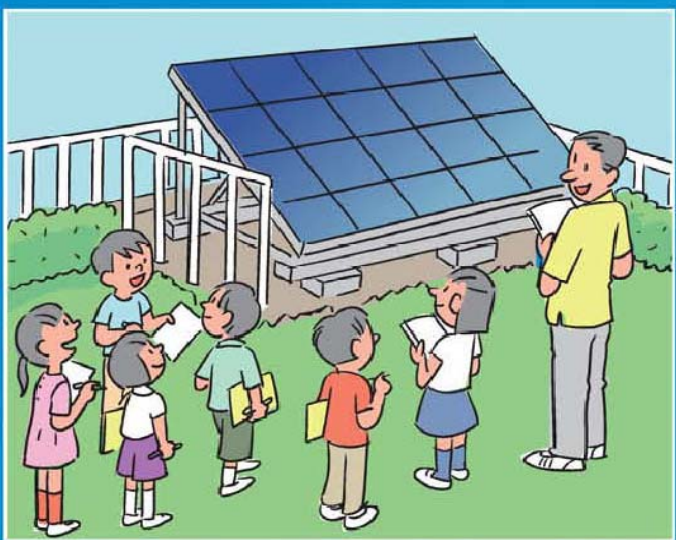
Learning through the Use of Solar Power

Guidebook on the Introduction of Solar Photovoltaic Power Generation



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Minister's Secretariat
Ministry of Education, Culture, Sports, Science and Technology (MEXT)

Educational Facilities Research Center, National Institute for Educational Policy Research

With the cooperation of
Ministry of Economy, Trade and Industry
Ministry of the Environment
and
Ministry of Internal Affairs and Communications

Japan

Introduction

Global warming is a concern common to all countries. Of all the world's issues that require full-scale efforts, it is one of the most significant. The Kyoto Protocol's first commitment period started in 2008, and various measures have been taken by many countries so that they may attain their goals of reducing greenhouse gas (GHG) emissions. Japan aims at a 6% reduction in emissions in the five years ending in 2012, relative to the 1990 emissions level.

In July 2008, the Cabinet approved the official Action Plan for Achieving a Low-carbon Society, setting a long-term goal of reducing GHG emissions by 60 to 80% by 2050, relative to current emission levels.

In April 2009, the School New Deal Plan was propounded in a policy package formulated to address the economic crisis. One of the three main pillars of this plan, environment-focused renovations including the use of solar photovoltaic power generation, is in its implementation phase.

The smooth introduction of photovoltaic power generation facilities into schools nationwide will be enhanced through the use of a guidebook that provides concise information necessary for school authorities to meet the requirements for preliminary surveys, design, construction and maintenance. The Ministry of Education, Culture, Sports, Science and Technology (MEXT) decided to prepare such a guidebook in view of the conditions and characteristics of school facilities. In collaboration with the Educational Facilities Research Center of the National Institute for Educational Policy Research, and with the cooperation of relevant ministries and agencies as well as outside experts, MEXT has compiled this guidebook.

School is a part of life for children. They learn at school, and their experiences there affect their growth and development in many ways. By implementing environment-focused renovations such as the installation of solar photovoltaic power generation facilities at school, school facilities will be places to provide environmental education to children. Everything they learn and experience at such facilities will greatly enhance their environmental awareness.

Schools are among the public facilities with which the public is most familiar, being established in all corners of the country. It is expected that environmental measures will be promoted at the regional level when environment-focused renovations are implemented at as many schools as possible.

The information in this guidebook was carefully selected to satisfy the needs of school authorities. It includes examples of photovoltaic power generation programs that are used for environmental education, the effects of such use, the use process, points to be checked in designing and building the photovoltaic power generation facilities, and maintenance of the facilities. Specific data and preceding cases are also shown. It is hoped that this guidebook will be fully utilized by school authorities when they build photovoltaic power generation facilities at their schools.

July 2009

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[Contents]

I. Significance and Effects of Photovoltaic Power Generation at School

1. The Gift of Sunlight, and Environmental Education

1

Photovoltaic power generation plays a significant part in efforts to address global warming, because photovoltaic power is renewable energy and its generation process does not emit CO_2, a greenhouse gas. Photovoltaic power generation facilities at school will be utilized as educational tools for children and local residents to learn about the effects and mechanisms of CO_2 reductions and energy saving.

(1) Environmental Education

Solar cell modules/panels and devices for displaying the electricity output are useful for helping children/local residents to learn about power generation systems/mechanisms and the effects of CO_2 reductions.

a. Use of solar cell modules

(The case of Idogaya Elementary School, Yokohama City, Kanagawa Pref.)

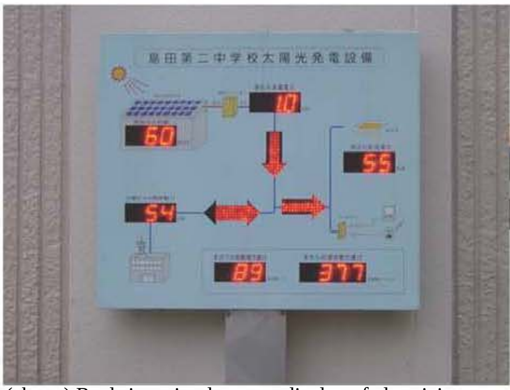
The chance for children to gain firsthand experience of solar cell modules by seeing and touching them is part of environmental education.

(above) Children of higher-grade explain a power generation system and its mechanism to lower-grade children while touching the module.

(left) Children measure the size of the module.

b. Use of the device for displaying electricity output

Children can see the amount of electricity generated each day on the display unit, which is mounted in a prominent place.



(above) Real-time simultaneous display of electricity generated and electricity purchased* (Shimada-Daini Junior High School, Shimada City, Shizuoka Pref.)

(left) Children look at the display panel to learn about power generation. (Tonami-Tobu Elementary School, Tonami City, Toyama Pref.)

(right) Students use PCs to learn about daily/ monthly/ yearly changes in electricity output. (Yasuzuka Junior High School, Joetsu City, Niigata Pref.)

* Notes:

- A type of display unit that shows both generated and purchased electricity in real time is available. When the lights near the display unit are turned off, children can immediately see that the consumption of purchased electricity is reduced and that photovoltaic power accounts for a greater proportion of the power consumed by the school. Other types display the amount of electricity generated in terms of the equivalent CO_2 reductions, or the surplus electricity made available by saving on electricity.
- To draw children's attention to the power generation monitoring system, it is helpful to mount the system at a low position, for example.

c. Use of the electricity generated

(The case of Idogaya Elementary School, Yokohama City, Kanagawa Pref.)

The learning experience of children is shared by their parents and other local residents, who receive reports about the children's experience of recharging batteries with the electricity generated by the photovoltaic power generator

Wall sockets for charging are placed near the solar cell module.

リチャージブル電池(単3)への充電のお知らせ

(above) Children understand the use of photovoltaic power by recharging batteries. They use the recharged batteries at home.

(left) A report informs parents and other local residents that batteries can be recharged with photovoltaic power.

d. Cooperation of experts

(The case of Idogaya Elementary School, Yokohama City, Kanagawa Pref.)

By ensuring the cooperation of experts from NPOs and manufacturers as well as that of local residents, children are encouraged to learn voluntarily; thus, environmental education at school is further promoted.

An expert provides an outreach program.

Children, under the guidance of an expert, learn about photovoltaic power generation, global warming and resource saving.

Children report their learning outcome to local residents.

The new Courses of Study provide that social studies at elementary schools include study on "electricity saving and efficient use of resources." It is also required that children learn about "the function of solar cells and the use of electricity" and "the importance of using energy effectively" in science classes at elementary schools and junior high schools, respectively.

School subjects that can include study of photovoltaic power generation:
Integrated study period, social studies, arithmetic, science, life environmental studies, domestic science, special activities, etc.

<<Extracts from the new Courses of Study (notification given in March 2008 regarding elementary schools and junior high schools and in March 2009 regarding high schools)>>

Social studies for grades 3 and 4	Children are given opportunities to learn about the efficient use of resources, including economization of water and electricity.
Science for grade 4 (elementary school)	The children are made to research the function of dry/solar cells so that they understand the usefulness of electricity.
Science for grade 6 (elementary school)	The children are made to research the utilization of electricity so that they understand the specific properties and usefulness of electricity.
Social studies (civics) for junior high school	The students learn that economic and technical assistance is necessary for solving the problems of resources/ energy/ poverty around the world.
Science I for junior high school	The students learn that humans use thermal/ hydro/ nuclear power as energy sources, and they recognize the importance of efficient energy use.
Science I and II for junior high school	The students understand the importance of a sustainable society.
All science subjects for high school	The students' awareness regarding the importance of a sustainable society is enhanced from a scientific viewpoint.

Points to remember in using solar cell modules as teaching materials

□ Ensure sufficient space around the modules according to the style and content of the learning activities.

□ Apply protective materials and/or set up a fence, where appropriate, to prevent children from suffering injuries to their heads by bumping against the mounting frame/ support structure of the modules as well as to prevent them from climbing on the solar panels. Instruct children on matters needing special attention.

□ When solar cell modules are fixed on the roof, take the security measures of installing a safety net, a fall-prevention fence and the like to prevent children from falling from the edge of the roof or a window roof. (Government subsidies are available for the installation of such nets and fences.)

□ When solar cell modules are mounted on the roof, lock the doors to the roof to ensure that children do not have free access to the roof.

□ Ensure that the ladders of the modules/towers on the roof are properly maintained to prevent children from climbing them.

Encouraging children to take good care of the solar power generation facilities

Because solar power generation facilities at school are useful for environmental education, school officials, including those involved in establishing schools, are responsible for educating children to take good care of the facilities. In the event of any deliberate destruction of the solar power generation facilities or of other school facilities, appropriate measures should be taken according to the notices below.

□ Guidance to children/students having behavioral problems: Notice by the Director-General of the Elementary and Secondary Education Bureau, MEXT, February 5, 2007 (No.1019)

□ Arrangements in school to respond to the problematic behavior of children/students: Notice by the Director-General of the Elementary and Secondary Education Bureau, Ministry of Education, April 30, 1998 (No.313)

Topic **Examples of themes used in environmental education by scholastic year and subject**

Environmental education is provided as part of efforts to develop human resources that can help to build a sustainable society. In view of this, the Ministry of the Environment selected major items related to environmental education from the Courses of Study. Sorting them by subject and year (i.e., lower, middle and higher elementary grades and junior high school), the Ministry compiled a brochure for use at school.* A list relevant to photovoltaic power generation is excerpted below from the brochure. The themes in the list are “the mechanism and the effects of global warming” and “resources and energy.”

