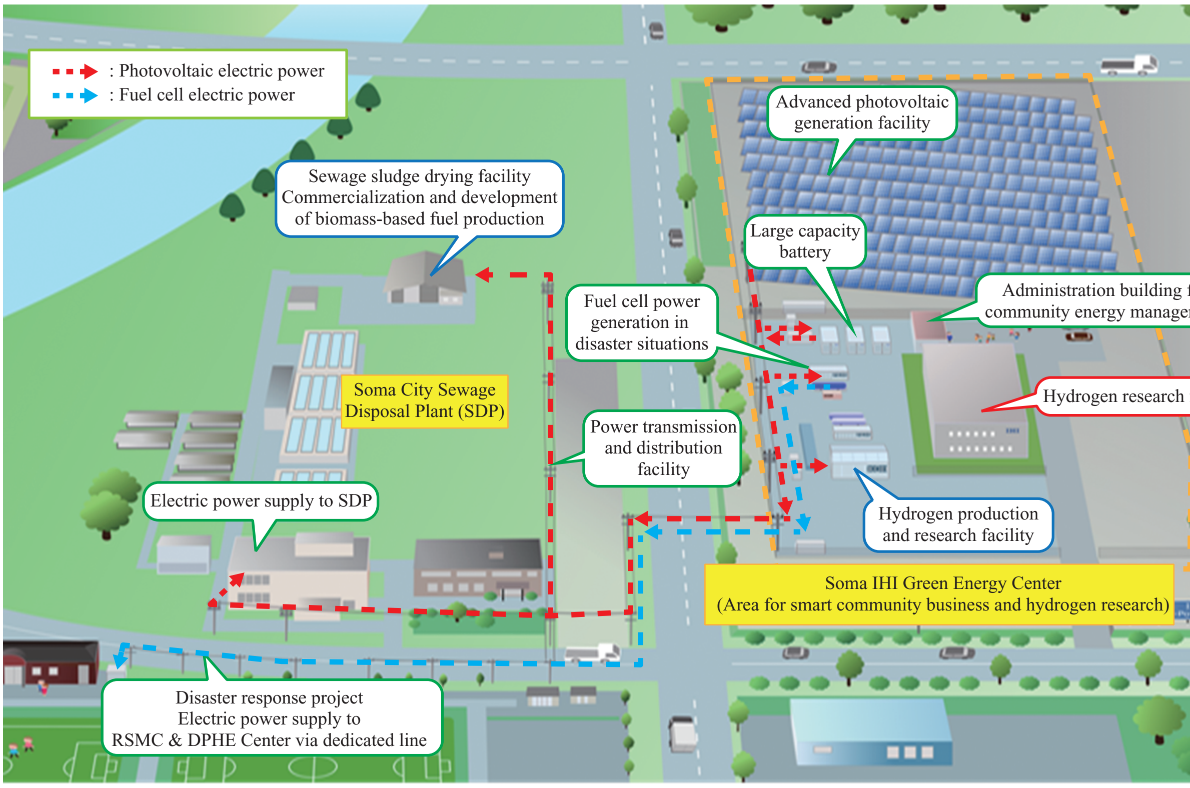
Soma Energy-Recycling Society

A Local-Production-for-Local-Consumption System

IHI and Soma City (Fukushima Prefecture) have jointly launched a demonstration research facility — a pioneer to a "smart community" aiming to produce, store, and smartly use energy, not just consume it.
Soma IHI Green Energy Center started an initiative for local production of energy for local consumption.

