The Dawn of Japan's Solar Age

By Yuta Sagara

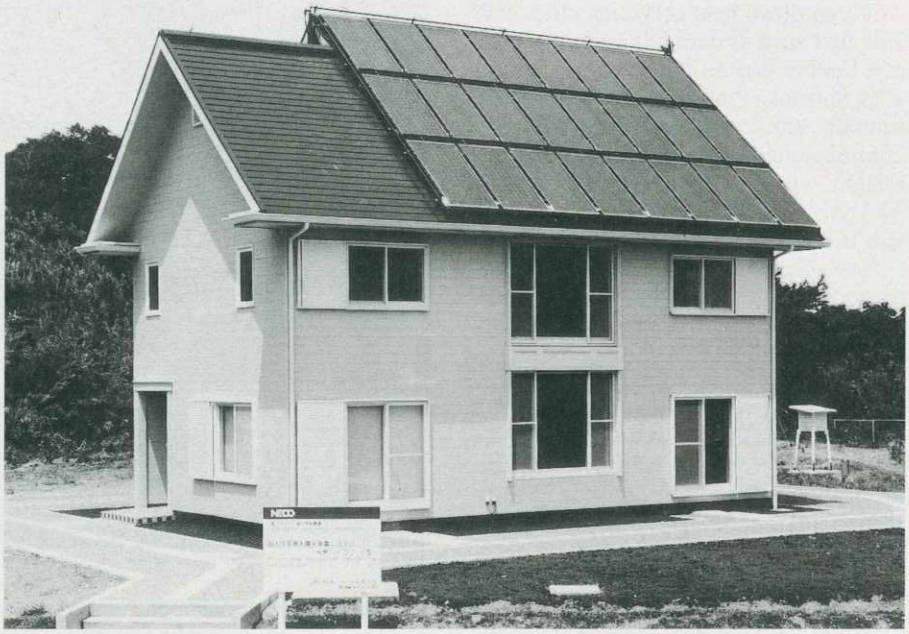

Photo: NEDO

An experiment involving a photovoltaic power generation system for households.

Japan's serious pursuit of solar energy technology dates back to July 1974, when the Ministry of International Trade and Industry (MITI) launched its Sunshine Project to reduce Japan's dependence on oil. The New Energy and Industrial Technology Development Organization (NEDO) was established to promote alternative energy and industrial technology development efforts, recruiting specialists from both the government and the private sector.

NEDO's new energy-related budget in fiscal 1989 was ¥67.4 billion, with ¥10.5 billion earmarked for the development of solar energy.

Broadly speaking, solar energy can be used in two ways: as a heat source and as a light source. As a heat source, it is already widely applied for household hot water supplies and heating. Solar heat power generation, a form of large-scale solar heat utilization, is still under research and development in the United States and Europe, but has been largely abandoned in Japan.

A less direct form of solar energy is photovoltaic power, best represented by the solar cell. A solar cell utilizes the natural generation of electricity which occurs when silicon is exposed to light. These versatile cells are used for watches and pocket calculators and as independent power sources for remote mountain lodges, lighthouses and radiowave relay stations. They are used to power satellites in outer space, and even solar cars.

The Sunshine Project led to great strides in solar systems for household use. Production of solar water-heating systems reached 750,000 units in 1980, partly spurred by the first oil crisis. As oil prices softened in the 1980s, however, production began to slip, and has fallen by some 50,000 units annually for the past five years. Installation of other home-use solar systems has also been on the decline since 1983.

Nevertheless, an estimated five million solar water heaters and 330,000 other solar systems have been installed throughout Japan, reaching some 10% of households. Solar heat supplies 0.2% of Japan's total energy demand, a figure that, while still small, makes it one of the most powerful of new energy sources.

To encourage the spread of solar power, MITI subsidizes 50% of the cost of introducing solar systems in public facilities, including local government offices, public gymnasiums and halls, hospitals, health clinics, elementary and middle school swimming pools, nursery schools, and facilities for the handicapped and elderly. Some 1,650 large-scale solar systems for airconditioning and hot water were installed across the country with MITI subsidies from fiscal 1980 to 1988.

Benefiting industry

Industry, where heat accounts for 70% of energy needs, has also benefited from solar energy. Among industrial solar systems already in practical use is a lumber drying system utilizing solar thermal energy.

The components of an industrial solar energy system usually include a heat collector for efficiently collecting solar energy; a heat storage tank used when solar energy is not available at night and in rainy weather; heat conducting piping to efficiently transfer heat; a heat exchanger which efficiently utilizes solar heat; thermal insulation; and auxiliary heat sources.

NEDO has already developed and introduced a high-temperature heat collector for a dyeing plant using cascading heat process-type technology designed to supplying hot water at different temperatures, an essential requirement for many industrial processes.