	Resources and energy	The mechanism and effects of global warming
Aim	・Recognizing that underground resources and fossil fuels are finite ・Understanding the development and current utilization of natural energy, including solar and wind power ・Considering and practicing a way of life that reduces resource consumption	・Understanding that production activities and lifestyles that heavily depend on fossil fuels have altered the composition of the atmosphere and have accelerated global warming ・Considering and practicing in children'/students' daily lives whatever is possible to curb global warming
Lower grades, elementary school		
Middle grades, elementary school	Social studies: ● Disposal and reuse of wastes ● Securing of drinking water/electricity/gas ● Science ● Behavior of wind and rubber ● Properties of light ● Flow of electricity ● Behavior of electricity	Science: ● Behavior of air and water ● Metal, water and air, and their temperatures
Higher grades, elementary school	Science: ● Behavior of electric currents ● Use of electricity	Science: ● Mechanism of combustion
Junior high school	Social studies: ● Regional characteristics of Japan in comparison to other parts of the world (focusing on resources, energy and industries) ● Issues facing the international community and our lives (focusing on issues of the global environment, resources and energy)	Social studies: ● Contemporary Japan and the world at present ● Issues facing the international community and our lives (aiming at a better community)
	Science: ● Electric currents ● Electric currents and magnetic fields ● Aqueous solutions and ions ● Energy ● The development of science and technology	Science: ● Changes in material states ● Chemical changes ● Weather changes ● Living things and the environment ● Conservation of the natural environment and use of science and technology
	Industrial arts and domestic science: ● Technologies used at home and by industries ● Mechanism and maintenance of energy converters; design and production by utilizing energy conversion technologies	

**Environmental Education at School: A simple guide to themes by scholastic year and subject* (Ministry of Environment: http://www.env.go.jp/policy.nerai/

By combining the themes in this list with other themes, teachers can provide comprehensive environmental education. The Ministry of the Environment's portal site "ECO-learning library" (http://www.eeel.go.jp) is available to those who are interested in environmental education and eco-learning at school, home or work.

(2) Reduction of CO_2 emissions (Efforts to address global warming)

The renewable energy produced by photovoltaic power generation at school replaces some of the electricity supplied by thermal power plants, thereby greatly supporting the efforts by schools and local communities to reduce CO_2 emissions.

- The amounts and percentages of CO_2 reduction per school when photovoltaic power generation facilities (20 kW) are introduced:
  Amount of CO_2 reduction: 10 to 13 t per year
  Percent CO_2 reduction: 8 to 9% (in cold regions); 14 to 17% (in warm regions)
  The CO_2 reductions per school are equivalent to the CO_2 absorbed by woods covering an area the size of the Tokyo Dome.
- Electricity generated at a school per day: 50 to 63 kW
  The amount of electricity is equivalent to the electric energy consumed by fluorescent tubes in eight to ten classrooms during the school's daytime hours.
- When photovoltaic power generation facilities have been installed at all 36,000 public elementary/ junior high/ high schools nationwide, their annual output will be about 760 million kWh:
  The amount of electricity generated is equivalent to the output of a small thermal power plant, or the annual electricity consumption of 220,000 households.

Notes:
1) The amount of CO_2 reduction was calculated on the assumption that solar panels (20-kW) are installed at a school of average size having a total floor space of 5,000 m^2.
2) The value (0.000555 t - CO_2/kWh) provided in the Ministerial Ordinance on the Calculation of Greenhouse Gas Emissions Resulting from Business Activities by Specified Emitters (Ordinance by the Ministry of Economy, Trade and Industry and the Ministry of the Environment, No.3, 2006) was used in calculating the amount of CO_2 reduction.
3) With the June 2008 revision to the Law Concerning the Promotion of the Measures to Cope with Global Warming, the ministerial ordinance specifying the CO_2 emission factor used for the calculation of CO_2 reduction was also revised.
4) In December 2008, the latest CO_2 emission factor of electric power suppliers was published. When that factor is applied to calculation, the amount of CO_2 reduction is smaller.

(3) Economic efficiency

When photovoltaic power generation facilities (20-kW) are introduced to schools:
- The annual utility power demand per school will be reduced by 12 to 27%, resulting in a savings of 210,000 to 260,000 yen in school electricity expenses.
- When photovoltaic power generation facilities are installed at all 36,000 public elementary, junior high and high schools nationwide, the total savings will be about 8.7 billion yen annually.
- In Tokyo, for example, an annual electric generation of about 20,000 kWh per school is expected.

Notes:
1) The amount of CO_2 reduction was calculated on the assumption that solar panels (20-kW) are installed at a school of average size having a total floor space of 5,000 m^2.
2) The electric power rate of Tokyo Electric Power Co., Inc. as of July 2009 was used for calculating the electricity costs.

(4) Emergency power source

Photovoltaic power generation facilities with additional necessary equipment provide emergency power when power companies are unable to supply electricity due to damage by a large earthquake or other disasters.

By adding a power conditioner with emergency support[1], a power line exclusively for emergency load[2] and storage batteries[3] to the photovoltaic power generation facilities, electricity stored in the batteries is available for emergency load when power companies are unable to supply electricity due to disasters such as severe earthquake. The quantity of stored electricity is limited, as is the number of electric machines/devices to which emergency electricity can be supplied.

Necessary equipment:

[1] **Power conditioner with emergency support:** A device for converting DC power from solar cells to AC power. When the supply of electricity by power companies is stopped due to a disaster, this device supplies emergency power that has been stored in and is discharged by storage batteries.

[2] **Power line exclusively for emergency load:** A line used exclusively for supplying emergency power. Being independent of the power system that is usually used, this line is connected to photovoltaic power generation facilities and used when the power supply is interrupted.

[3] **Storage batteries:** Batteries used when power the supply from power companies is interrupted due to a disaster.

After a disaster, emergency power supply by photovoltaic power generation is useful for the following:
* Lighting facilities and TVs at evacuation centers
* Water supply facilities (e.g., water for drinking and showering, water purifiers and units for pumping water from swimming pools)
* Communications equipment (e.g., radios, cell-phones, computers and broadcast equipment)
* Rescue activities (in radios, etc.)

Notes:
- Whether to introduce storage batteries should be determined from a comprehensive perspective. The initial cost and the necessity for maintenance/ replacement should be taken into account. (The expected service life of a valve-regulated MSE-type lead battery is 7 to 9 years.)
- The plan for installing storage batteries must satisfy the conditions for installation sites, etc. provided in the fire prevention ordinance.
- It should be noted that the amount of electricity supplied to storage batteries varies because the output of photovoltaic power generation depends on weather conditions.
- Government subsidies are available for installing storage batteries together with photovoltaic power generation facilities.

I. Significance and Effects of Photovoltaic Power Generation at School

2. Outline of Photovoltaic Power Generation Facilities

2

Photovoltaic power generation facilities have no moving parts; thus they are clean and noiseless.

System configuration

1. Solar cell module

・Panels for converting solar energy to electric energy (DC power)

2. Mounting frame

・A frame for setting a solar cell module at a predetermined tilt angle

3. Solar cell array

・An array of solar cells. Solar cell modules are mechanically and electrically connected to mounting frames.

11. Actinometer and thermometer

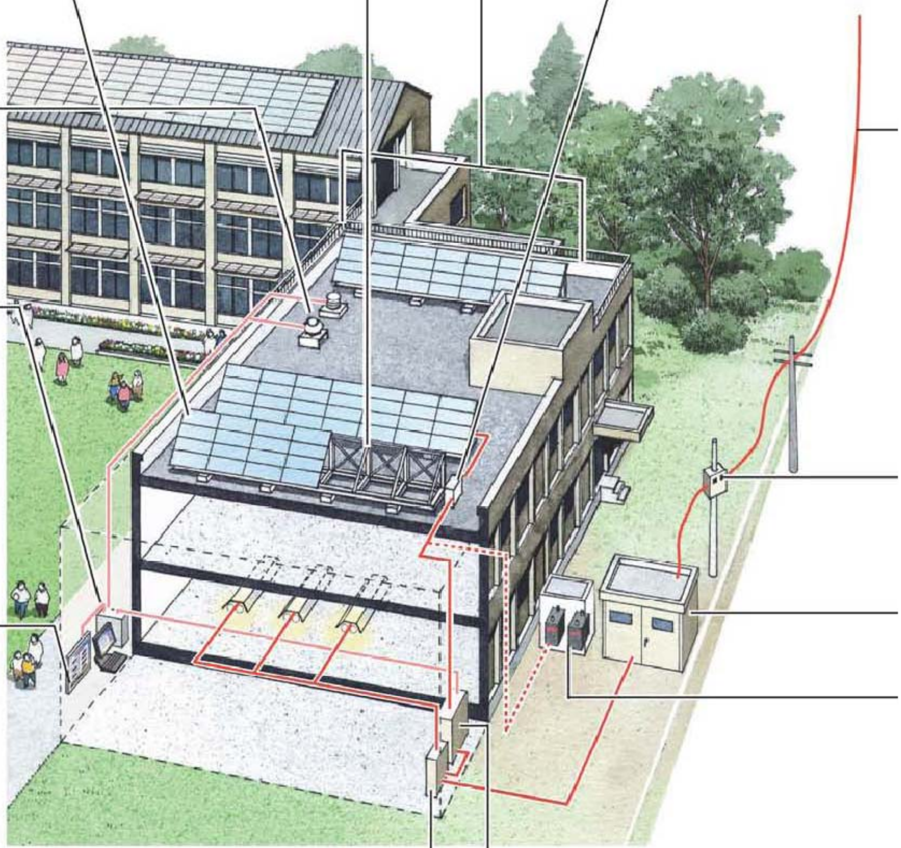
・Devices for measuring insolation and air temperature

12. Data acquisition system

・A device for collecting and recording data on the electricity that is generated. A general-purpose computer serves this purpose.

13. Display unit

・A device for displaying data that are useful for environmental education, such as the generated power, electric energy and insolation.



(yellow)	Standard equipment necessary for photovoltaic power generation
(green)	Equipment that is desirable because it is necessary for environmental education
(beige)	Existing facilities that serve the purpose
(gray)	Equipment to be installed when needed

6. Power distribution board/ switchboard

・A device for distributing power to apparatuses in the building
・In this device, the commercial power line and the power line from the power conditioner are connected.
・A built-in or separate circuit breaker is necessary exclusively for the photovoltaic power generation system.

4. Junction box

・A box for joining wires from solar cell modules which are set in blocks at multiple places
・It contains lightning arrester elements and switches used during maintenance/ inspections of solar cells as well as diodes for preventing back-flow to solar cells.
・It can be integrated with a power conditioner.

