# Energy Management System for a Microgrid with Solar PV, Battery Storage and Hydrogen/Ammonia Fuel Supply

**Hirotaka Takano[1], Hiroshi Asano*[,1,2], Kento Harada[1], Xuan Gao[1], Welma Mogiti Nyabuto[1], Shinji Kambara[1]**
( [1] Gifu University, Japan / [2] Central Research Institute of Electric Power Industry, Japan )

## 1. Cross-ministerial Strategic Innovation Promotion Program (SIP)

A 5-year research program of Smart Energy Management Systems (Fig.1), the Cross-ministerial Strategic Innovation Promotion Program (SIP) in Japan, has started in FY2023.

The authors propose an **ammonia-hydrogen hybrid decentralized energy system (microgrid in Fig.2) including water electrolyser and hydrogen storage**, and **its energy management system (EMS) framework.**

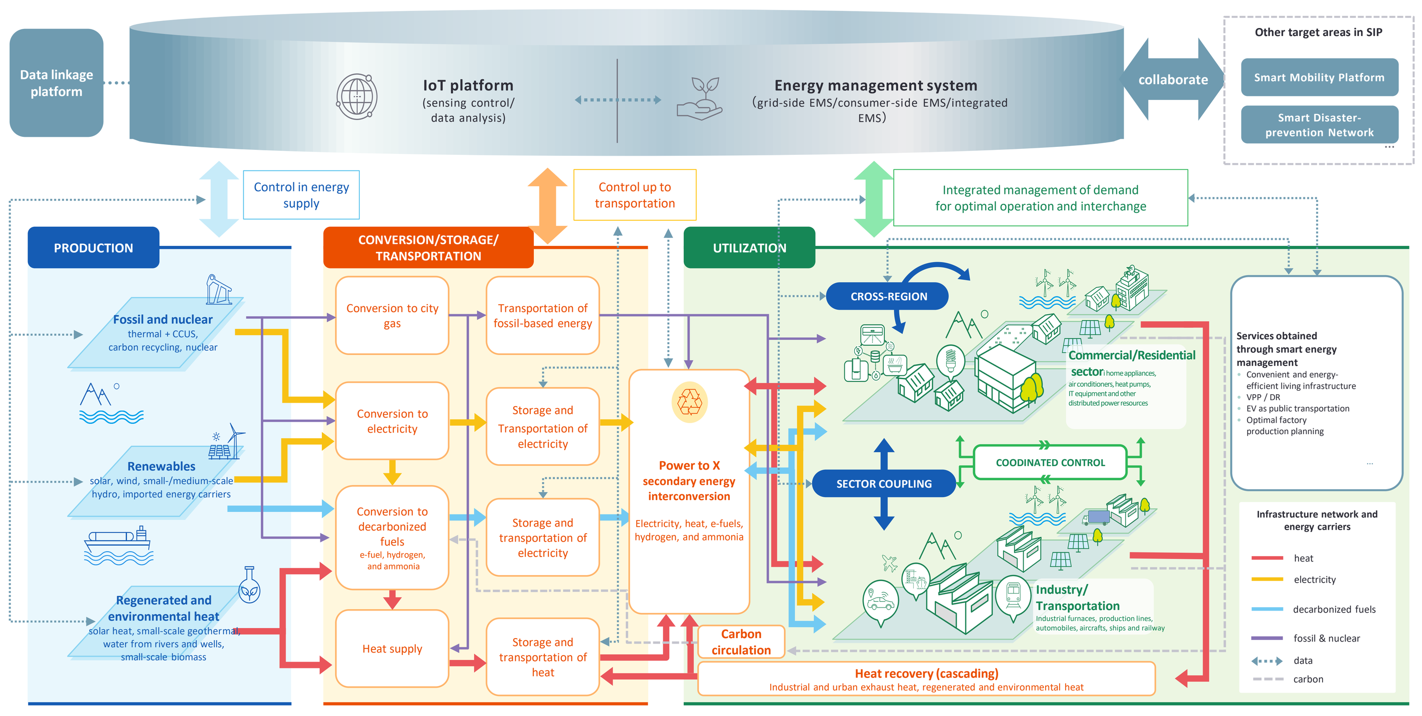

Fig. 1. Conceptual diagram of Smart EMS.

## 2. Overview of a Microgrid

Harnessing RESs and storing them as long-term storable resources, such as hydrogen, is effective to strengthen energy resilience and promote RES integration, especially in suburban or rural area.