Other processes have other needs. NEDO has also used fixed heat process-type solar energy technology to build a fixed temperature storehouse which stays at 15°C and a constant humidity of 45% in semitropical Okinawa. More than 70% of the energy used by the storehouse depends on solar energy.

The lumber-drying system is another NEDO achievement. The system uses pneumatic heat collecting technology and is characterized by the use of low-priced pitch carbon fiber for heat collecting which provides an enlarged area for the heat collectors and catalyst air to come

into contact. These innovations significantly improve heat collecting efficiency. The first such system has been installed at a lumber precutting factory in Tenryu City, Shizuoka Prefecture for drying cedar lumber. Sumitomo Metal Industries was commissioned by NEDO to develop the system, which has also been exported to Malaysia for drying lumber from broadleaf trees.

Now NEDO is working on element technology for advanced heat process-type solar energy systems. Research is already under way on a refrigerated storehouse system designed to maintain temperatures between zero and minus 5°C. The storehouse will use water heated to about 140°C by solar heat to drive the absorption refrigerator, and has already helped in the development of a high-temperature heat-collecting system operating at 150 to 200°C.

NEDO is also leading efforts to develop long-term heat storage technologies to enable seasonally variable solar energy to be used for stable energy supplies the year round. Current work involves using a hydrogen-absorbing alloy as the energy-storing material, in combination with a heat-transporting system using hydrogen as its transport medium.

The most ambitious Japanese solar project was the development of large-scale solar electric power generation systems. Two pilot plants, one a tower light collection plant and the other a curved surface light collection plant, were built at Nio, Kagawa Prefecture, in 1981, and operated experimentally until 1984.

When it entered service in August 1981, the tower light collection-type plant became the world's first large-scale solar power plant. The curved surface collection plant also worked as planned, generating 1,000 kilowatts (kW) of electricity in September the same year. Over the long term, however, both plants proved ill-suited to Japan, where frequent rain, cloudy weather and the low reflectivity of the sun made it difficult to obtain enough heat from mirrors alone.

Far more successful have been solar cells. Solar cells are now commonly used to power small consumer products like pocket calculators, watches and radios, as well as in such special applications as satellites, unmanned lighthouses and radio-wave relay stations. Yet they have not found practical use as a general power source because of their high cost, averaging ¥700 to ¥800 per watt peak. Better DC/AC converters, cheaper storage batteries and other peripheral devices must be developed before solar cells are fully utilized for photovoltaic power generation systems.

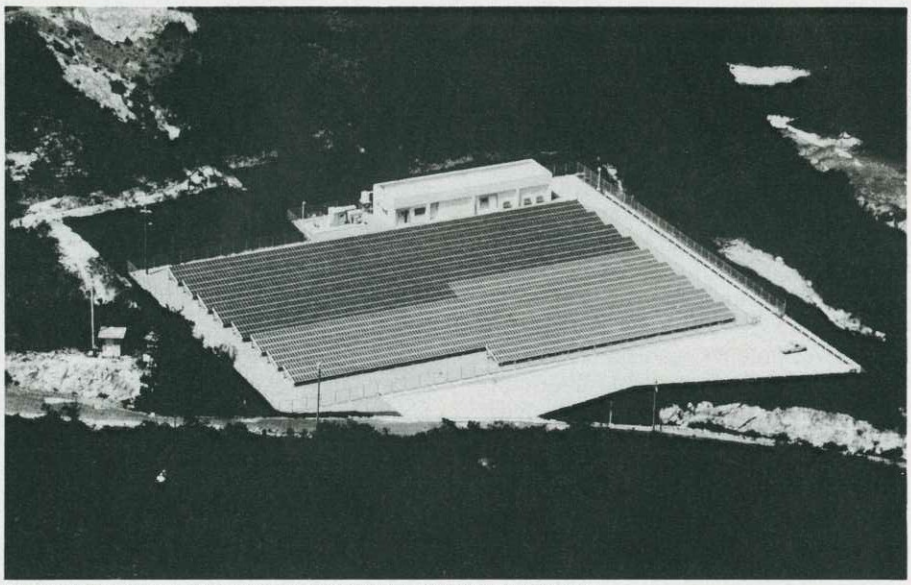

Photo: NEDO

Photovoltaic power supply systems on Tokashiki Island, Okinawa Prefecture.

Pushing studies

NEDO is pushing studies on ways to efficiently use photovoltaic power generation systems. It is already operating pilot plants, one designed for regions with new demand for electric power, and the other designed for installation at existing power stations. Each system can either be connected to existing power lines, or use its own independent transmission network.

NEDO has been conducting joint research with the private sector to accelerate the practical application of the independent solar cell power plants since 1987. Isolated islands are one candidate for such facilities. These islands presently use diesel engines as a power source for their generators, raising their electricity bills and making photovoltaic power generation a more attractive alternative.