8. Commercial power line

・A line for power supply by a power company

9. Integrating wattmeter for electric power sales

・An electric energy meter for measuring the amount of surplus power for sales. (Some power companies charge sellers of surplus power for the cost of the meter.)
・The type of integrating wattmeter that is needed depends on the power purchase agreement.

10. Integrating wattmeter for electric power purchase

・An electric energy meter for measuring the amount of surplus power purchased or demanded by a power company
・A conventional electric energy meter is modified by a power company by adding a backstop.

7. Equipment for receiving and transforming electricity

・Equipment for receiving electricity via a commercial power line (6.6 kV, etc.) and transforming it, when necessary, to low-voltage power for lighting, etc.
・When electricity is received at low voltage, this equipment is not necessary.

14. Storage batteries

・Batteries for storing electricity generated during daytime hours. Stored electricity is available in the night or when power supply is interrupted due to a disaster. (A control unit for discharge/ recharge and a junction box for connecting to storage batteries are also needed.)

5. Power conditioner

・A control device for maximizing the DC power generated by solar cells as well as for converting DC power to AC power
・Some types of power conditioners, though optional, are equipped with emergency support to supply power to specified equipment when the supply of electricity by power companies is interrupted due to a disaster.

<<Features and points to keep in mind>>

Features of photovoltaic power generation

1. It is a clean method of power generation.
Because solar energy is directly converted to electric energy, no physical and chemical changes are involved, and thus no chemical substances are emitted. Having no parts that move or rotate, the generation facilities generate power noiselessly.
2. Unattended operation is possible and maintenance is easy because the facilities have no moving parts and are not operated at high temperature/ pressure.
Maintenance is easy and unattended operation is possible, although the service life of the facilities should be kept in mind. (ref. 8. Maintenance and Inspections)
3. Solar energy is inexhaustible.
Photovoltaic power generation provides energy almost perpetually, because the energy source is solar power.
4. Cell modules are suited to mass production.
Irrespective of the scale of the power generation facilities and the type of electric load, solar cell modules are manufactured in the same single process; thus, mass production is possible.
5. The power generation facilities can be designed in various sizes.
The amount of electricity generated depends on the combined area of the solar cells, but the power generation efficiency does not. The same efficiency is ensured whatever the size of the generation facilities.

Points to keep in mind

1. The output depends on the insolation.
Power is generated only during the day when the sun is shining. The amount of electricity generated is determined by the insolation, which depends on the season, the time of day and the weather conditions.
2. A large area is needed for generating a large amount of electricity.
Because the solar energy density per unit area is small, a large area is necessary for obtaining a large amount of electricity by photovoltaic power generation.
3. The cost is relatively high.
Due to the limitations of the current manufacturing technology and the production volume of the facilities, the cost of electricity generated by solar power is higher than that of commercial electricity.
4. Direct current power is generated.
Because most facilities require that the power be AC power, a power conditioner with a built-in inverter is necessary for converting DC power to AC power.
5. The appropriate tilt angle of solar cell modules should be determined to suit to each installation site, which preferably is on the south side of the building.
It is necessary to carefully determine the orientation and the tilt angle of the generation facilities, and the installation site should never be shaded.

Reference:

The expected annual output is calculated as follows:

$$Ep = H \times K \times P \times 365 \div 1$$

Ep: Expected annual output (kWh/year)
H: Annual average solar radiation per square meter per day (kWh/m^2・day)
K: Loss factor = about 73% (depending on the type of the module and whether there is dust, etc. on the light-receiving surface)
* Yearly loss due to temperature rise of the cells = about 15%
* Loss due to the power conditioner = about 8%
* Loss due to dust, etc. on the light-receiving surface and wiring = about 7%
P: System capacity (kW)
365: Days in a year
1: Solar irradiance under normal conditions (kW/m^2)
Source: "Guidebook on the Introduction of Solar Photovoltaic Power Generation," New Energy and Industrial Technology Development Organization (NEDO)

II. Key Points for Consideration in Installing Photovoltaic Power Generation Facilities

3. Process for Installing Photovoltaic Power Generation Facilities at School

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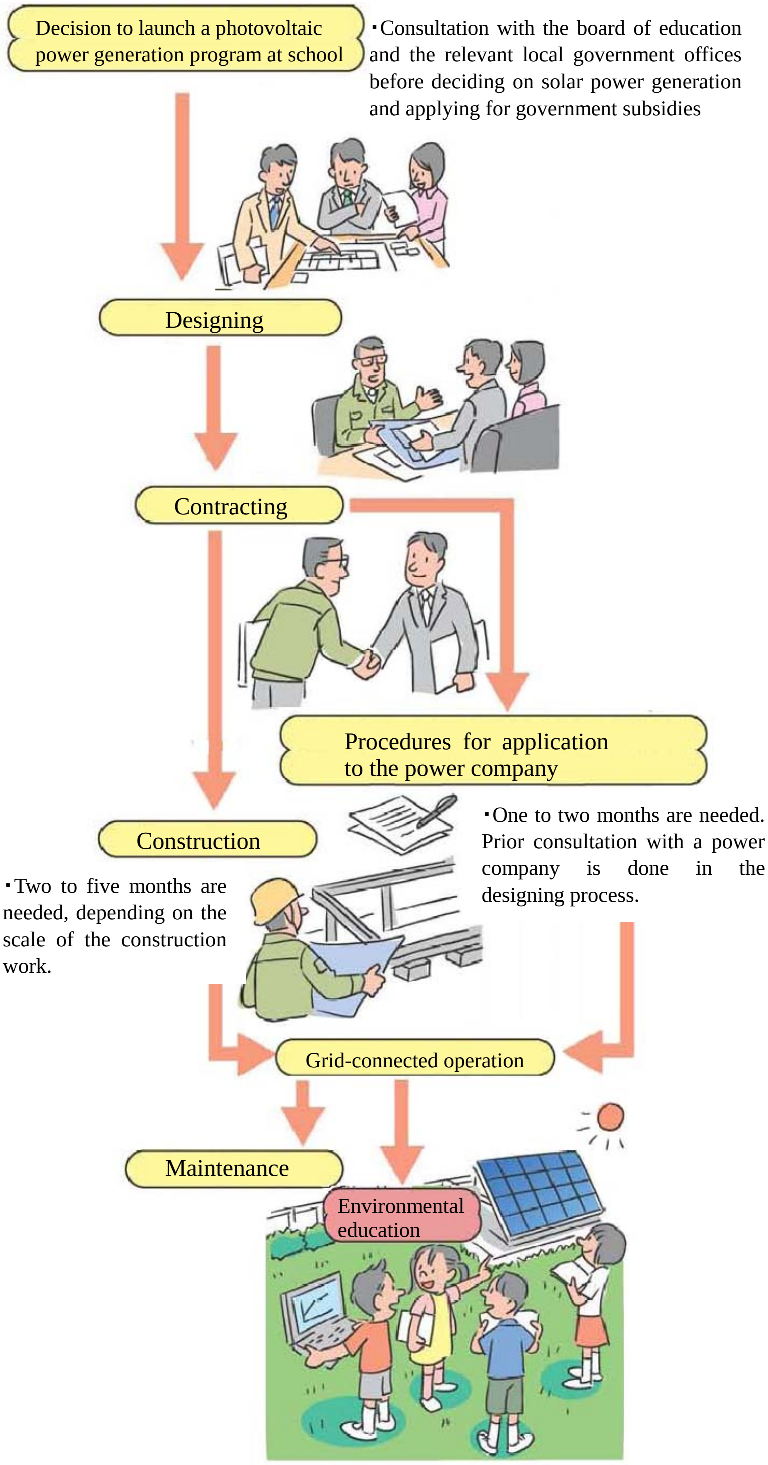
The process for installing photovoltaic power generation facilities at school is shown below. Well-planned smooth introduction should be aimed at.

Installation Process



	Major players
Decision on a solar power generation program	School authorities
Designing	Architectural office (in keeping with the intentions of the school authorities)
Contract	School authorities
Application procedures	Construction company on behalf of the school authorities
Construction	Construction company
Grid-connected operation	Power company
Maintenance	Electrical Safety Inspection Association, power company, school authorities
Environmental education	School (school authorities, manufacturers, local residents, NPOs)

Consultation with manufacturers of photovoltaic power systems and the power company supplying electricity to the region is necessary before deciding on the introduction of photovoltaic power generation facilities. When a stand-alone system is installed, no consultation with or application to a power company is required.

Details	Pages to refer to this brochure
・ Understanding the significance/ effects of the program ・ Selecting schools for installation ・ Selecting installation sites and solar cell panel capacity ・ Acquiring budget ・ Confirming installation schedule (from decision on operation to completion of construction/ cooperation with parties concerned)	・ Significance/effects →pp. 1 - 4 ・ Feasibility →pp. 9, 10 ・ Estimated construction cost →pp. 11, 15, 17, 19, 20 ・ Subsidy programs →pp. 9, 33
(Preliminary survey) ・ Technical points to be considered for environmental education ・ Verification of the structural safety of the school buildings ・ Decision on installation sites ・ Checking the surrounding conditions ・ Confirming the types of power lines/ specifications ・ Determining the installation schedule ・ (Designing) ・ Power system design ・ Solar cell array design ・ Selecting peripheral devices ・ Estimating the system cost	・ Environmental education →pp. 1 - 3 ・ Seismic resistance →pp. 12, 15, 17 ・ Installation sites →p. 9 ・ Orientation/ tilt angle →pp. 13, 15, 18 ・ Snowfall/ strong wind →pp. 21, 22 ・ Schedule →p. 10 ・ Waterproofing the roof/foundation →p. 13 ・ Array configuration →p. 14 ・ Safety of children/ students →pp. 3, 12 ・ Things to be checked →pp.27, 28
・ Contract with a construction company ・	・ Order placement, specifications, etc. →pp. 36 – 39
・ Making necessary applications to the power company ・ Making the necessary reports and applications to the relevant authorities	・ Consultation with the power company →p. 23 ・ Contract for selling surplus power →p. 23
・ Construction ・ Control of construction schedule and safety	・ Things to be checked →p. 28
・ Starting grid-connected operation	
・ Daily check ・ Periodic check	・ Maintenance →pp. 25, 26 ・ Service life →p. 26 ・ Warranty period →p. 39
・ Environmental education in cooperation with the parties concerned	・ Environmental education →pp. 1 - 3

A high-voltage grid-connected system is regarded as electric facilities for private use; thus, it is necessary to appoint a licensed electrician and to submit to the relevant authorities safety guidelines that are specific to the electric facilities. A low-voltage grid-connected system (under 20 kW) is regarded as electric facilities for general use, and it is not necessary to appoint a licensed electrician or to prepare safety regulations.

