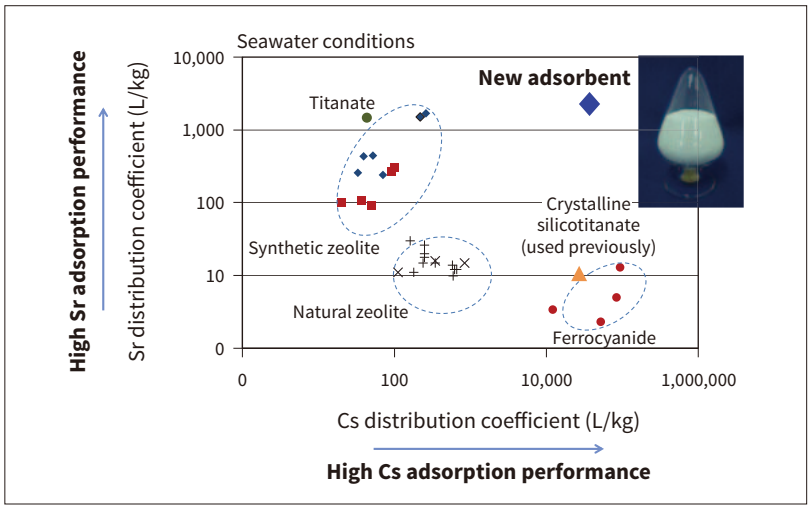
Technology Innovation:
Energy



1 Cs and Sr adsorption performance

1 Development and Application of Material Able to Adsorb Radioactive Cesium and Strontium

Contaminated water from the accident at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings, Inc. contains high levels of radioactive cesium (Cs) and strontium (Sr). This makes it desirable to decontaminate the water as soon as practical to reduce the ambient level of radiation and the risks of the water leaking. The equipment installed in the aftermath of the accident was only able to remove radioactive Cs, with contaminated water containing radioactive Sr being stored in tanks. Accordingly, Hitachi has developed a material able to adsorb both Cs and Sr with the aim of using this existing equipment to also remove radioactive Sr.

This ability to also adsorb Sr was achieved by means of a chemical treatment that improves the ion exchange performance of crystalline silicotitanate, a known Cs adsorbent. The new adsorbent performs at a level similar to existing high-performance adsorbents for Cs and Sr, selectively removing both radioactive Cs and Sr at the same time. A technique for maintaining high Cs and Sr adsorption performance was also developed that works by adjusting the pH of the contaminated water and treating it using the adsorbent.

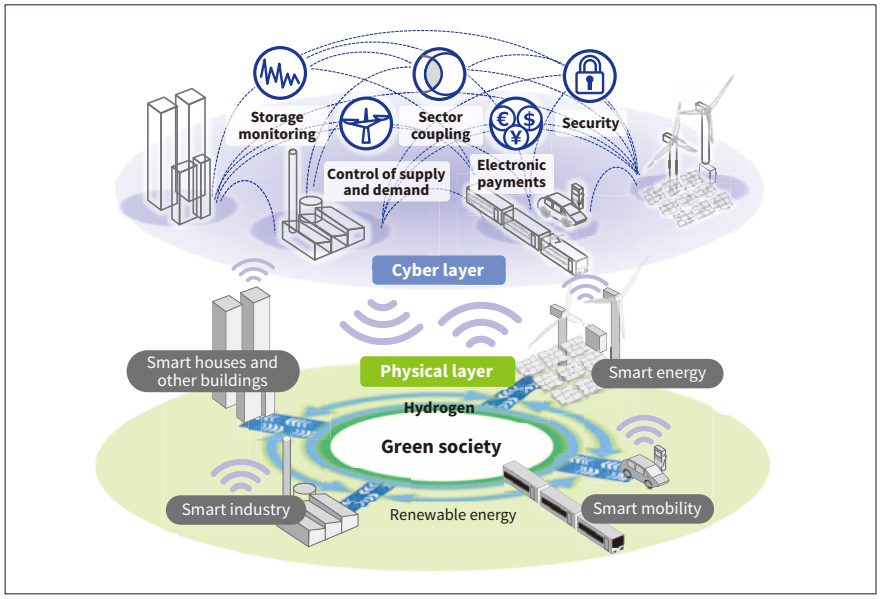
The adsorbent is currently helping to reduce risks and minimize the production of new contaminated water through its use in water treatment equipment at Fukushima Daiichi Nuclear Power Station and for treating groundwater from the vicinity of the power station building.

