Journal of Photochemistry, *29* (1985) 115 - 122

SOLAR ENERGY DEVELOPMENT IN JAPAN*

TAKASHI HORIGOME
New Energy Development Organization, Sunshine 60, Toshima-ku, Tokyo (Japan)

Summary

A review of the Sunshine Project and, in particular, the role of the New Energy Development Organization (NEDO) is presented.

The work of NEDO in developing solar thermal power systems, photovoltaic systems and a wind power system for a variety of uses is discussed.

---

1. Introduction

The Sunshine Project was started in July 1974 for the purpose of securing solutions to basic energy problems and reconciling energy utilization with the need to protect the environment. This project is the first large-scale, long-term, technical development effort which deserves to be designated as a national project. It has as its object the investigation of all aspects of new energy technology with the exception of nuclear energy technology.

Solar energy development in Japan has been promoted as one part of the Sunshine Project. The basic research on solar energy is being undertaken by the Agency of Industrial Science and Technology (AIST) and the development and demonstration (D&D), by the New Energy Development Organization (NEDO).

NEDO is a governmental body operating with the assistance of the private sector to promote the general development of technology for the purposes of commercializing alternative energy and developing alternative energy resources, except nuclear energy. NEDO is now investigating solar energy, geothermal energy, coal conversion, hydrogen energy, energy storage and biomass conversion etc.

This paper is mainly concerned with the solar energy development at NEDO. NEDO is promoting five projects in the field of solar energy: (i) D&D of a solar thermal power system, (ii) D&D of a photovoltaic energy system, (iii) D&D of a solar system for industrial process heat, (iv) D&D of solar desalination technology, (v) D&D of a wind power system.

The NEDO budget for solar energy development was about ¥ 8500 million in 1984.

*Paper presented at the Fifth International Conference on Photochemical Conversion and Storage of Solar Energy, Osaka, Japan, August 26 - 31, 1984.

0047-2670/85/$3.30

2. Development and demonstration of a solar thermal power system

It is known that NEDO has constructed two types of solar thermal power pilot plants each of which has a rating of 1 MW. One is a tower type in which sunlight is concentrated at the top of a tower by means of plane mirrors. The other is the plane–parabolic type in which sunlight is concentrated by a combination of plane mirrors and parabolic mirrors. Both pilot plants were constructed at Nio in Kagawa prefecture in 1980. Test operation was continued until the end of March 1984.

During the initial operation, some problems were encountered but these were overcome. After test operation, we shall analyse the operating characteristics and evaluate the cost effectiveness and reliability of the solar thermal power plant. We shall base our next plan on the evaluation of the 1 MW pilot plants.

Fig. 1. A pilot 1 MW solar thermal power plant.

3. Development and demonstration of a photovoltaic energy system

NEDO is promoting two ways of reducing the cost of the photovoltaic energy systems. The first is the development of low cost mass production technology for solar modules. The second is the development of a photovoltaic demonstration system to establish photovoltaic system technology and to expand the solar cell market.

3.1. Development of low cost mass production technology for solar modules

NEDO designed and constructed a 500 kW yr^{-1} experimental mass production system. The block diagram of the 500 kW experimental mass production system is shown in Fig. 2.

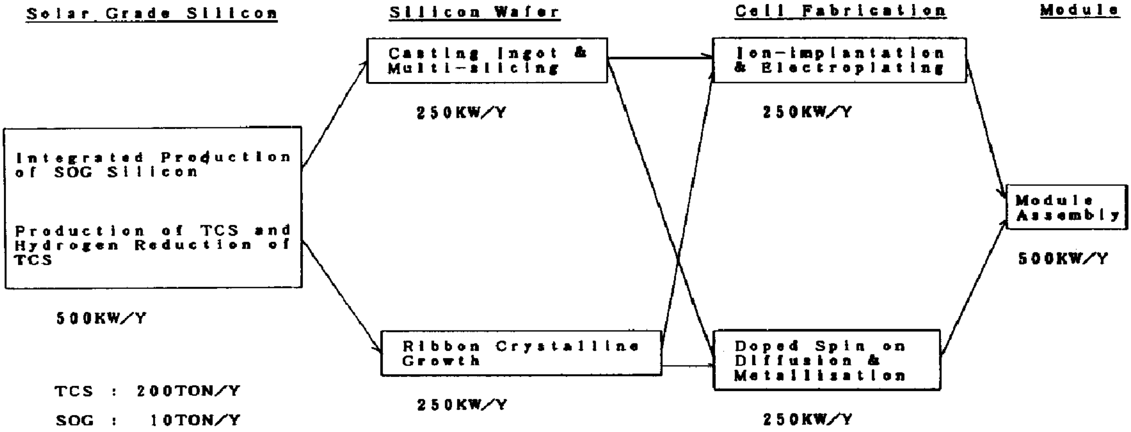

Fig. 2. A block diagram of a mass production process for the manufacture of solar cells.