4. Items to Consider before Deciding on a Solar Power Generation Program

4

When a budget and an installation site for the solar power generation program are secured, the installation of photovoltaic power generation facilities is basically possible.

a. Selecting an installation site

First, a site should be secured for installing solar cell modules of the desired capacity.

Points to notice:

- Modules are usually mounted on the roof of a school building, but they can be also installed on the wall, the window roof or the roof of a swimming pool.
- When modules are planned to be installed on an existing school building, a building that will be used for longer than the other buildings is preferred. In that case, the service life of each building and possible elimination/ consolidation of school buildings are among the considerations.

b. Acquiring budget

The national government has ample subsidy programs for alleviating the financial burdens on local governments and private education institutions.

Points to notice:

- It is necessary to fully understand the details of the government subsidy programs available for installation of photovoltaic power generation facilities at schools. (ref. 1: Government subsidy programs)
- Subsidies provided to public elementary schools and junior high schools are also available for the following purposes: i) Waterproofing of the roof surface, building of a fence on the roof, and other work necessary for solving technical problems; ii) work necessary for implementing environmental education; and iii) repair work for energy saving executed at the same time as the installation of power generation facilities.
- The work covered and the grant rates differ depending on the type of subsidy program.

Reference:

Installation schedule

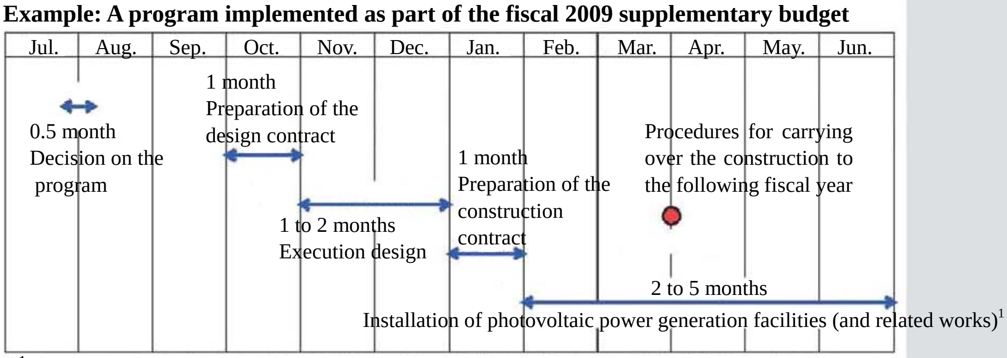
For the second time in fiscal 2009, applications for government subsidies will be accepted in autumn from those who intend to implement environment-focused renovations. Each accepted applicant will be able to enter into a construction contract within the fiscal year. It is possible for a local government to place an order for power generation facilities to be installed at multiple schools.

Points to notice:

- ●As long as the safety of children/students and of their learning environment are secured, it is possible to construct facilities not only during the summer vacation but also on weekdays by scheduling the installation of large construction materials and work involving noise and vibration on holidays/weekends.
- ●**A 10-kW system and a 30-kW system take 1 to 2 months and 3 months to install**, respectively, including installation of power generation facilities, inspections and onsite visits by the power company (not including the period for manufacturing solar cell panels, etc.).

The above-mentioned construction period does not include the time necessary for renovations that are implemented at the same time as the installation of the power generation facilities.

Example: A program implemented as part of the fiscal 2009 supplementary budget

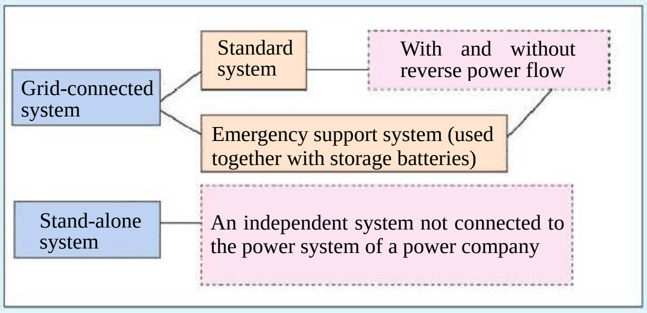


[1]Including the manufacturing lead-time (It takes 1 to 3 months to manufacture solar cell panels, although the manufacturing period depends on the cell capacity.)

Types and sizes of power generation systems

Photovoltaic power generation facilities are largely divided into grid-connected systems and stand-alone systems. The grid-connected systems include a standard type (with and without reverse power flow) and an emergency support type. The appropriate type should be selected according to the school’s power demand. The size of the facilities should be comprehensively determined on the basis of installation purpose, the space available, etc.

- ･The grid-connected systems are connected to the power system supplied by the power company, and the stand-alone systems are not.
- ･When a standard grid-connected system with reverse power flow is installed, it is possible to sell surplus power to the power company. (ref. 7: Selling of surplus power)
- ･A stand-alone system is not supplied with electricity from the power company. With this system, it is not possible for the school to sell surplus electricity to the power company.



Notes:

1) It is important to check the existing electric facilities to determine whether the power capacity of the cable connecting the distribution board to the equipment for receiving and transforming electricity is good enough for receiving power generated by the installed facilities, and whether the equipment for receiving and transforming electricity should be modified.
2) The standard grid-connected system is the most popular, and power conditioners suitable for such systems are mass produced. Thus this type of system is recommended for installation in large numbers.
3) Because there is less demand for power conditioners with emergency support (used together with storage batteries), which are suitable for use with grid-connected emergency support systems, and because only several hundred can be manufactured a year, an increase in manufacturing facilities is necessary in order for power conditioners of this type to be supplied in large quantities.

II. Key Points for Consideration in Installing Photovoltaic Power Generation Facilities

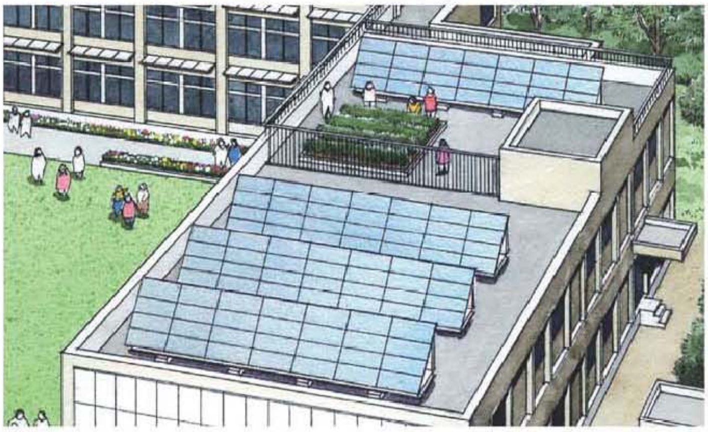
5. Check Items according to Installation Sites

5

Photovoltaic power generation facilities are designed by an architectural office that contracts with each school in consideration of the information described below*. It is recommended that school authorities also understand the same information before contracting with an architectural office.

*The points to be checked before contracting with an architectural office are elaborated below for each of the major installation sites: (1) on a flat roof, (2) on a pitched roof, (3) on a wall, (4) on window roof, and (5) on louver boards

(1) On a flat roof



Solar cell modules are installed on a flat roof of the school building. Mounting frames are necessary for tilting the solar cell panels to ensure maximum power generation efficiency. A concrete foundation may be needed for fixing the mounting frames.

a. Installation cost

An accurate cost estimate that considers the specific conditions is necessary, but the mean actual cost for constructing standard photovoltaic power generation facilities (10 kW to 30 kW) is 0.9 million to 1.1 million yen/kW*, according to a NEDO field test conducted in fiscal 2006.

*The cost does not include expenses for waterproofing and other renovations.

Investigate the costs!

- Before estimating the necessary budget, the contractor should be asked to give a cost estimate for the planned facilities.
- The costs for related work, such as for foundations, waterproofing, renovations and reinforcements, need to be budgeted separately

b. Space for installing the solar cell arrays

Roughly 10 to 15 m^2/kW is necessary for installing solar cell arrays*.

* 200 to 300 m^2 for 20-kW solar cell arrays

c. Structural safety of the building

The structural safety of the building needs to be verified in terms of the increase in load on the roof due to the installation of solar cell arrays. The verification procedures can be entrusted to an architectural office. Technical staff of school authorities may be available for verification.

Building certification* is legally required only when large-scale repairs are executed or when a building is enlarged. Such certification is not necessary for installing photovoltaic power generation facilities on a roof.

*Certification according to the Building Standards Act is required when the solar cell arrays are higher than 4 m above the surface to which they are fixed.

Check the structural performance!

- Buildings constructed pursuant to the former earthquake-resistance standards:
  When seismic reinforcement work and installation of solar cells are executed at the same time, the load of the solar cells should be taken into consideration in the reinforcement plan.
- Buildings conforming to the new earthquake-resistance standards or buildings otherwise retrofitted against earthquakes:

In addition to the load of solar cells, the load of i) machinery, such as outdoor air conditioning units, installed on the roof and ii) children/students when they have outdoor activities on the roof should be taken into consideration when verifying the structural safety of the building.

Points to notice:

The building is considered to be structurally safe when it is quakeproof, its structural calculation sheets are available, and the following conditions are satisfied:

- The foundation to which to fix the mounting frames of solar cell arrays is basically built above the girders or posts of the building
- The total load of the solar cell arrays and their foundation plus the load of i) and ii) above is less than the total live load of the roof area, namely the load used for structural calculation of earthquake load. It is also useful to set off a large increase in the load exerted by the solar sell arrays as well as i) and ii) above by reducing the load of other things (e.g., by removing the waterproof concrete, relocating heavy loads on the roof to the ground, partially removing the parapet, reducing the roof area available for live load, etc.).
- The total of the weight of the foundation to which to fix the mounting fames of the solar cell arrays and the load applied to the foundation is smaller than the design live load of the girders/posts on which the foundation is built (i.e., the live load used for structural calculation of the foundation of the girders/posts).
- Safety is secured against things falling as a result of seismic force or strong gusts of wind.

Other than in exceptional cases, evaluation by the local seismic capacity evaluation committee is unnecessary for buildings that conform to the new quake-resistance standards and for buildings reinforced against quakes.
When structural calculation sheets are not available, safety should be verified by detailed investigation.