Along with storage batteries, the research and development of microgrids that leverage hydrogen production and storage technology as an alternative to the batteries is attracting significant attention for industrial microgrids with process heat demand.

This research and development focuses on ammonia-hydrogen utilization, particularly in industrial furnaces, boilers, and hydrogen power generation and storage systems.

The microgrid system has hydrogen power storage systems (HSSs), facilitating the conversion of renewable electricity to hydrogen and its subsequent storage.

Within the microgrid context, the hydrogen facilities function similarly to storage batteries.

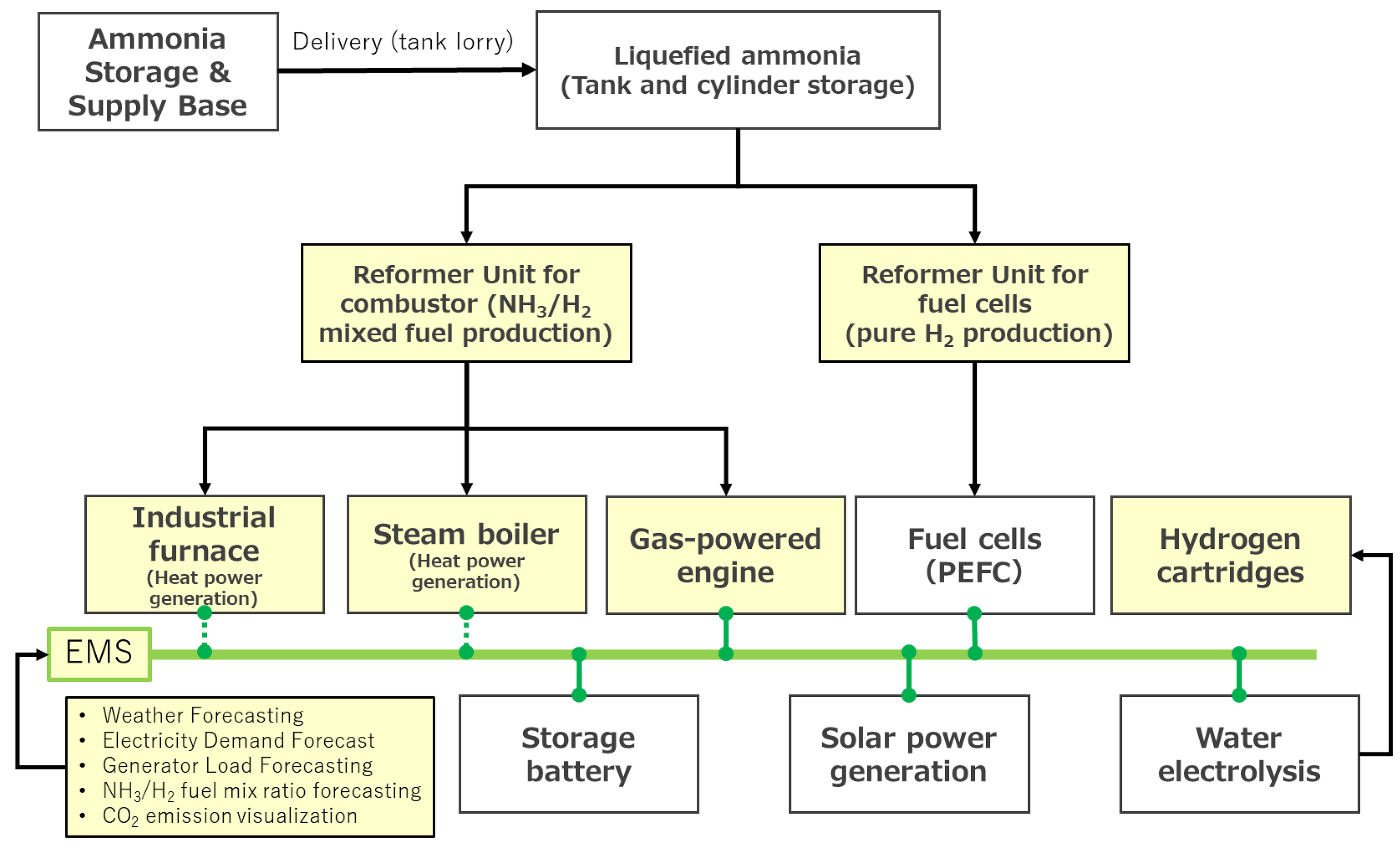


Fig. 2. System configuration of proposed microgrid.