The development was recognized at the 52nd (2019) Ichimura Prize, winning the Ichimura Prize in Industry for Distinguished Achievement.

2 Environmental Innovations

Mitigation and adaptation to global climate change and critical weather conditions have become a central concern for economic policies. The focus of debate has shifted from quantity to quality: not only "how much" but "how" we can reduce carbon emission have become crucial questions. It is important to ensure that the rapid paradigm shift embodies a "just transition" to a sustainable society, where everyone receives respect and can play a key role in the transformation.

Hitachi aims to create economic and environmental values by supplying products including energy-efficient equipment and energy management systems. In the future, it intends to provide integrated solutions to help customers overcome the challenges in their own transition. Cyber-physical systems (CPSs) that mediate the distribution of green energy and data across different stakeholders will enable collective solutions that



2 Connecting physical and cyber layers for a decarbonized society

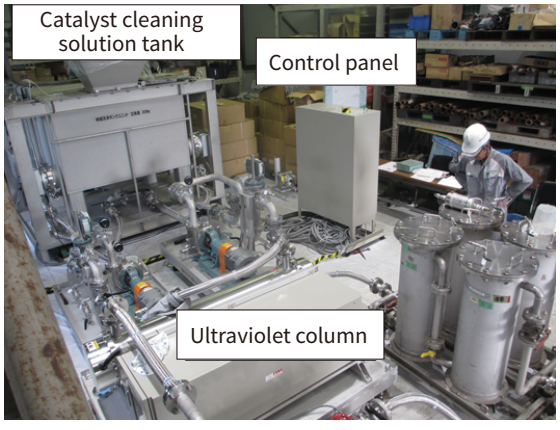
individual efforts are unable to achieve. Through these innovations, Hitachi will contribute to the creation of a sustainable society.

3 Completion of Decontamination for Decommissioning of Unit 1 at Chubu Electric Power Company's Hamaoka Nuclear Power Plant

In the process of decommissioning a nuclear power plant, decontamination is conducted prior to dismantlement to reduce the radiation exposure of workers. One of the issues with this decontamination is how to deal with the 400 t of radioactive secondary wastewater produced by the combined decontamination of the reactor, piping, and other equipment.

Hitachi is developing a highly efficient technique for de-toxifying this secondary wastewater by using a catalyst to break down the decontamination reagents it contains into water and carbon dioxide. The problem is that, because the reactor decontamination process requires the detoxification of such a large amount of radioactive secondary wastewater, it leaves behind a high level of waste catalyst, the catalytic activity of which has degraded with use. In response, Hitachi has developed a new technique that is used in parallel with detoxification to reactivate a catalyst that has become less efficient at breaking down the reagents. It works by washing the catalyst in organic acid to restore its activity, with this cleaning liquid then being cleaned itself by exposure to ultraviolet light.

The technique allows the radioactive secondary wastewater from reactor decontamination to be treated in a way that does not increase the amount of waste material nor impact on the process. It has been used in the decontamination associated with decommissioning Unit 1 of the Hamaoka Nuclear Power Plant, with the reactor decontamination being completed in August 2019, the first time such work had been undertaken for a boiling water reactor (BWR) in Japan.