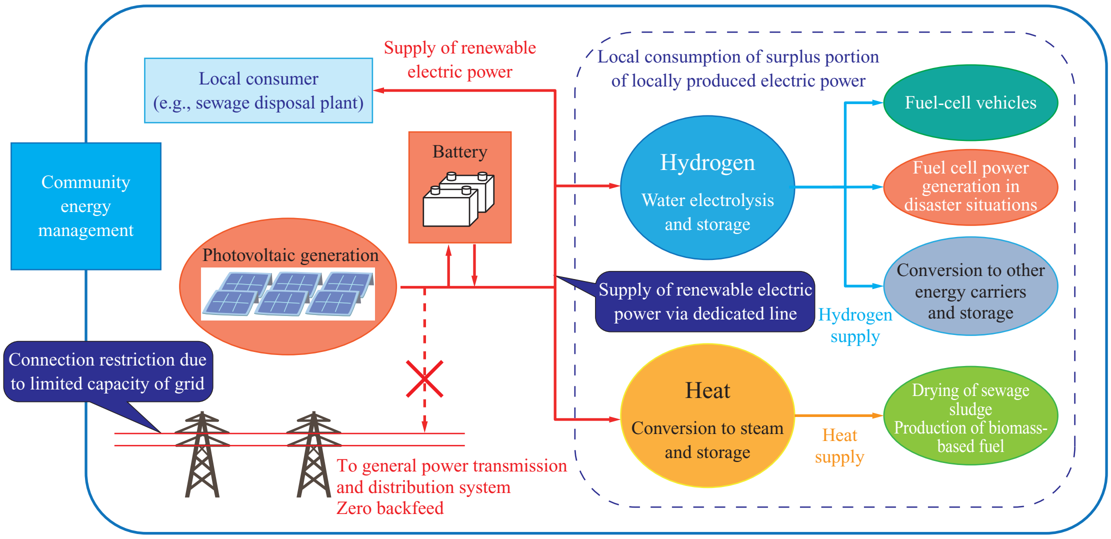


Soma IHI Green Energy Center

Why is local production for local consumption drawing attention now?

The introduction of renewable energy is being expedited worldwide, with mega solar power plants and wind farms being constructed one after another, for the purpose of overcoming the issue of global warming and the realization of a decarbonized society. However, renewable energy, such as photovoltaic power generation, suffers from the variable energy depending on the time and season. Whereas some countries have achieved a ratio of renewable power generation of more than 20%, Japan has yet to achieve 10% (source: Policy Issues in the Era of Large-volume Introduction of Renewable Energy and Discussions on Next-Generation Electricity Networks "Agency for Natural Resources and Energy" (December 18, 2017)), and this slow progress of efforts toward decarbonization is in question.

One issue in the large-scale introduction of renewable energy is the balance of supply and demand in a utility grid. A utility grid system is designed to stably supply electric power in response to society's demand for electric power — in other words, it is designed so that supply and demand are balanced — and this balance is regulated at substations and other such facilities. However, if electric power exceeding the supply capacity of such facilities is input from a renewable energy source, a phenomenon known as "backfeed" (the flow of electrical energy in the reverse direction from its normal flow, which may occur when electrical power is supplied into the local power grid from a source other than a utility company generator) occurs. Since backfeed is detrimental to



CO_2-free smart community business model

a stable power supply, a restriction is imposed on the amount of electric power that can be sent back into the utility grid.

A smart community producing electric power for consumption within the community is one solution to the aforementioned "inability to immediately use electricity generated with renewable energy." This is the concept of effectively consuming generated renewable electric power within a local community, rather than supplying it to the general transmission and distribution system of an existing utility grid. This paper describes the demonstration project that IHI and Soma City jointly launched to show the feasibility of a smart community.

Soma IHI Green Energy Center

In April 2018, Soma IHI Green Energy Center (approximately 54 000 m^2) was opened in Soma City (Fukushima Prefecture) with the aim of realizing "local production of renewable energy for local consumption" — that is, consuming as much generated renewable electric power as possible within the local community, rather than supplying it to an existing utility grid — as well as contributing to the development of the local area community. The approach to the realization of a smart community comprises photovoltaic power generation, hydrogen production, drying and pelletizing of sewage sludge, and disaster preparedness.

In addition, a "local production for local consumption energy management system" acts as a control center that manages variations in renewable energy in a well-balanced manner. Consequently, the greatest feature of this approach is that the amount of surplus electric power from photovoltaic power generation is controlled by adjusting the amount of steam produced with electric boilers and hydrogen produced with water electrolyzers, in order to balance power demand and power supply in the community without affecting general power transmission and distribution systems. With this feature, this system will help stabilize the utility grid when a large amount of renewable energy from dispersed power sources, such as photovoltaic and wind-power generation, are put into use as is expected to happen.