## 3. Overview of Management Framework

The proposed EMS has the following two functions:
One is **to calculate optimal sizes of storage batteries and HSSs**.
Another is **to determine a coordinated operation schedule for microgrid components (Fig.3)**.

The former function provides optimal capacities of storage batteries and HSSs **in consideration of economical microgrid operations after their installation**.

The latter function optimizes the operation schedule of the microgrid **according to the actual condition of the components** including the storage batteries and the HSSs.

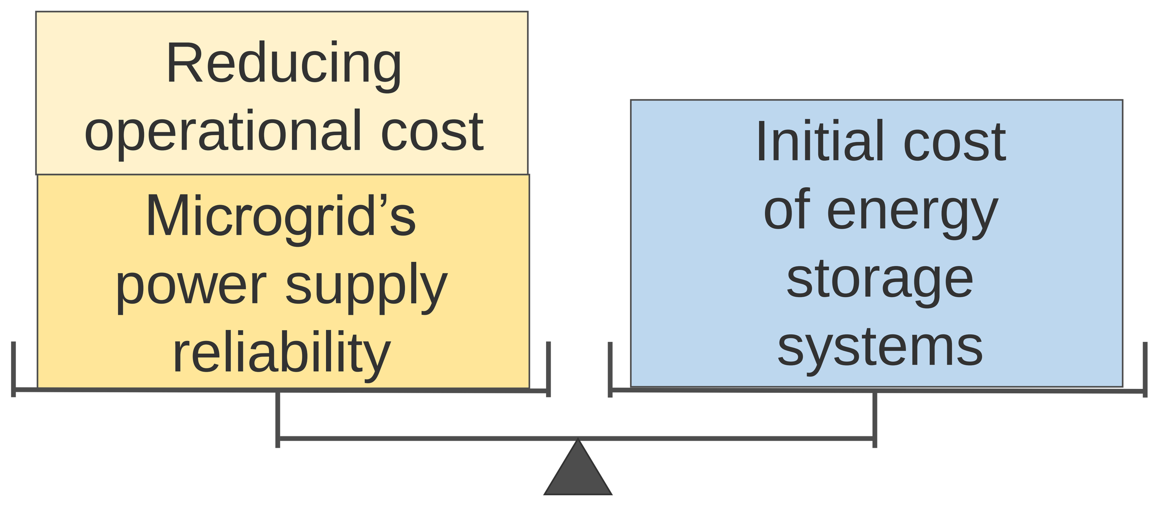


Fig. 3. Trade-off in optimization problems.

## 4. Numerical Simulation and Its Results

The optimal operation schedule was determined on a microgrid model consisting of **five generators**, **one aggregated storage battery** (Li-ion), and **one aggregated hydrogen storage system**.
Maximum load: 90 MW (a campus assumed), Total amount of PV capacity: 20.0 MW,
Total maximum and minimum outputs of generators: 76.0 MW and 15.2 MW,
Optimal capacity of aggregated Li-ion battery: **26.7 MWh**, Optimal capacity of aggregated hydrogen storage system: **20.4 MWh**.

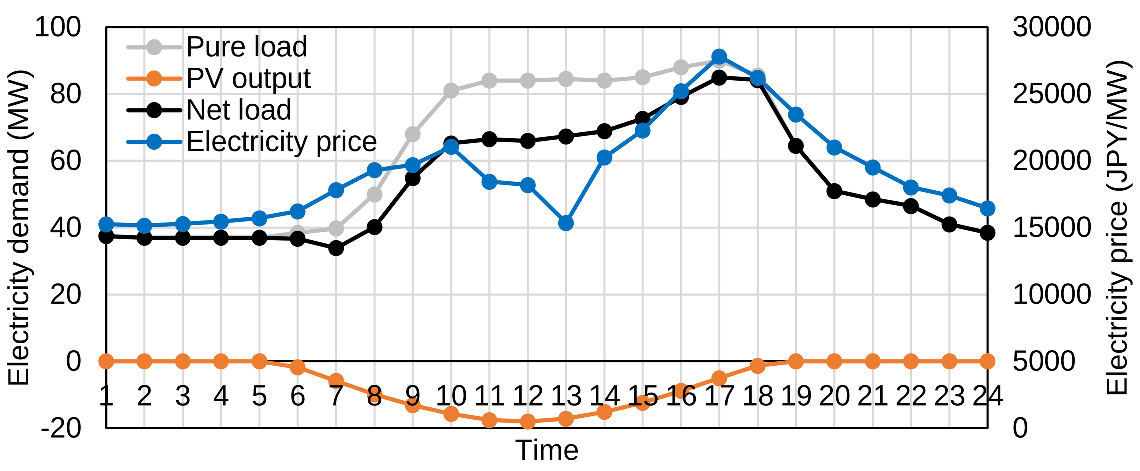


Fig. 4. Assumed profiles of demand and electricity price.