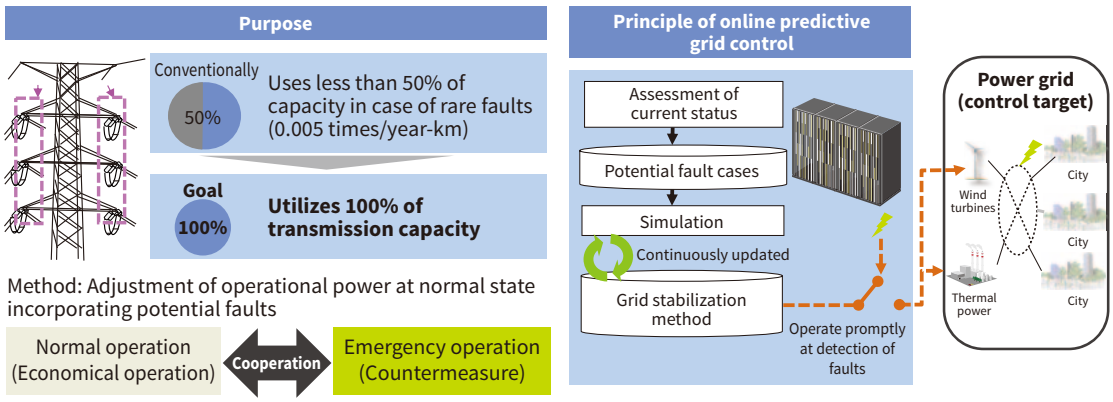


3 Cleaning system for detoxification catalyst

4 Online Grid Control for Accelerating Installation of Renewable Energy

Hitachi has developed online predictive grid control technology that enables greater use of renewable energy by increasing transmission capacity while keeping the upgrading of grid infrastructure to a minimum.

The conventional method used by electricity transmission systems is to operate below maximum transmission capacity to secure safety margin in case of rare faults such as lightning strikes. As an alternative, Hitachi developed new technology that determines in advance how to



4 Implementation of online grid control

operate when a fault occurs and incorporates this into normal operation so that operation at close to thermal capacity of transmission line becomes possible. In practice, this means operating the grid in a state that enables both normal operation based on economic considerations and emergency operation when a fault occurs. The main features are as follows:

(1) Continuous assessment of grid faults based on real-time power flow data in power grid.

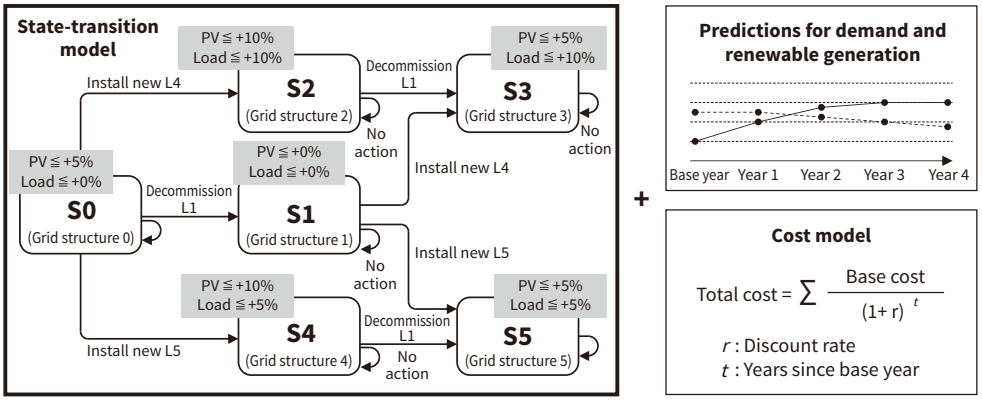
(2) Adjustments of generation output in order to secure stable operation of power grid in case of severe fault events.

(3) Grid stability is maintained by exercising control of power output and other factors promptly after detection of grid fault.

In the near future, Hitachi will contribute to the decarbonization of energy systems by using a simulator to conduct commercialization testing of this new technology.

5 Planning Support Technique for Establishing Social Infrastructure that is Highly Reliable and Makes Economic Sense

Largely built during the period of rapid economic growth, Japan's electricity grid is now quickly aging. It has also been experiencing rapid change over recent years, including the growth of renewable energy and unevenly distributed demand. This has created a need for grid planning



5 Overview of how planning is done using state-transition model to represent changes in grid structure

to be conducted with a view to likely structural changes due to changing circumstances as well as the upgrading of aging equipment.