How the center produces and consumes electric power

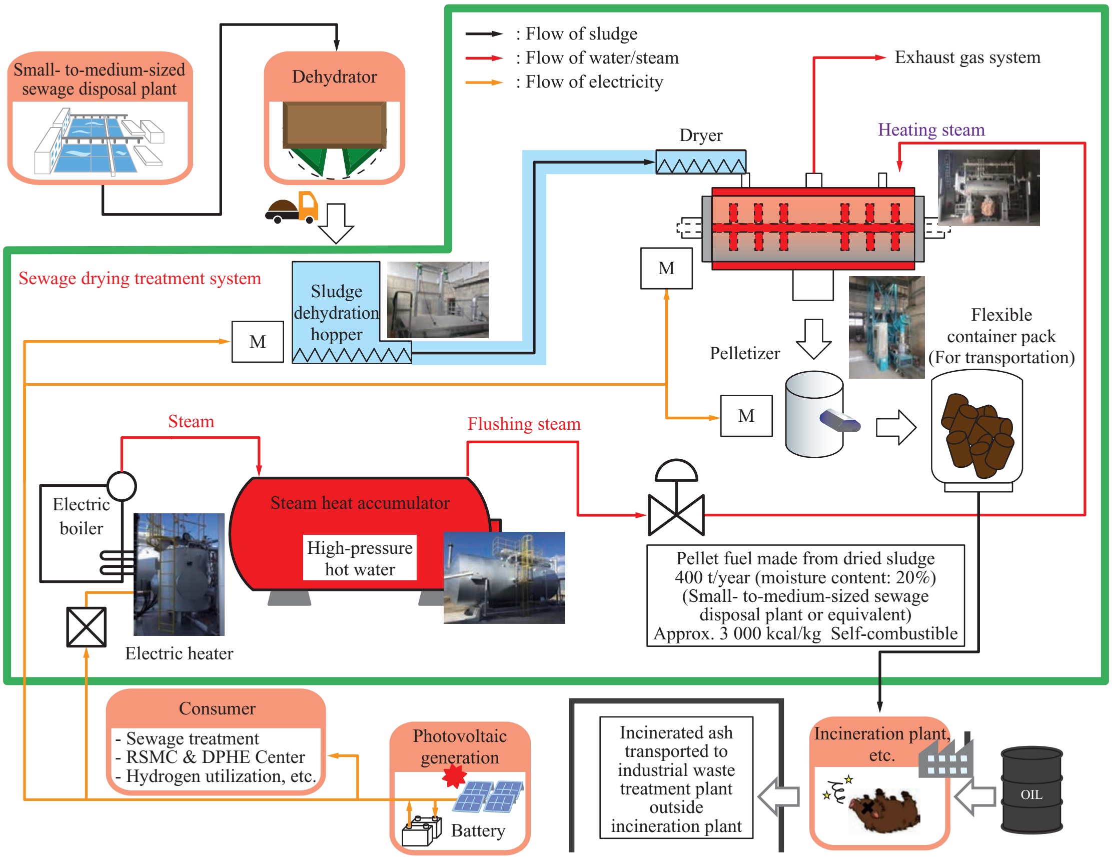
As is widely known, there are many types of renewable power generation, including photovoltaic, wind-power, ocean-current, and hydroelectric generation. From among these types, the Center adopted photovoltaic generation based on geographical and meteorological conditions. The installed photovoltaic generation system is capable of generating 1 600 kW of electricity, equivalent to the average power consumption of about 500 households. Electric power generated at the Center is first used in the sewage disposal plant via a dedicated distribution line. Electric power used in sewage disposal plants across Japan accounts for approximately 0.7% of domestic power consumption. Besides, efficiency decreases with a decrease in the size of the sewage disposal plant. The Center controls photovoltaic power generation on a local production for local consumption basis to stably supply power for consumption in the sewage disposal plant at low cost, irrespective of the season or weather, and at any hour, thereby contributing to the reduction of CO_2 emission.