3.1.1. Silicon material technology for producing low-cost chlorosilane

Highly purified silicon for use in semiconducting devices is made from trichlorosilane. Therefore, technology development is in progress on the low cost fabrication of trichlorosilane by re-utilizing the silicon tetrachloride and hydrogen chloride which are generated in the silicon refining process.

3.1.2. Silicon material technology for hydrogen reduction using a fluidized reaction

Low cost silicon production technology is being developed by using a fluidized bed reactor with which we aim to provide a large stable supply of low-cost silicon.

3.1.3. Silicon sheet technology using a casting process

Production of low cost silicon substrates is achieved by practical application of a casting process. Silicon is melted, solidified and multisliced to produce low cost silicon plates which can be utilized in solar cells.

3.1.4. Silicon sheet technology using ribbon growth cell fabrication technology

This process has the advantage that ribbon crystals are fabricated from silicon without any loss, owing to their square shape, and a high efficiency model can be manufactured.

3.1.5. Cell fabrication technology using ion implantation and electrolytic plating

Silicon substrates fabricated without a p–n formation process are only dark coloured metal plates without a p/n junction. Owing to the p–n formation process, solar cells have a most important function in power generation. The ion-implantation method has been applied here to evaluate its improved productivity and potential as a new production technology for semiconductor integrated circuits.

3.1.6. Cell fabrication technology using painting and printing

In this process, surface treatment of solar cell elements, p/n junctions, anti-reflection coatings, electrodes and side-face treatment are carried out according to a simplified new process. The aim of the work is to develop a low cost automated solar cell production line.

3.1.7. Module assembly technology

Module assembly processing is the last stage of solar cell production. Tens of solar cells are connected by wiring and then protected against severe environmental conditions.

3.2. Development of an amorphous solar cell for power use

NEDO is promoting research and development on amorphous silicon (a-Si) solar cells. NEDO is developing three fundamental technologies for the mass production of amorphous solar cells for power use. The first is a production technology for high efficiency a-Si cells, the target of which is to produce 10 cm × 10 cm cells at more than 12% efficiency. The second is a production technology to produce a large size a-Si cell which is 40 cm × 30 cm. The third is a high speed production method for a-Si cells.

We are also studying the reliability of a-Si cells by using solar simulators. In 1985, NEDO will evaluate both the polycrystal solar cell and the amorphous solar cell from the technical and economical point of view. NEDO is also developing ceramic and polyester substrate a-Si cells.

3.3. Development of the photovoltaic demonstration systems

NEDO is developing six photovoltaic demonstration systems.

3.3.1. Photovoltaic power generation systems for single family houses

Solar cell panels for a roof-covering structure which can be easily introduced to private homes is being developed. The system rating is 3 kW.

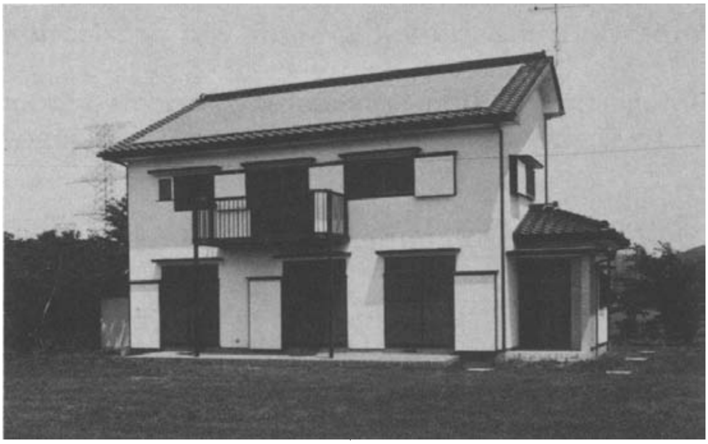

Fig. 3. A house with the photovoltaic system installed in the roof.