In response, Hitachi is proposing a planning technique that utilizes a state-transition model to represent this changing grid structure. This involves first generating digital twins for all of the possible grid structures that could emerge over the planning period, with these being determined based on possible actions such as the upgrading or decommissioning of equipment, and then building a state-transition model in which these possible grid structures are the nodes and the possible actions are the branches. Allowed values of generation capacity and load determined by reliability analysis are assigned as attributes to each node, with the branches being combinations of possible actions based on constraints such as budget and construction time. This model can then be used to identify the pathways to grid structures able to deliver the required level of reliability under the uncertain conditions of the future, thereby helping to plan for a grid that is both highly reliable and makes economic sense.

6 Highly Efficient Technique for Recovering Zirconium from High-level Radioactive Waste

Methods have been developed for extracting long-lived fission products (LLFPs) with half-lives measured in hundreds of thousands of years from the radioactive waste of nuclear power plants and rendering them less radioactive by means of nuclear transmutation, and also for recovering useful elements for reuse. This research has focused on zirconium, an element with industrial uses that include sensors and refractory materials, and which is one of the LLFPs found in the high-level radioactive waste liquid resulting from the reprocessing of spent fuel. It has resulted in the development of a highly efficient technique for the recovery of zirconium from this liquid waste.

This work has devised a zirconium recovery process that involves first adding molybdenum to the liquid waste to form a precipitate that selectively includes zirconium. The resulting precipitate is then reacted with fluorine to recover the zirconium by separating out the molybdenum by volatilization. A trial of zirconium separation and recovery using a simulated high-level radioactive waste liquid demonstrated high efficiency (a recovery rate exceeding 90%).

Hitachi intends to continue research and development work aimed at reducing the amount of radioactive waste and putting it to good use.

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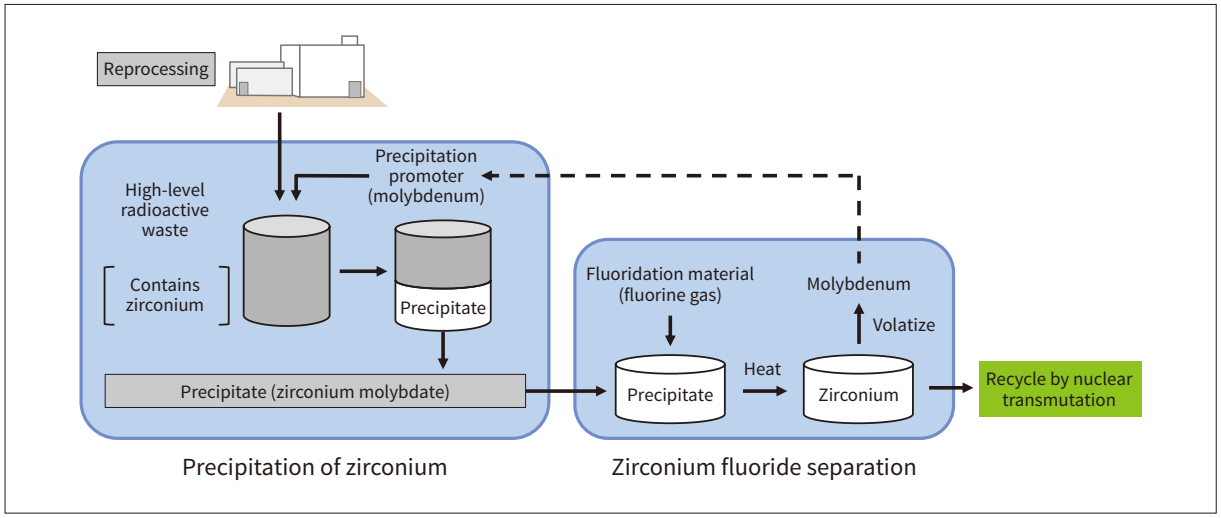

6 Zirconium recovery process