How the center stores and consumes renewable energy

Of the electric power generated at the Center, the portion remaining after consumption at the sewage disposal plant, i.e., the surplus electric power, is used to generate steam and hydrogen for storage and consumption, as described below.

(1) Use of steam for the production of biomass-based fuels

To date, small- to-medium-sized sewage disposal plants have been suffering from the cost of disposing sludge from sewage disposal as industrial waste. The water content of sewage sludge is about 70-85%; by reducing

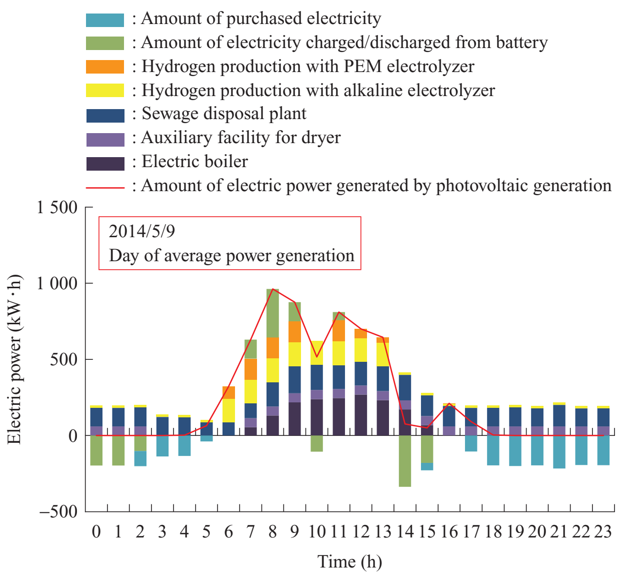


Sewage sludge drying system and pellet production

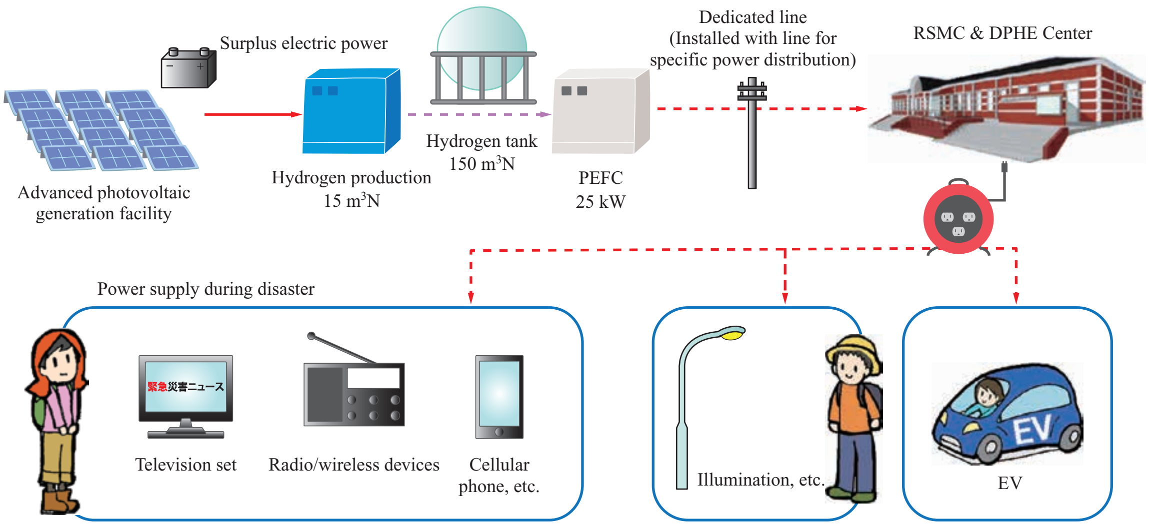
its volume to about 20% and its mass to about 1/5, costs can be reduced. Thus, part of the surplus electric power is supplied to electric boilers to produce steam, which is stored in a high-temperature, high-pressure steam tank called an accumulator and it is then used to dry sewage sludge. When the sludge drying system is in service, sludge is put into a cylindrical container enclosed in metal walls heated with high-temperature steam and then agitated in order to heat, dry, and reduce the volume of the sludge. This demonstrates that energy from photovoltaic generation is fully utilized. Furthermore, dried sludge can be pelletized with a pelletizer to produce biomass-based fuels. Therefore, this is promising as a new business. In this connection, as a result of calorimetry of pellets produced in Soma City on a trial basis, it was revealed that their calorific value was 3 260 kcal/kg (moisture content: 19.1%), and it has been confirmed that they are promising as a high-quality fuel. This conversion of sludge to a resource will enable further recovery and reduction of disposal costs.