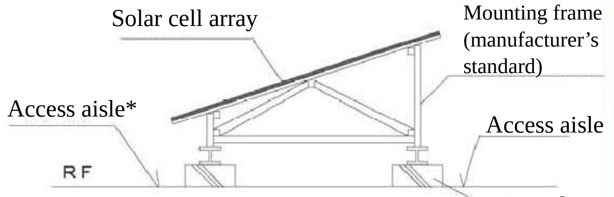
Reference:

Example: A standard frame for mounting solar cell arrays

Capacity	Weight of the arrays	Weight of the mounting frame	System load per unit horizontal projected area
10 kW	About 1.0 - 1.6t	About 1.5 −3.0t	About 25 - 50 kg/m^2
20 kW	About 2.0 - 3.2t	About 3.0 −6.0t	
50 kW	About 5.0 - 8.0t	About 7.5 −15.0t	

Notes:
1) In regions with much snow or strong winds, the mounting frame should be stronger, which increases its weight.
2) When foundation work is necessary for installing the mounting frames, the weight of the concrete foundation must be taken into account.
3) The load per unit area is significant, because the installation area depends on the installation method and the tilt angle.

Reference drawing: Array



* Access aisles are needed for inspections.

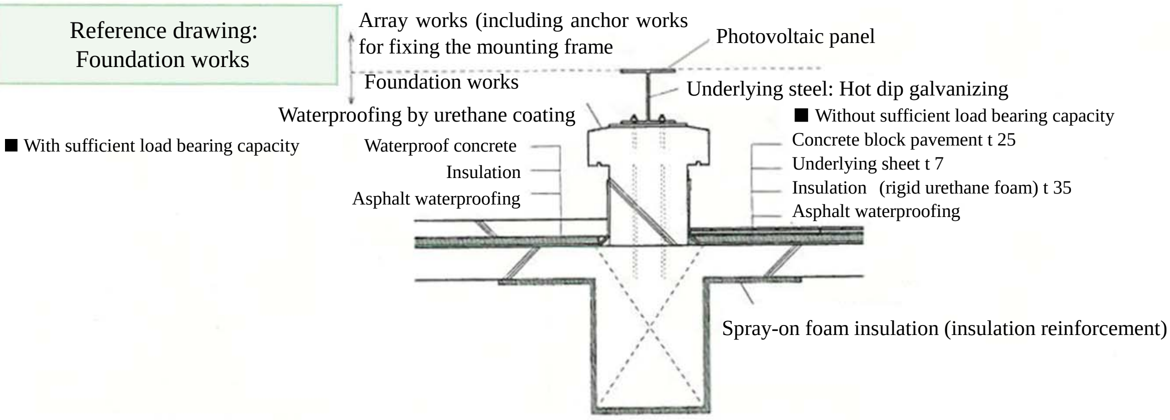
d. Foundation works and waterproof layer on the roof

The state of the waterproof layer on the roof must be checked to determine whether repairs or renovations are necessary before the foundation works are executed.

Check the waterproof layer on the roof!

- The surface of the roof is covered with a waterproof layer for preventing rainwater seepage. To start with, the state of the layer should be checked.
- The waterproof layer on the roof of an existing building must be repaired or renovated when foundation works are implemented for the installation of solar cell arrays. When solar cell arrays are installed on a newly built building, waterproofing is necessary for the roof.
- An appropriate repair technique should be chosen with consideration of the state of the waterproof layer and also of whether or not concrete is placed for protecting the roof surface.

Reference drawing: Foundation works



e. Insolation depending on the tilt angle and the orientation

For power generation, it is optimum to orient solar cell modules facing south, but they may also face the due east or west.

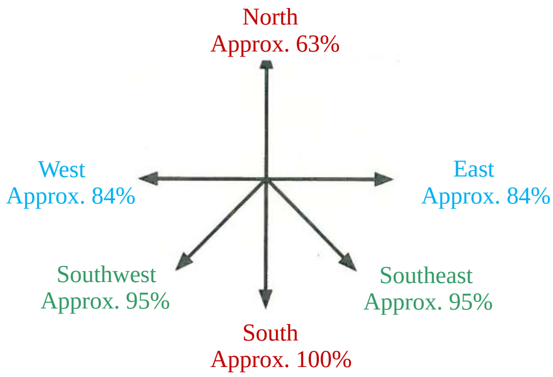
Check the tilt angle and the orientation of the modules!

- The electricity generated by solar cells is maximized when they face due south.
- The tilt angle should be about the same as the annual optimum angle at which the maximum possible amount of electricity is generated. (The optimum tilt angle differs by region, as shown below.)
- On the basis of a thorough understanding of the relationship between electricity-generating capacity and orientation/ tilt angle and in view of the ease of construction and safety, an optimum installation site should be comprehensively determined.

Annual optimum tilt angle in different cities

City	Annual optimum tilt angle
Naha	17.8
Kagoshima	27.2
Osaka	28.6
Kanazawa	25.7
Tokyo	32.0
Sapporo	35.4

Difference in electricity-generating capacity by direction



(Tokyo, a tilt angle of 30°)

Reference:

Annual photovoltaic power generation in Tokyo by orientation and tilt angle

Orientation/ Tilt angle	0 Due south	15	30	45 Southeast/ Southwest	60	75	90 Due east/west
0 (horizontal)	89.3%						
10	94.9%	94.7%	94.1%	93.0%	91.7%	90.1%	88.5%
20	98.4%	98.1%	97.1%	95.2%	92.5%	89.8%	86.6%
30	100.0%	99.5%	97.9%	95.2%	92.0%	88.0%	83.7%
40	99.5%	98.7%	96.8%	93.6%	89.8%	85.0%	79.7%
50	96.5%	96.0%	93.9%	90.4%	85.8%	80.7%	75.1%
60	91.7%	91.2%	88.8%	85.3%	81.0%	75.7%	69.8%
70	85.0%	84.5%	82.4%	79.1%	74.9%	69.8%	63.9%
80	76.7%	76.2%	74.3%	71.7%	67.9%	63.1%	58.0%
90	67.1%	66.8%	65.5%	63.4%	60.2%	56.4%	51.6%

100%: the maximum electric energy generated at a tilt angle of 30º and facing due south

f. Structures blocking sunlight (effects of shade)

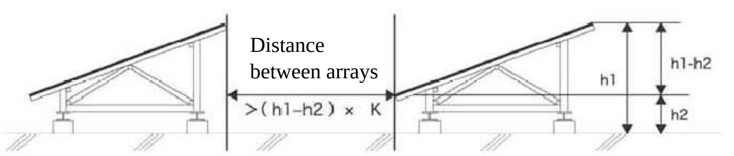
Solar cell modules shouldn’t be in the shade.

Check the shade!

- The amount of electricity generated is reduced when the solar cell modules are in the shade.
- Shadows are their longest on the day of the winter solstice.
- It may be useful to place the modules at some distance from towers, outdoor air conditioning units and other equipment on the roof to prevent these from shading the modules.
- It is also necessary to ensure a certain distance between the modules to prevent them from shading each other.

Care should be taken to prevent the front-row array from shading the back-row array.

The distance between arrays > (h1 - h2) × K

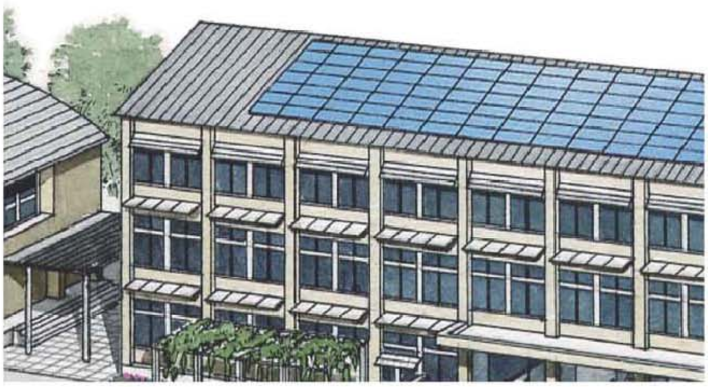


h1: Array height
h2: Mounting frame height
K: A factor depending on the region
(Refer to the table below.)

Shadow length factor K on the day of the winter solstice

City	North latitude	Solar altitude (elevation angle)	Orientation	K (a factor by which (h1- h2) is multiplied)
Naha	26°	24～25°	45～46°	1.6
Kagoshima/Miyazaki	31°	21°	44～45°	1.9
Fukuoka/Kochi	33°	19～20°	43～44°	2.1
Tokyo/Nagoya/Tottori	35°	18°	43°	2.3
Sendai	38°	16°	42°	2.6
Aomori	40°	14～15°	42°	2.9
Sapporo	43°	12°	41°	3.6

(2) On a pitched roof



Solar cell modules are installed on the sloped roof of a school building. Because the modules are fixed almost flat on the roof surface, a roof facing an appropriate direction should be chosen. Care may be needed to determine the module design in terms of color, quality of material, shape, etc., because modules on a pitched roof* are conspicuous.

*Differences from the modules fixed on a flat roof and some supplementary notes are provided below.

a. Installation cost

The cost for installing standard photovoltaic power generation facilities on a pitched roof is almost the same as that for installing the same on a flat roof, or a little lower because large mounting frames are unnecessary.

Notes:
1) An accurate cost estimate that considers the specific conditions is necessary.
2) When modules are designed to be fixed at a certain tilt angle, mounting frames tailored to the specifications may be necessary.
3) When a color or a shape different from that of standard types is ordered in consideration of appearance, the installation cost may increase accordingly.

b. Structural safety of the building

When modules are installed on an existing sloped roof, the structural safety of the building must be verified by taking into account the load of the modules because such a roof is not usually designed to bear live load.

If need arises, it may be necessary to reduce the weight of the roof by rebuilding the roof with solar roofing materials.

c. Insolation depending on the tilt angle and the orientation

It is economically efficient to install the modules on a south-facing roof and at a tilt angle equivalent to the pitch of the roof.

Notes:
1) A sloped roof on the south side is desirable.
2) Avoid a roof that is shaded by adjacent buildings or trees.
3) It is most economical to fix the modules almost flat on the roof. (Power generation is ensured with the modules set at a tilt gradient of 4/10 - 2/10 of normal roof pitches.)

d. Space for installation

When solar cell modules are installed on a flat roof, the power conditioner can be placed either outdoors or indoors. Because the power conditioner must be placed indoors for solar cell modules fixed to a sloped roof, the place of the power conditioner must be carefully determined in consideration of the routes of the electric wiring and piping that penetrate the exterior wall.

