

TSUKUBA GREEN HOLONISM TOWN (I)-BUILDING A CARBON-NEUTRAL COMMUNITY

^{1*} Kenji Morita, ² Ichiro Sugimoto, ¹ Hiroyuki Mitsuishi, ³ Masayoshi Ishida

¹ Japan Automobile Research Institute, Environment Research Division, 2530, Karima, Tsukuba, Ibaraki, Japan
² Laboratory of Energy & Human Life Science Inc., 3-6-2, Asahigaoka, Ikeda-city, Osaka, Japan
³ University of Tsukuba, Faculty of Engineering, Information and Systems, 1-1-1, Tennoudai, Tsukuba, Ibaraki, Japan

*Corresponding author e-mail: kmorita@jari.or.jp

ABSTRACT

This study illustrates a concept of "Tsukuba Green Holonism Town" in Japan, comprising three basic policies: achieving carbon neutrality in the community, balancing the energy demand and supply, and changing the lifestyle, work style, and mobility style of residents and workers. Furthermore, this community is constituted of five functional categories: community facilities with nearby renewable energy sources (RES), energy dispatching station and energy networks, common facilities equipped with fuel cells (FC), vehicle-to-microgrid integration facilities, household demand installed RES or FC, household demand with both controllable and uncontrollable appliances. Japan and other OECD countries are taking on the considerable challenge of reducing greenhouse gas emissions to zero by 2050, thus we must push for more robust green policies and decarbonization breakthroughs immediately. The workgroup of Tsukuba 3E Forum has been developing the concept of Tsukuba Green Holonism Town, which implements a carbon-neutral community using demand response methods in harmony with residents, workers, household FCs, and electric vehicles. An example of cooperative scenarios among the functional categories for a rainy week is also described.

Keywords: carbon-neutral community, balancing the energy demand and supply, hydrogen, and demand response

INTRODUCTION

Japan decided on October 26, 2020, to achieve a decarbonized society by 2050, and to reduce its greenhouse gas (GHG) emissions by 46% in 2030 compared to 2013 levels [1], therefore we should push for more robust green policies and lower-carbon breakthroughs. The Tsukuba 3E Forum's workgroup has been discussing a low-carbon community in Tsukuba city [2] and is developing a concept of "Tsukuba Green Holonism Town," which aims to implement a carbon-neutral community in harmony with its residents and workers by 2030 [3]. This study illustrates the community concept, which consists of three basic policies and five functional categories. An example of cooperative scenarios among the functional categories for a rainy period is also described.

TSUKUBA GREEN HOLONISM TOWN

This is a community concept based on three basic policies with five functional categories according to the capacity of available renewable energy sources (RES), household quantity, population, and energy demand in the community. The basic policies, functional categories, and an example of cooperative scenarios are described below. Fig. 1 shows a concept image of Tsukuba Green Holonism Town.

Basic Policies

The concept comprises three basic policies: environmental, energy demand and supply, and energy consumption behavior policies as follows.

• Achieving carbon neutrality in the community.

As shown in Fig. 1, the community attains and maintains net-zero carbon dioxide (CO₂) using RES, nuclear power, energy conversion, and CO₂ recycling technologies, such as solar photovoltaic (PV), power-to-hydrogen, hydrogen storage and transport, and fuel cells (FC).

• Balancing the energy demand and supply in the community.

The community supplies clean and variable energy depending on the weather through PV power plants located in and near the community. According to the demand response (DR), the energy demand meets the community supply.





Fig. 1. A Concept Image of Tsukuba Green Holonism Town

The DR applications are, for example, water electrolysis and FC, and electric vehicle (EV) charge and discharge in Fig. 1.

• Changing lifestyle, work style, and mobility style of the community residents and workers.

The residents and workers in the community change their lifestyles, work styles, and their mobility styles in accordance with the energy production forecast, such as daylight savings time and remote work.

Functional Categories

The basic policy, carbon neutrality by 2030, means that zero-emission energy sources (e.g., PV, nuclear power) near the community should be introduced into the grid, and the generation capacity for the community should be shared rationally. The policy, balancing the energy demand and supply, means that the supply is estimated based on the weather in a given period, and the demand should meet the energy supplied to the community through water electrolysis, hydrogen storage, and network transport, FC regeneration, and vehicle-to-microgrid integration (VmGI). The changing lifestyle, work style, and mobility style means that the demand curve ought to be reshaped and fit to the energy supply by increasing the power generation of household FCs, discharging power from household EVs, and reducing the energy consumption of household appliances automatically or manually. Community facilities, common facilities, NmGI facilities, household demand with FC or RES, and household demand with appliances are the five functional categories that constitute the community. Table 1 shows the Tsukuba Green Holonism Town's functional categories and system configuration.



Table 1. Functional Categories and System Configuration in Tsukuba Green Holonism Town

Functional categories	System Configuration	
	Supply side	Conversion and Demand side
Community Facilities	Neighboring RES (PPA ^{*2})	Energy Dispatching Station, including Electrolyzer, Fuel Cell, and Storage Tank
	Neighboring Nuclear Power (PPA ^{*2})	Hydrogen Refueling Station and FCV, Charging or Discharging Station and EV
	Energy Networks (Power, Hydrogen, and Hot water)	
Common Facilities	RES deployed in the community	Conversion and Storage Equipment deployed in the community
VmGI ^{*1} Facilities	Charging or Discharging Station, EV, FCV	Energy Network (Power)
Household Demand with FC or RES	Household FC and RES	Household FC and EV. Appliances (Controllable / Uncontrollable)
Household Demand with Appliances		Appliances (Controllable / Uncontrollable)

(*1) VmGI: Vehicle-to-Microgrid Integration

(*2) PPA: Power Purchase Agreement

An Example of Cooperated Scenarios

Assuming that the neighboring RES power supply of the community facilities is primarily PV, power generation is dependent on solar insolation and weather-related temperature. If the weather forecast predicts rain for a week, this means the power supply will be drastically reduced for a week, then FCs both in the community facilities and in the household demand, and EVs in the VmGI facilities will generate and supply electric power to the community systematically for a week. Synchronously, energy consumption in the household demand will be curtailed by changing the lifestyle (e.g., disuse of vehicles), and the work style (e.g., remote work).

CONCLUSIONS

This study proposed a community concept of the Tsukuba Green Holonism Town, including three basic policies and five functional categories. A distinctive feature of this community is that the demand in collaboration with its residents, workers, and EVs meets the energy supply and varies based on weather conditions. Furthermore, it described an example of cooperative scenarios between common facilities and household demand against a dark period.

ACKNOWLEDGMENT

The authors gratefully acknowledge the Tsukuba 3E Forum Task Force workgroup members for discussing and clarifying the concept of Tsukuba Green Holonism Town.

Fuel Cell Vehicle Solar Photovoltaic

FCV

PV/

NOMENCLATURE

EV	Electric Vehicle
GHG	Greenhouse Gas

RES Renewable Energy Source

REFERENCES

1. Ministry of Foreign Affairs of Japan Press Release, Intended Nationally Determined Contributions (INDC): Greenhouse Gas Emission Reduction Target in FY2030, July 26, 2021.

2. Tsukuba 3E Forum brochure, Tsukuba Environment-Energy-Economy Forum - Reduce CO₂ emissions by 50% in Tsukuba by 2030, August 27, 2013.

3. K. Morita, I. Sugimoto, M. Ishida, et al.: Tsukuba Holonism Town—Building A Carbon Neutral Community, The 11th International Symposium on Solar Energy and Efficient Energy Usage (SOLARIS), Proceedings, September 2021, Tokyo, Japan.