3.3.2. Photovoltaic power generation systems for collective housing

An experimental photovoltaic power generation system was constructed in Nara prefecture to develop a system to supply electricity for each room. The system rating is 20 kW (for eight families).

3.3.3. Photovoltaic power generation systems for school buildings

A solar cell system of 200 kW output has been sited on the roof and parking area of Tsukuba University to supply electricity for lighting and laboratory facilities.

3.3.4. Photovoltaic power generation systems for factories

An automobile battery factory has been equipped with this system to conduct initial charging of batteries by solar cells. The system rating is 100 kW.

3.3.5. Central power station type photovoltaic power generating systems

(i) Distributed power system with dispersed array location. Solar cells are placed on the roof of buildings or in empty areas. The output is converted through the inverter into alternating current and supplies electric power to each distribution line. Each generation unit is operated by remote-control from the substation. Accordingly, the system supplies enough electric power for the demands of the surrounding area.

(ii) Centralized power system with centralized array location. For the centralized system, a 200 kW unit has already been installed in Saijo, and is now under partial operation. This system began supplying electricity to the utility network in 1982. It thus became the first photovoltaic power plant in Japan. The output of the system increased to 600 kW in 1984, and now in 1985 is 1000 kW. It is difficult to find a large enough space for such a centralized plant in Japan. However, such a system would be feasible for stand alone power systems in remote islands. If it becomes technically feasible to build such a system on the sea, centralized systems will be sited on the sea. Furthermore, NEDO is studying the feasibility of a photovoltaic system sited on the lake and on the sea.

Fig. 4. A 1 MW photovoltaic central power station.