Horo Elementary School, Matsue City, Shimane Pref.
(30-kW, installed in fiscal 2004)

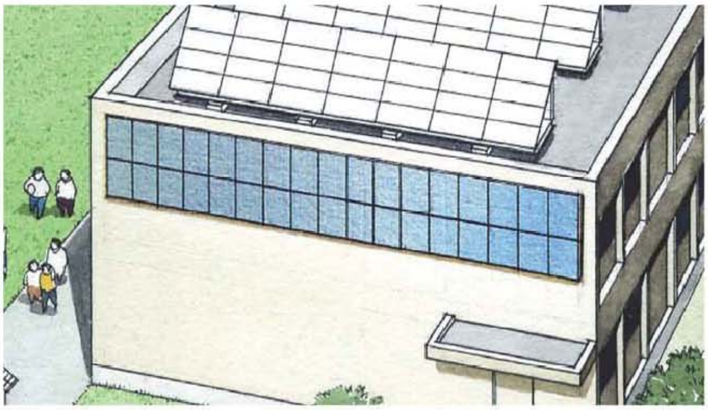
Niikura Elementary School, Wakou City, Saitama Pref.
(10-kW, installed in fiscal 2007)

Topic Types and features of solar cells

Crystal silicon solar cells have been the predominant solar cells on the market, but the market has been expanding with a variety of solar cells, including thin-film silicon, compound and organic solar cells. The table below shows the types and features of the solar cells for which subsidies are available under the support program for residential photovoltaic power generation facilities. Building Integrated Photovoltaics (BIPV) are added because they are superior in architectural design and are applicable to schools.

Types	Silicon crystal			Compound	BIPV (Building Integrated Photovoltaics)
	Crystal silicon		Thin-film Silicon	CIS (CIGS)	
Features	The oldest type; consists of monocrystal silicon cells	Consists of multicrystal silicon cells; the crystallization process costs less than for monocrystals.	A laminate of amorphous silicon film and microcrystal silicon film	A thin-film solar cell made of copper, indium and selenium	A light-transmissive module suitable for walls, connecting corridors, roofs, etc. of school buildings
Module conversion efficiency	< 15%	< 14%	< 10%	< 11%	Depends on the cell transmittance
Power generation characteristics	Power generation characteristics typical of solar cells; monocrystal cells produce a larger quantity of electricity than multicrystal cells.		Better performance in the ultraviolet light range, at high temperatures and in strong sunshine	Output capacity under a wide range of solar irradiation conditions, producing a relatively large quantity of electricity	Superior in terms of architectural design because of the power generation characteristics
Temperature characteristics	Output performance deteriorates at higher temperatures; superior low-temperature characteristics		Superior high-temperature characteristics in summer	Midway between crystal silicon cells and thin-film silicon cells	Characteristics depend on the cells that are used.
Module photos					

(3) On a wall



Solar cell modules are installed on the wall* of the school building. Standard types of solar cell modules can be used. Modules with see-through perforated solar cells or those allowing light transmission between cells can be used in windows.

*Differences from the modules fixed on a flat roof and some supplementary notes are provided below.

a. Installation cost

Standard types of solar cell modules can be used, but the installation cost greatly varies depending on the building configuration.

Notes:
1) An accurate cost estimate that considers the specific conditions is necessary.
2) Although standardized solar cell modules can be used in building walls, it should be confirmed whether the module dimensions suit the conditions of the wall in terms of height, pole span, size of wall finishing materials, etc.
3) When repair of the exterior wall is needed and the contractor is determined by tender, the contractor chooses a manufacturer for the wall materials; thus the dimensions of the wall that can be used for installation depend on the manufacturer. In this case, the installation plan should be formulated for multiple module dimensions.
4) Because the installation of the modules affects the appearance of the building, customization of the solar cell panels may be desired in consideration of their color, material quality and shape. The installation cost increases in that case.

b. Structural safety of the building

It is important to check whether the additional load on the wall will affect the structural safety of the building.

Notes:
1) Because the load added by solar cell modules is not taken into account in the design of the wall, the structural safety of the building must be verified.
2) The design of modules installed on a wall should be based on considerations of the safety of children/students, measures for preventing modules from falling at the time of earthquakes, etc.

c. Insolation depending on tilt angle and orientation

South-facing walls are desirable. On a vertical surface, the modules are basically fixed almost flat to the surface.

Notes:
1) Walls on the south side are desirable.
2) Installation on the west or the east, but not on the north, is acceptable when the installation plan requires it, although less electricity will be generated.
3) Avoid portions of the wall that are shaded by adjacent buildings or trees.
4) On a vertical surface, the modules are basically fixed almost flat to the surface, so the quantity of electricity generated is roughly half that for those fixed on a roof, etc.
5) Power generation efficiency is enhanced when modules are installed on a slightly tilted wall or on louvers.

Tamatsukuri Junior High School, Namegata City, Ibaraki Pref.
(see-through type, 1.87-kW, installed in 2007)

Higashinose Junior High School, Toyono Town, Osaka Pref.
(see-through type, 0.68-kW, installed in 2006)

(4) On window roofs

Solar cell modules are installed above windows on mounting frames*. The modules serve as window roofs and can be used as sunshades. The panel dimensions depend on the manufacturer, and modules are usually custom-fabricated.

*Differences from the similar type, i.e., modules fixed on the wall, and some supplementary notes are provided below.

a. Installation cost

The installation cost is relatively high because the solar cell modules are basically customized.

Notes:
1) An accurate cost estimate that considers the specific conditions is necessary.
2) In principle, modules installed on window roofs are different from standard solar cell modules.
3) Solar cell modules tend to be made of glass laminated with resin, which makes them impenetrable to light.
4) A module for a window roof is made of solar cells placed between two sheets of glass. The transparent resin between the cells lets light through.
5) For the reason mentioned above and also because modules need to be customized to the dimensions of sashes, the installation cost is higher than that of other module types.

Sakura Elementary School, Kitashiobara Village, Fukushima Pref.
(3.2- kW, installed in 2007)

(5) On louver boards

Solar cell modules are installed outside the windows* or any openings of the school building, serving as window shades or blinds. They are similar to the modules fixed on window roofs, in that the panel dimensions depend on the manufacturer, the modules are usually custom-fabricated, and the modules are used for shading the sun; however, these modules differ in terms of where they are installed.

*Differences from a similar type, i.e., modules fixed on the wall, and some supplementary notes are provided below.

a. Installation cost

The installation cost is relatively high, because the solar cell modules are basically customized.

Notes:
1) An accurate cost estimate that considers the specific conditions is necessary.
2) In principle, modules installed on louver boards are different from standard solar cell modules.
3) A module for a louver board is made of solar cells placed between two panes of glass. The transparent resin between cells or modules lets light through.
4) For the reason mentioned above and also because modules need to be customized to the dimensions of sashes, the installation cost is higher than that of other module types.

Ueda-Higashi Elementary School, Nagoya City, Aichi Pref.
(10-kW, installed in 2008)

6. Points to Consider with Regard to Regional Characteristics

6

Installation of photovoltaic power generation facilities should take regional characteristics into consideration.

Measures that take regional characteristics into consideration

a. Snowy regions

Solar cell modules and mounting frames should be designed to support the weight of snow covering them and to let snow that accumulates on the modules slide off naturally.

Points to notice:

- The allowable load for each solar cell module and the mounting frame should be confirmed with the manufacturer to verify that both are designed to bear the weight of accumulated snow.
- It is recommended to consider the adoption of **a tilt angle that allows accumulated snow to slide off under its own weight (50 to 60°)**, so that snow does not remain on the module surface.
- When modules are installed on a flat roof, the mounting frames should be set sufficiently high to prevent them from being buried under accumulated snow or snow that falls from the modules. Power conditioners placed outdoors should never be buried under snow, either.
- Care should be taken to prevent all equipment and structures on the roof from being destroyed by snow that falls from the modules.
- The modules and the mounting frames should be configured such that snow manually removed from the modules does not damage the frames.
- At the time of maintenance work, the modules and the frames should be checked as to whether they have been damaged or joints have been loosened by repeated accumulation and melting of snow.

Reference:

Snow load:

The average unit load of snow is 20 N/m^2 or more. (Unit load of snow: weight of snow per 1 m^2 area per 1 cm of snow depth.) It can exceed 30 N/m^2 in some very snowy regions.

- Snow load [Pa] =
  Roof slope factor × Average unit weight of snow [N/m^2] × Depth of snow [m]

- **Slope factor**

Gradient of snow-covered surface	Roof slope factor
$\leq 30°$	1.0
$> 30°$ and $\leq 40°$	0.75
$> 40°$ and $\leq 50°$	0.5
$> 50°$ and $\leq 60°$	0.25
$> 60°$	0

b. Cold regions

Anti-freezing measures are needed, because rainwater that remains on the surface of solar cell modules and other parts of the facilities can freeze in cold months.

Points to notice:

- It is recommended to use tilt angle and weep holes effectively to ensure that solar cell arrays and the surrounding area are free of water.
- At the time of maintenance, the modules and frames should be checked to determine whether they have been damaged or the joints have been loosened by repeated freezing and melting of water.

c. Windy regions

Solar cell modules and mounting frames should be designed to use materials that are able to bear high wind loads.

Points to notice:

- It should be confirmed with the manufacturer as to whether **the solar cell modules and the mounting frames are designed to bear the wind load** peculiar to the installation site. A formula for calculating the wind load is shown below. Calculation is actually very complicated, however, because various factors must be taken into account, such as the region, the installation height and the ground roughness. Thus it is recommended to request that an architectural office or the manufacturer check whether the modules and the frames are suitable for the wind conditions of the region where they are planned to be installed.
- Construction of a fence is desirable for ensuring safety during maintenance.
- At the time of maintenance, the modules and frames should be checked as to whether they have been damaged or joints have been loosened by repeated wind load.

Reference:

Wind load:

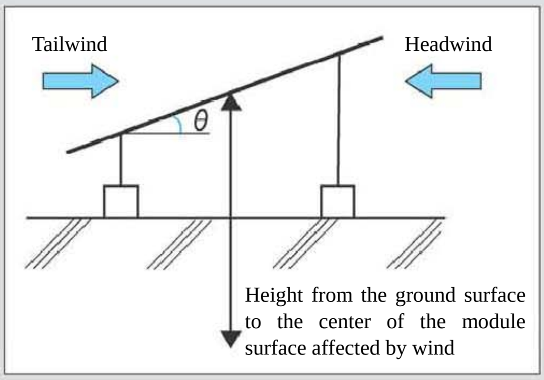
- Wind load [Pa] = Wind pressure factor × Wind pressure [N/m^2] × Area of modules [m^2]

- Wind pressure factor (when the modules are installed on a roof): Obtained by the following approximation formulae

•Tailwind (positive pressure) $0.65 + 0.009\theta$

•Headwind (negative pressure) $0.71 + 0.016\theta$

Provided that $15° \leq \theta \leq 45°$



d. Regions affected by windborne sea salt

In regions close to the shore where sea salt damage is anticipated, solar cell modules and mounting frames should be designed to be made from materials to which corrosion control measures are applied.