(2) Optimization of hydrogen production by electrolysis

Part of the electric power is sent to the water electrolyzer. There are two types of electrolyzers: alkaline electrolyzers, and PEM (Polymer Electrolyte Membrane) electrolyzers which uses a solid polymer electrolyte membrane. Alkaline electrolyzers are relatively inexpensive, but they are generally inferior in their ability to track sudden changes in output. PEM electrolyzers are disadvantageous in that the material for the cell structure is expensive, but they are superior in tracking ability. In order to make efficient use of renewable energy, which suffers from variable energy, by appropriately using one of the two



Example of optimum distribution to facilities (mostly clear)



Disaster response project

types of electrolyzers and taking advantage of its features, the Center has built an all-new composite water electrolytic hydrogen production system (alkaline electrolyzer: 25 m^{3}N, PEM electrolyzer: 30 m^{3}N). As a result, a system has been realized that is more efficient, less expensive, and more capable of tracking the amount of sunlight than systems comprised of a single type of electrolyzer.

We plan to use the produced hydrogen for research into hydrogen utilization and energy carrier conversion with a view to a hydrogen society in the future, and the Center will implement the "Creating a CO_2-free Recycling-oriented Society Utilizing Hydrogen" initiative.

Disaster preparedness

Part of the surplus electric power is also used for emergency power generation. Hydrogen is produced with the PEM water electrolyzer and then stored in the hydrogen storage tank for use in emergency response. The Center is equipped with a solid PEFC (Polymer Electrolytic Fuel Cell) generation facility with an output of 25 kW, which is the highest in Japan. In conjunction with this facility, the Center is equipped with a facility for transmitting up to 420 kW·h (equivalent to 21 days of power consumption) to the Reconstruction Support and Meeting Center, which becomes Disaster Preparedness Headquarters in Emergencies (RSMC & DPHE Center), via a dedicated line. In emergency situations, hydrogen will be converted to electric power, which will be supplied to the RSMC & DPHE Center and then utilized until the recovery of the power grid. This initiative is also compatible with the slogan "Establishment of a more robust disaster prevention system" as stated in the Soma City Reconstruction Plan.

Future deployment

A smart community business has been realized through various efforts, including coordination with the Reconstruction Plan of Soma City; setting up key concepts "business deployment leading to local production of renewable energy for local consumption, strengthening of disaster prevention function, and community revitalization"; and endeavors to create a CO_2-free, recycling-based community in cooperation with Soma City. We will roll out the business to neighboring local governments with the objective of realizing local production of renewable energy for local consumption and spreading this model of a new community-led autonomous business.

Moreover, we have plans to carry out public relations activities, including a joint demonstration by Soma City and IHI, from various perspectives, such as spreading renewable energy, endeavoring to develop hydrogen utilization technologies, and strengthening disaster prevention functions. We have another plan to implement an experience learning program about hydrogen, science, and energy for elementary and junior high school students in the community at a hydrogen research facility scheduled to be brought into service in fiscal 2020. Furthermore, we will provide a place for open innovation, where we can conduct hydrogen-related research jointly with research institutions and companies in and outside Japan, thereby promoting initiatives for increasing people interacting with the community.

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