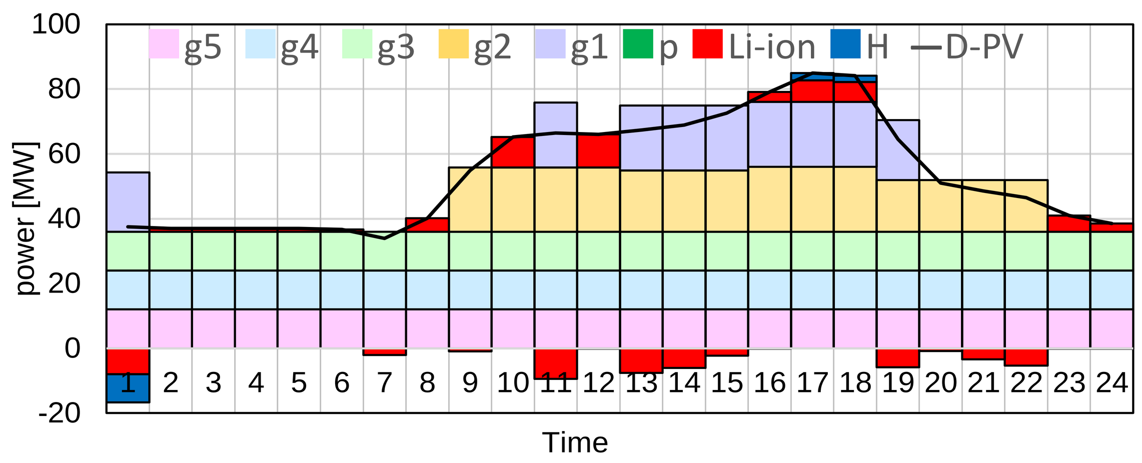


Fig. 5. Optimal operation schedule.

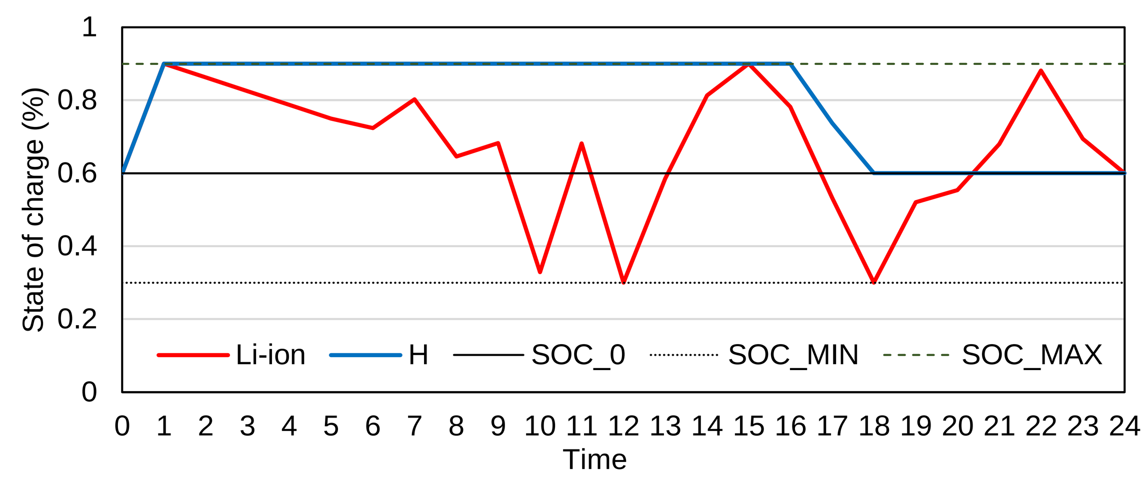


Fig. 6. SoC of energy storage systems.

**An economic operation schedule satisfying all operational constraints** was obtained.
=> We can conclude that the proposal was functioned appropriately.

## 5. Concluding Remarks

We are developing the EMS and preparing field tests of an energy system for a new factory of an automobile component manufacture in Gifu as a pilot within the SIP project until March 2028. Future plan is a zero-carbon campus.