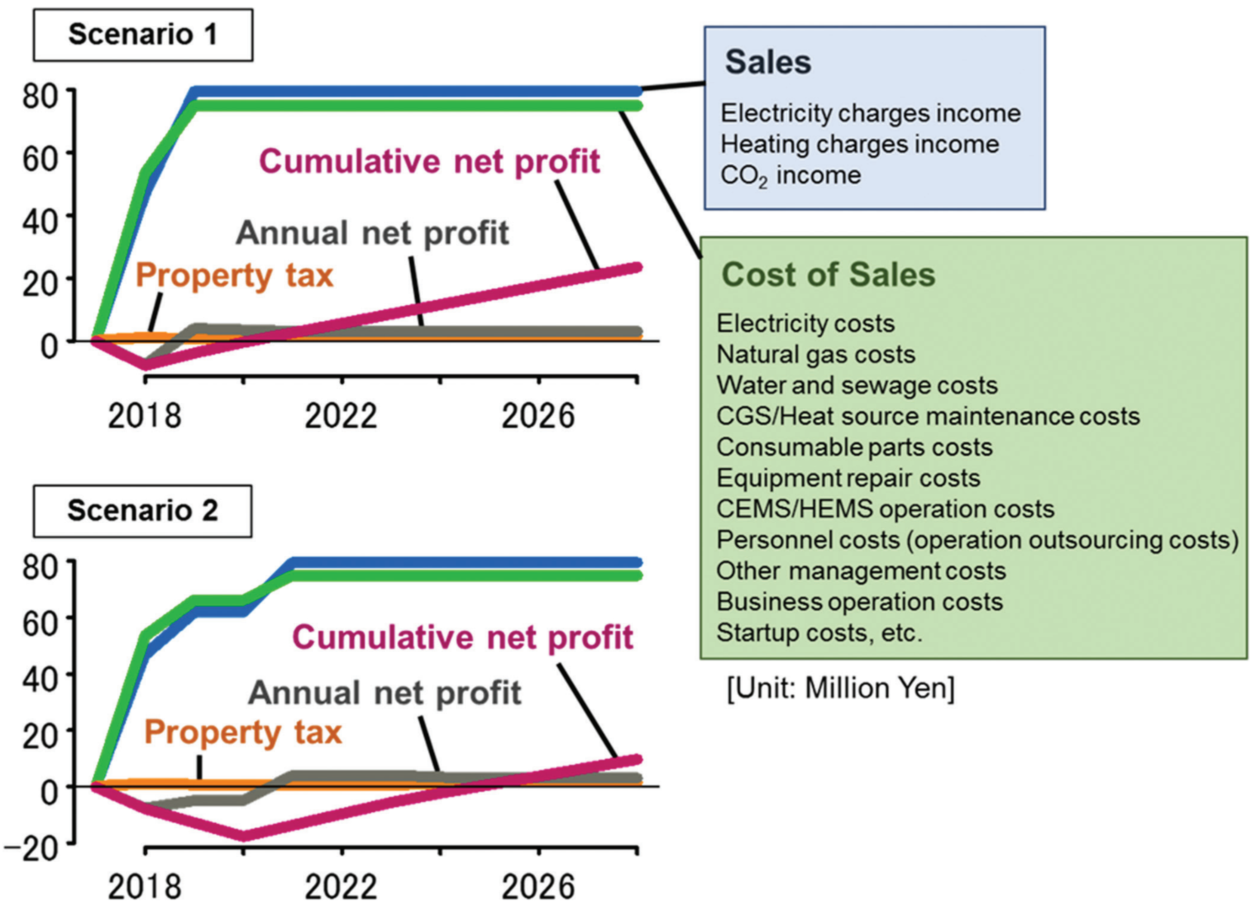

Figure 14. Estimation of business earnings and expenses.

businesses, which is the subject of the city's call for submissions, will have to be investigated. It is also necessary to consider adjusting the heating and electricity charges as needed.

7. Conclusions

In this paper, we introduced an example of a community energy project that is in progress in the town of Shinchi. For the redevelopment of the JR Shinchi Station district being carried out by the local government of Shinchi, construction of the cogeneration-type district heat and cooling system and community energy system is currently in progress.

In this case, the key to improving environmental performance is effective energy management that combines heat and power. In other words, multiple autonomous energy management systems must work together to optimize demand and supply through energy demand predictions and power consumption reductions during peak energy demand, ultimately improving energy conservation and achieving a low-carbon society. The heat and power supply system introduced in this paper is a useful and advanced example. This technology can be developed in other communities as a model of local production and consumption of heat and power, which promotes locally produced energy and vitalizes the community.

We developed a central control server system known as the "smart hybrid center" and a user information terminal, the "Shinchi Life Assist Tablet," for which demonstration experiments involving local residents have already begun. With this information network, continuous power monitoring in households has been implemented, providing energy consumption data for the present community. In addition, by examining individual household energy consumption, power-saving activities were proposed to suit each household, heightening power-saving awareness in the community and optimizing power demand. Utilizing an existing base of 75 households and adding residences being constructed around Shinchi Station to this base, energy demand information from typical households can be collected. By sharing information on CO_2 emission reduction efforts in the area among residents, new communities around the station can be planned. As community-linked energy conservation measures develop, the new smart community can progress smoothly. Residents can gain energy-related knowledge and can be expected to approve of the system. Furthermore, through an integrated supply and demand energy management system that is linked via the CEMS, automatic demand response control can be introduced, and further improvements in energy efficiency and CO_2 emission reductions can be expected.

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