Successful experiments with electric power systems for isolated islands are being conducted on two Okinawa islands. A 200-kW photovoltaic power plant installed on Tokashiki Island and a 50-kW plant on Zamami Island are part of a demonstration study on combining photovoltaic power plants and generators driven by diesel engines.

The next step will be a large-scale power supply system built around photovoltaic power generation on Okinawa's Miyako Island. MITI's Agency of Natural Resources and Energy is now selecting a site for the system, estimated to cost ¥2.5 billion. The plant will combine a 750-kW photovoltaic power plant with wind power generation and fuel cells. Together, when completed by the end of fiscal 1991, the plant should produce electric power at the megawatt level—enough to meet about 10% of the island's electric power needs.

Other photovoltaic power generation projects include a multi-hybrid power generation system combining a 30-kW solar power generator and a 3-kW hydropower generator in Hayato-cho, Kagoshima Prefecture; a 65-kW seawater desalination system in Fukue City, Nagasaki Prefecture; a hybrid system for a mountain cottage, combining a 70-kW photovoltaic power generator with a 1-kW

wind power generator at Mt. Hakuba in Nagano Prefecture; a hybrid irrigation system using a wind power generator in China-cho, Kagoshima Prefecture; and a 200-kW system for supplying electric power to large agricultural plants in Kami-Shihoro, Hokkaido.

Further research on a demand-based system is under way at a factory of Komatsu Ltd. The project will use a flat-plate type light-heat hybrid system with a hybrid panel which will absorb 10% of the solar energy collected by solar cells as electric energy, and absorb the remainder with a black liquid heat catalyst by the flat-plate heat collector. The absorbed solar energy will be fed into a heat-collecting tank and a hot water storage tank.

Meanwhile, NEDO is pursuing work on solar installations for existing power generation stations. In Saijo City, Ehime Prefecture, a 1,000-kW photovoltaic power generation system is feeding electricity into the trunk line of the Shikoku Electric Power Co., which supplies electricity throughout Shikoku.

In another experiment in interconnectability with existing electric power networks, 100 solar cell panels generating 2 kWs of electricity each—enough to meet the needs of 100 homes—have been installed on Rokko Island, a man-made island off Kobe. Fifteen of the panels are actually placed on rooftops to supply electric power for lights, air conditioners, TV sets, refrigerators and washing machines in the home. The aim is to see how small, household photovoltaic systems will affect power line networks.

All this extensive research and development work on photovoltaic power generation is ultimately aimed at lowering the cost of electricity to current electric power rates—¥20 to ¥30 per kWh. As things stand now, photovoltaic power is still tremendously expensive: a small household system with an output of 2 to 3 kWs costs an exorbitant ¥5 to 6 million. Half of the price is for the solar cell panel, and the rest for an DC/AC converter and storage battery.

Cutting prices

Yet prices are going down. Today a solar cell costs about ¥700 per watt, only one-tenth of what it was 10 years ago. Now NEDO is seeking to push the price down to ¥100 to ¥200 by the year 2000.

This requires reducing manufacturing cost, increasing the efficiency of solar cells and improving their durability and reliability. This R&D focuses on crystalline silicon solar cells and amorphous solar cells. Meanwhile, other work is under way on peripheral parts to lower the cost of inverters and batteries, minimize system damage and increase the durability and reliability of the entire system.

The main areas of NEDO's solar cell research can be summarized as follows:

Crystalline silicon solar cells: R&D is focused on how to obtain higher efficiency of polycrystal silicon solar cells with larger surface areas suitable for electric power generation. Over the past 15 years, the Sunshine Project has heightened the conversion efficiency of polycrystal silicon solar cells to 15.7% for a cell 10 centimeters square. NEDO projects efficiency of 17 to 18% by 1992.

Advanced solar cells: Work began in 1989 to sharply improve solar cell efficiency and cut costs, including the development of thin substrate and tandem solar cells. The thin substrate cell should make possible thinner solar cells with larger surface areas, which in turn will raise conversion efficiency and cut costs. R&D of tandem solar cells is focused on developing high-efficiency, reliable solar cells by combining two different cells in order to fully utilize photovoltaic energy. Two possible combinations are amorphous solar cells with polycrystal silicon wafer solar cells, and amorphous solar cells with chemical compound semiconductors.

Amorphous solar cells: The goal is to develop a highly efficient, highly reliable amorphous solar cell measuring at least 30 centimeters square by 1992. Amorphous solar cells are already widely used in low-output electrical equipment, but their performance must be improved before they can be used for power generation.

Despite the many remaining obstacles, MITI is confident that photovoltaic power generation systems will be in wide use in Japan, including the home, in the next century. The ministry has already started revising the Electricity Utilities Industry Law and is setting technical standards for photovoltaic and solar cells. It's been a long time in coming, but Japan's solar age may finally be just around the corner.

Photo: NEDO

Development of photovoltaic power supply systems at Mt. Hakuba, Nagano Prefecture.

Yuta Sagara is a senior writer at Kyodo News Service.