Points to notice:

- It is recommended that corrosion-inhibiting materials be used for building photovoltaic power generation facilities.
- Measures should be taken to avoid electrolytic corrosion caused by contact between dissimilar metals used for the facilities.
- The power conditioner and other equipment should be placed indoors where the ambient temperature does not exceed 40°C.
- A maintenance plan should be formulated to include periodic washing.

III. Sales of Surplus Power, and Maintenance

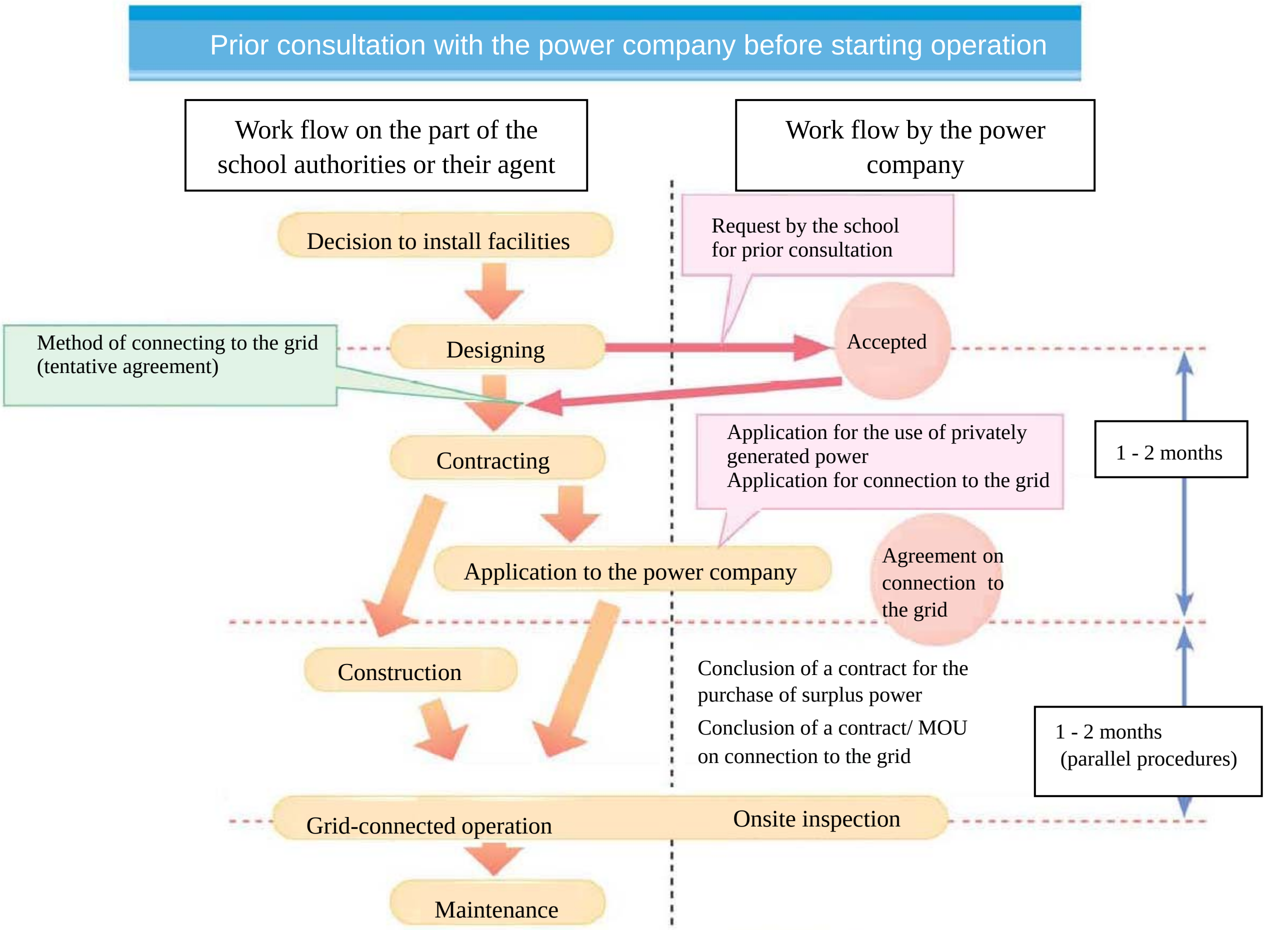
7. Sales of Surplus Power

7

Surplus power is efficiently utilized when an electric energy meter for power interchange is available. It is recommended that equipment necessary for power sales be installed when a simulation in the phases of prior survey and designing has verified the feasibility of power sales.

Examples of prerequisites for sales of surplus power:

- The photovoltaic power generation capacity is more than enough.
- Electric power is not in great demand at school on holidays and in vacation periods in view of i) the size of the school, ii) the electric power needs associated with club activities and public use of the school building (depending on the season), and iii) the use of electric air conditioners (depending on the season).



<<Surplus power interchange contract>>

School authorities wishing to sell surplus power to a power company need to consult with the company about power sales and connection to the grid and then to conclude a surplus power interchange contract with the company.

It is recommended that prior consultation with the power company about connection to the grid* be conducted as early as possible after the basic design of the power generation facilities is finalized.

*Independent consultation with the power company is needed when photovoltaic power generation facilities are connected to its utility.

Reference:

Purchase price of surplus power

The purchase price of surplus power depends on the season and the power company. Currently, the national average purchase price is 11 to 15 yen/kWh, almost the same as the price of electricity sold by power companies. An increase in the purchase price of surplus power is being considered by the national government.

●Estimated installation cost and calibration of the electric energy meter measuring reverse power flow for sales

It costs about **150,000 to 300,000 yen to install an electric energy meter that measures reverse power flow for sales.** Calibration, which every electric energy meter needs to undergo every 5 to 7 years, costs about 100,000 yen.

Notes:
1) The estimated installation cost shown above is only a rough standard, and the actual cost of installation depends on the power company.
2) Calibration may be needed every 10 years when the electric energy meter is connected to a low-voltage grid.

Topic **Applying the revenue from sales of surplus power to educational activities at school**

Not only can the electricity expenses saved by power generation at school be used effectively for environmental/energy education and other activities at school, but so can the revenues from surplus power sales. It is economically inefficient to fail to sell surplus power when such sale is feasible.

Reference: An example in the city of Kyoto (discretionary powers of schools)

1. Budget implementation

To help enhance distinctive education at school, the city allows flexible budget appropriations. Within an annual initial budget for operating expenses, each school can give priority to the programs regarded as most necessary for the school, without being bound by a ceiling that was previously set on each budget item.

2. Benefit of reduction in light, fuel and water expenses

Thanks to the flexible budget appropriations program of the city, a sum of money equivalent to the reduction in light, fuel and water expenses (as compared to fiscal 2003) has been applied to school library expenses and educational activities. This has been made possible by modifying the budget items specified in the initial annual budget during the same fiscal year.

3. Benefit of revenues from surplus power sales

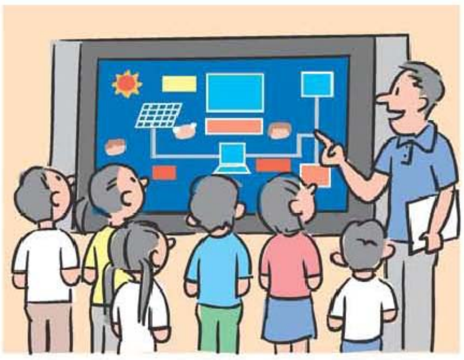
The power company pays the city of Kyoto for the surplus power that the company purchases from schools. The revenues are designated by the city as miscellaneous income. Thus, it is not possible for schools to use the revenues from surplus power sales in the fiscal year that the sales take place. The amount of revenue for each school, however, is added to the initial budget of the following fiscal year; thus, it is available for educational activities.

Reference:

Schools with good sales performance

Shiroi-Daini Elementary School, Shiroi City, Chiba Pref.
School size: 6 classes
Installed capacity: 30 kW
Annual sales in fiscal 2004: 142, 838 yen

Shibakari Elementary School, Kurume City, Fukuoka Pref.
School size: 7 classes
Installed capacity: 20 kW
Annual sales in fiscal 2007: 52,269 yen



8. Maintenance and Inspections

8

Photovoltaic power generation facilities are basically maintenance-free, but periodic visual inspections are desirable.

(1) Daily checks

Because operation of photovoltaic power generation facilities is automated, daily checks are unnecessary and there are no legal regulations for such checks. However, it is recommended that a visual inspection be conducted **once a month** for early detection of any system malfunctions as well as to maintain a constant power output. Please seek advice from the manufacturer or the contractor in the event that any malfunction is found.

Equipment	Points of visual check
Solar cell array	Dirt, dust, etc. on the surface; damage to the surface
	Corrosion or rust on the mounting frame
	Damage to external wiring
Junction box	Corrosion or rust on the outer case
	Damage to external wiring
Power conditioner	Corrosion or rust on the outer case
	Damage to external wiring
	Unusual noise/odor during operation
	Clogging in the filter of the air vent
	Surrounding conditions (no high temperature, no water)
Earth connection	Damage to wiring
Power generation	Normal power generation indicated by instruments/displays

(2) Periodic inspection

Periodic inspections should be performed by a **licensed electrician** pursuant to the operational safety programs that were prepared specifically for the facilities and submitted to the authorities concerned.

□Low-voltage system
(< 20 kW):
Voluntary inspection

□High-voltage system:
Statutory inspection
< 100 kW:
Two or more times a year
≥100 kW:
One or more times per two months

Equipment	Points of visual check	Measurement test
Solar cell array	Dirt, dust, etc. on the surface; damage to the surface	Measurement of insulation resistance
	Corrosion or rust on the mounting frame	Measurement of open voltage
	Damage to external wiring	
	Damage to earth wires, and loosening of earth terminals	
Junction box	Corrosion or rust on the outer case	Measurement of insulation resistance
	Damage to external wiring	
	Damage to earth wire, and loosening of earth terminal	
Power conditioner	Corrosion or rust on the outer case	Check of display behavior
	Damage to external wiring	Measurement of insulation resistance
	Damage to earth wire, and loosening of earth terminal	Testing of inverter protection operation
	Unusual noise/odor during operation	
	Clogging in the filter of the air vent	
	Surrounding conditions (no high temperature, no water)	
Earth condition	Damage to wiring	Measurement of earth resistance

When the safety management of a high-voltage system is outsourced, it is efficient to add inspections of photovoltaic power generation facilities to the safety management contract.