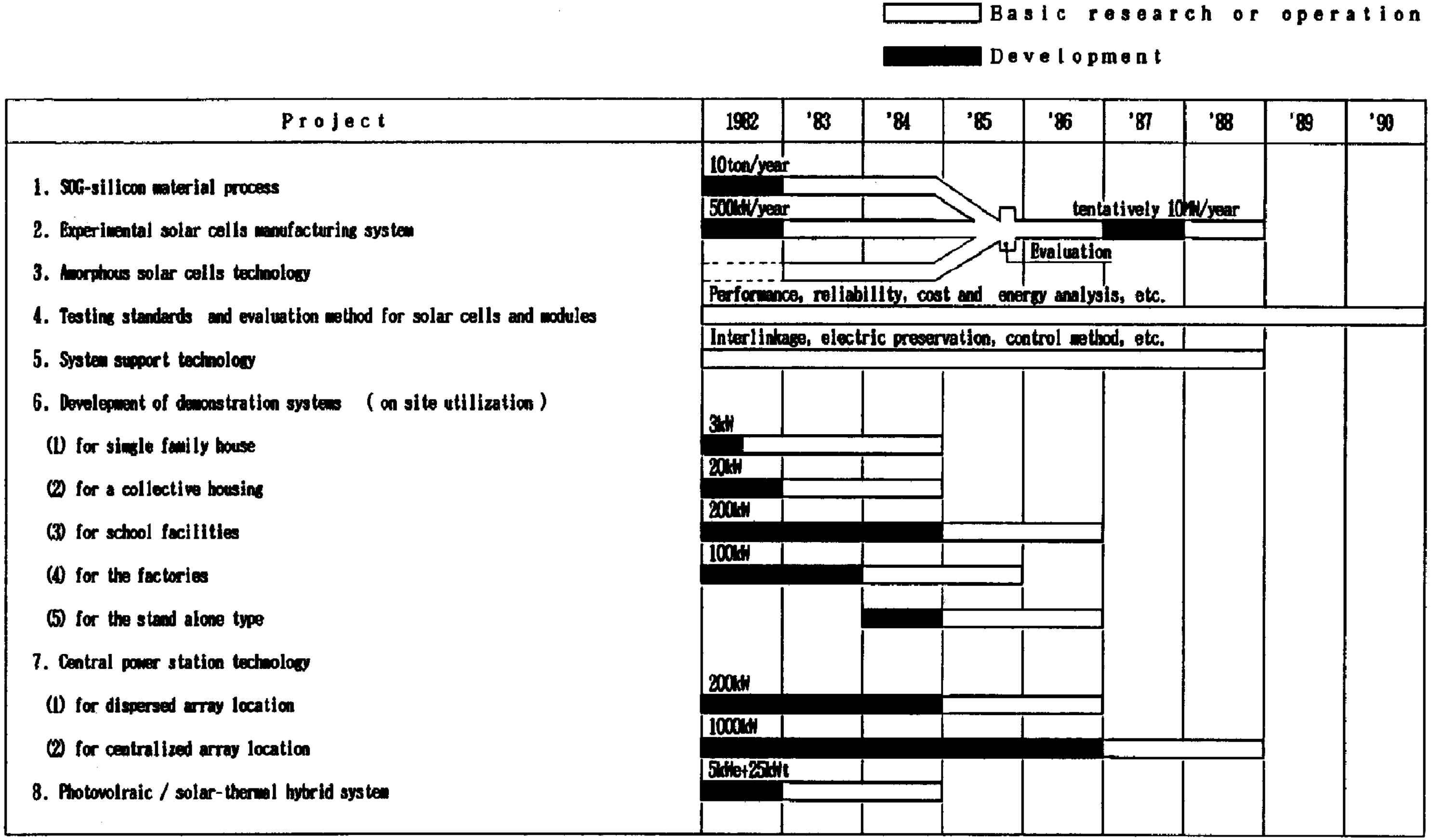

Fig. 5. The solar photovoltaic energy system D&D project.

3.3.6. Photovoltaic solar thermal hybrid systems

Through the hybrid system power generation system which combines the solar thermal system with solar cells, the coefficient of utilization of solar energy increases to obtain a large quantity of thermal energy and electricity. Its ratings are 25 kW and 5 kW.

4. Development and demonstration of solar systems for industrial process heat

It is intended that through the technological development of industrial solar systems a more sophisticated control of solar thermal energy as applied to industrial processes may be achieved. Two types of representative systems have been selected, namely, fixed-temperature control and cascaded-temperature heat process which aims at an energy supply system for the heating process which requires the control of programmed multiple temperature levels. The operational efficiency for the overall system must be raised and techniques developed for its control. The development of these processes is the key to the application of solar thermal energy to industrial problems.

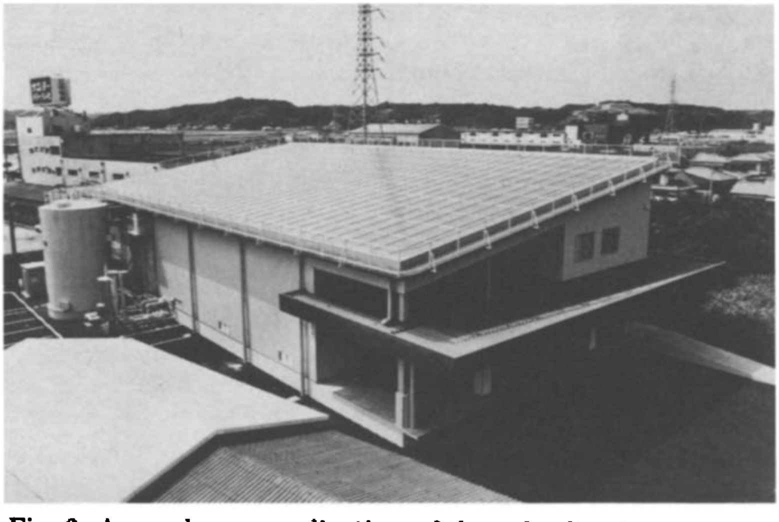

Fig. 6. A warehouse application of the solar fixed-temperature heat process.

5. Solar desalination technology development

Solar desalination technology development is needed to secure a stable supply of water in isolated islands. The research and development on a desalination plant will be conducted in the United Arab Emirates, where the climatic conditions are more severe, after due consideration of effective technical cooperation between the countries.

6. Large scale wind energy conversion systems

The origin of wind energy is solar energy. Wind energy is a clean energy. The wind speed varies greatly and its direction is not steady, and in order to utilize this resource these problems must be overcome. Accordingly, it is necessary to develop a low cost conversion system. Through large scale wind energy conversion systems, wind energy is converted into mechanical motion and is transmitted to a generator to produce electricity. The rating of a pilot system which was constructed in Miyake Island in 1983 is 100 kW.

Fig. 7. A 100 kW wind power generation pilot plant.