# Tsukuba Holonism Town—Building A Carbon Neutral Community

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**Abstract.** This paper demonstrates the basic policies of the "Tsukuba Holonism Town": achieving carbon neutrality in the community, balancing the energy demand and supply, and changing the lifestyle, work style, and mobility style of the community residents and workers. Furthermore, we propose an example of scalable energy networks for expanding the community and alternative personal mobility, photovoltaic (PV) powered recumbent tricycle. Japan is taking on the considerable challenge of reducing greenhouse gas emissions to net-zero by 2050, so we have to raise more robust green policies and push for lower-carbon breakthroughs. The workgroup of Tsukuba 3E Forum Task Force has been developing the Tsukuba Holonism Town concept, which implements a carbon-neutral community in harmony with its residents and workers. The basic policies and functions of the energy networks are described, and the use of a PV-powered recumbent tricycle is recommended.

**Keywords:** carbon-neutral community, balancing the energy demand and supply, photovoltaic, hydrogen, and PV-powered recumbent tricycle

#### **1. Introduction**

In order to mitigate greenhouse gas (GHG) emissions, it is essential to expand the use of renewable energy (RE) and realize a decarbonized society [1]. Although individual elemental RE technologies such as solar photovoltaic (PV), wind power, and hydropower have almost matured, there is no example in Japan where RE and its carrier, hydrogen, have been integrated and put to practical use as an energy supply and demand system. Therefore, it is necessary to combine these technologies to build up a robust community where people can continue to live and work without barriers even if the external energy supply is cut off due to a disaster. The workgroup of Tsukuba 3E Forum, Next-generation energy system Task Force [2], has been developing the concept of "Tsukuba Holonism Town," which implements a carbon-neutral community in harmony with its residents and workers. This paper describes the basic policies of this concept. It proposes an example of scalable energy networks for expanding the community and using alternative personal mobility instead of an electric vehicle (EV) or fuel cell vehicle (FCV), e.g., a PV-powered recumbent tricycle.

#### 2. Tsukuba Holonism Town

Tsukuba Holonism Town is a community concept based on three basic policies and has scalable energy networks according to the capacity of available RE, household quantity, population, and energy demand in the community. The basic policies and energy networks are described below, and PV-assist tricycles are also recommended. A concept image of Tsukuba Holonism Town is shown in Figure 1.



Figure 1. A concept image of Tsukuba Holonism Town

# 2.1. The 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.

The community attains and maintains net-zero carbon dioxide  $(CO_2)$  employing RE, atomic power, and  $CO_2$  recycling technologies (e.g., PV power-to-hydrogen, storage and transport hydrogen, and fuel cells (FCs) as displayed in Figure 1).

• Balancing the energy demand and supply in the community.

The community supplies clean, and variable energy depending on the weather through the PV power plants located in or near the community and meets the energy demand according to the demand response (DR) (e.g., DR with water electrolysis, FCs, and EVs in Figure 1).

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

The residents and workers in the community change their lifestyles and workstyles and their mobilitystyles in accordance with the energy production forecast (e.g., daylight savings time, stay-home work, and PV-powered recumbent tricycle instead of car or train for a work trip).



Figure 2. An example of scalable energy networks in Tsukuba Holonism Town

## 2.2. Energy networks

The main functions of the energy networks in the community are energy conversion (e.g., PV power-tohydrogen, hydrogen or methanol-to-power, and AC-DC conversion), locally secondary energy supply (e.g., hydrogen pipeline, DC power network, and hot water pipeline), and energy demand and supply management through DR methods (e.g., vehicle-grid integration, power-boosting by micro combined heat and power (CHP)) as illustrated in Figure 1. The energy dispatching station plans to accommodate from 100 to 200 houses in the first stage.

As the community grows in area, household number, and the population at the next stage, the energy networks need to increase energy dispatching stations corresponding to site conditions, which are interconnected and work complementarily in normal cases and independently in emergencies. An example of scalable energy networks in Tsukuba Holonism Town is displayed in Figure 2.

## 2.3. PV-powered recumbent tricycle

The European Commission (EC) presented the EU mobility strategy for a 90% cut in emissions by 2050 on December 09, 2020 [3]. This strategy demonstrates several milestones, such as at least 30 million zero-emission cars in operation by 2030 and nearly 100% zero-emission cars by 2050. Zero-emission cars correspond to EVs and FCVs, but it is not necessary to own these vehicles for private use in Japan because the loading capacity of private vehicles is over-specified [4]. Therefore, in the case that the community plans to increase other electricity supply due to the solar radiation on a cloudy or rainy day, the EVs and FCVs in the community have to stay at home or office and connect to the electric power network and charge or discharge electricity on demand based on DR requests. As alternative personal mobility, a PV-powered recumbent tricycle is available for a light-load vehicle. A skeleton image of the PV-powered recumbent tricycle, which the Task Force reconsidered, is shown in Figure 3.



Figure 3. A skeleton image of the PV-powered recumbent tricycle reconsidered

This type of vehicle is highly compact and lightweight compared to conventional vehicles and can significantly reduce energy consumption by combining PV and human power, which has already been commercially available from Organic Transit [5] in the US. The PV-powered recumbent tricycle design was reassessed in compliance with the Worldwide-harmonized Light vehicles Test Cycle mode in Japan to reduce its weight.

## 3. Conclusion

This paper proposed a community concept of the Tsukuba Holonism Town, including three basic policies, a concept image, and an example of scalable energy networks for expanding the community. Additionally, this study proposes a PV-powered recumbent tricycle as alternative personal mobility in the case of mobility style change corresponding to EV or FCV-based DR for the community. The design of the energy dispatching station and the energy networks, as well as the robust DR mechanism in harmony with residents and workers for the community, are specified in future research.

## 4. References

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