Reference:

Example of safety management fees in the Kanto region (based on data on power receiving facilities and power generation, as of June 2009)

Grid connection			Low-voltage connection		High-voltage connection		
Photovoltaic power generation facilities [System capacity (kW)]			< 20	≥ 20, > 50	< 50	≥ 50, > 100	≥ 100, < 300
Monthly fee	Power receiving facilities	Monthly fee	Voluntary inspection	7,900 yen/ inspection	Depends on the installed capacity	Depends on the installed capacity	Depends on the installed capacity
	Power generation facilities	Inspection frequency		Twice/year	Twice/year	Twice/year	Once/two months
		Fee/ inspection		4,000 yen	4,000 yen	7,900 yen	4,000 yen

- The fee may be calculated separately, depending on the facility type and other factors.
- The exact fee should be confirmed with the safety inspection association of the relevant region.
- “Power receiving facilities” means equipment for receiving and transforming electricity.

(3) System service life

The design life of equipment differs by device and manufacturer. In the course of daily operation, it is necessary to check whether each device is operating normally. The following situations may indicate the end of the service life.
a. A reduction in the power output
b. A reduction in the insulation performance (risk of earth leakage and electric shock)
The expected service life of the major equipment is roughly as follows:
・Solar cell module: **Expected service life of 20 years or longer**
・Power conditioner: **Expected service life of 10 years or longer**
- “Expected service life” means the period in which the equipment performs satisfactorily under certain conditions equivalent or quite similar to actual operation conditions. It does not mean a performance guarantee period.
The condenser capacity decreases gradually over time; thus, this part may need to be replaced in 10 to 15 years.

(4) Repairs

Periodic total replacement or repair of the system is not necessary. An inspection is needed whenever any failure or malfunction is found. In that case, it is recommended that only the defective part be replaced or repaired.

Topic **Worry-free use of photovoltaic power generation facilities**

Insurance plan

Property insurance is available for photovoltaic power generation facilities for institutional use. It is desirable to choose an insurance plan that suits the regional characteristics. Almost all movable property owned by a corporate body, including equipment, manufactured goods and office machinery, can be covered by insurance.

Property insurance covers the following:

a. Damage or loss by fire, lightning, burst pipes and explosion
b. Damage or loss by a wind, hail or snow disaster
c. Damage or loss by water (e.g., inundation above floor level)
d. Theft (e.g., theft of a computer)
e. Damage or loss by electric fault (e.g., short circuit)
f. Damage or loss by mechanical failure
g. Other one-time accidents

Coverage examples:

・Snow disaster: A module and part of the facilities fall away due to accumulated snow.
・Damage by a one-time accident
・Damage by water: Data measuring equipment become inoperative due to heavy rain.
・Damage by wind or water disaster: A mounting frame bends and the module is damaged by typhoon.
・Damage by lightning: Measuring equipment burns out due to lightning.
・Damage by lightning: A power conditioner is damaged by lightning.

Note that wear/deterioration from everyday operation and breakdown resulting from earthquake, tsunami or eruption are not covered.

9. Checklist for the Entire Process from Planning to Maintenance

9

Please use the check items shown below to adequately follow the procedures from planning to maintenance.

The following points need to be checked at each phase in the introduction of photovoltaic power generation facilities to schools.

(1) Decision of installation

Consideration of installation sites

□Where will the photovoltaic power generation facilities be installed? Have studies been conducted to narrow down candidate buildings and specific sites in those buildings? Will the facilities be installed on a new building or on an existing building?
 * Priority should be given to a building having a longer service life.

□What will be the power output level? Is it possible to secure a space large enough for installing the facilities needed for that output level?

□Are the procedures in place for applying for subsidies to MEXT, METI and the Ministry of the Environment?

□Has the schedule been confirmed with regard to the entire process from the start to the completion of construction?

□Have consultations been under way with and within the relevant local governments and the board of education?

(2) Designing

An architectural office is responsible for designing, but those involved with the establishment of the school should also check the following:

Arrangements for installation

□Have the necessary arrangements been made?
- □Have members been selected from the school for an installation project team?
- □Has the method for selecting a contractor been decided?
- □What will be the bidding method?
- □When will the power generation facilities be installed, and what will be the installation costs?
- □How will the facilities be maintained? Is a licensed electrician necessary, or will maintenance be outsourced?

Preliminary surveys

<Environmental Education>

□Are there concrete plans for the use of the power generation facilities in environmental education?
- □According to the details of environmental education, necessary technical matters will be checked (from the viewpoint of safety, use of the facilities, etc.)

<Structural safety of the existing building>

□When the generation facilities are built on a building conforming to the former quake-resistance standards, an aseismic reinforcement plan should be prepared in consideration of the load added by solar cells and other equipment.

□When the generation facilities are built on a building conforming to the new quake-resistance standards or one that has already been reinforced, structural calculation sheets should be used to verify the safety of the building.

<Surrounding conditions>

□Has it been checked as to whether there are structures shading the sun?
- □The surrounding conditions will be checked to see whether the power generation facilities will fall under the shadow of a building, a tree, a mountain, a chimney, a utility pole, a steel tower, a signboard, etc., and whether fallen leaves/dust may accumulate on the surface of the facilities.

□Has the depth of snow been checked?
- □The depth of snow accumulation should be checked (particularly in a snowy region).

□Has any possible damage by sea salt, lightning, wind, etc. been checked?
- □Potential factors for damage to the power generation facilities will be checked in order to select an appropriate installation site and to determine design specifications accordingly.

<Installation site>

□Have the conditions of the building for installation been checked?
- □The shape, dimensions, orientation and the surrounding conditions of the installation site should be checked.
- □The structure and waterproofing of the floor, as well as the direction/gradient of the drainage piping, should be checked.
- □Routes for carrying in materials and other conditions for construction works should be checked.
- □The visual effects/ appearance of the solar cell arrays should be checked.
- □The safety of pupils/students while they are using the power generation facilities for environmental education should be checked.

□Have the conditions of the installation site on the ground been checked (when installation on the ground is planned)?
- □The shape and the orientation of the site, surrounding conditions, drainage, ground condition, necessity of groundwork, and routes for carrying in materials should be checked.
- □The safety of pupils/students while they are using the power generation facilities for environmental education should be checked.

<Electric facilities>

□Has the current state or the construction plan of electric facilities been checked?
- □Onsite review should be done on the basis of electric system diagrams and equipment layout plans.
- □What kind of system will be installed? A grid-connected system with or without reverse power flow, or a grid-connected system with emergency support which necessitates use of storage batteries?
- □Is it possible to secure a place for installing peripheral equipment and storage batteries?
- □When an existing building is used for installation, is it possible to secure routes for wiring and piping?
- □Is a route available for carrying in equipment?
- □Is the power capacity acceptable by the main cable connecting the distribution board and the equipment for receiving and transforming electricity?
- □Does the power generation capacity make it necessary to modify the equipment for receiving and transforming electricity?

Prior consultation

□Have the necessary consultations been conducted?
- □To determine legal requirements, advice should be sought with the Building Guidance Division of the local government, the fire department and other authorities concerned, as necessary, with regard to the details of the power generation plan and necessary applications.
- □MEXT, NEDO and other agencies that subsidize photovoltaic power generation projects should be consulted with regard to the outline and the implementation schedule of their subsidy programs.
- □When necessary, advice should be sought with the power company about grid connection.
- □When necessary, advice should be sought with architectural offices/consultants that are experienced in designing of photovoltaic power generation facilities. Information should be gathered from manufacturers.

Interim verification

□Is the installation plan almost finalized with regard to the building for installation, the installation site, the electric load, the power output level, the system type, etc.?

□Is there a consensus on the timing of installation as well as on the entire schedule?

□Have the electric-generating capacity and the costs been estimated? Has a draft budget been assembled?

Clarification of the designing conditions

□Have the basic principles of designing been finalized?
- □Have the specifications of the devices for data display/collection been finalized?
- □Where will they be installed?

□Is information shared by all parties concerned, including school authorities and officials?
- □What will be the electricity-generating capacity?
- □What kind of system will be installed?
- □When will the generation facilities start operation?
- □What is the budget size?

□Regarding the following, are the designing conditions clear?
- □Surrounding conditions
- □Conditions of the installation site
- □Current state of the electric facilities
- □Legal conditions
- □Conditions for necessary application procedures

Review and execution of designing

□Are the orientation and the tilt angle of the modules optimum? (Both should facilitate generation of as much electrical energy as possible.)

□Are the configuration and the installation method of arrays optimum?

□Are the foundation and the mounting frames designed adequately on the basis of strength calculation?

□When foundation works are necessary to install mounting frames on an existing building, will the waterproof surface of the installation site be appropriately repaired?

□Regarding the mounting frames, have the quality of the materials applied and anticorrosion/antirust measures been checked?

□Will the power generation facilities be sufficiently protected with a good offset distance from a lightning protection system?

□Are the earth connections appropriate in view of the technical standards applied to electric facilities?

□Is a power source secured for measuring/display devices?

□Regarding the power conditioner, has it been checked as to whether its installation site and measures against high temperatures are optimum?

□Is a lightning arrester (surge protection device: SPD) necessary?

□Have legal regulations and requirements been checked?

□Do the details of the designing conform to the aim of the installation of the power generation facilities?

□Are the selected peripheral devices, their installation sites and their surrounding conditions appropriate?

□Have enough measures been taken to ensure the safety of pupils/students?

□Has an installation schedule been prepared? Have the electric-generating capacity and the costs been estimated?

Application procedures

□Have the necessary applications/ notifications been submitted to the authorities concerned (e.g., director of building and safety) regarding building certification, notification on facilities plan, etc?

□Regarding the following, have the necessary consultations with the power company been completed?

□Request for prior consultation with the power company regarding grid connection

□Application for/ agreement on grid connection (MOU on grid connection, surplus power interchange contract, etc.)

Conclusive confirmation

□Have the principal budget and the installation schedule been finalized?

□Have all necessary applications been submitted to the authorities concerned and to the power company?

□Has a construction contract been signed with a contractor selected by appropriate tender procedure?

(3) Construction and maintenance

Construction is executed by a contractor, but the school authorities and those involved in establishing the school should also check the following:

Construction

□Adequate measures have been taken to keep pupils/students safe during construction.

□There is an appropriate system in place for supervising the construction and safety measures.

□Information has been shared about the commencement and the progress of each construction process.

□The contractor has filed applications and submitted notifications as appropriate.

□Completion inspections have been conducted properly.

Notification

□An application has been filed with the Bureau of Economy, Trade and Industry regarding appointment of a licensed electrician approval for exemption from appointment.)

□The operational safety programs, which had been prepared before the start of the construction works, were submitted to the Bureau of Economy, Trade and Industry before starting the operation of the facilities.

Management

□Necessary arrangements have been made and budgetary measures have been taken for implementing daily and periodic checks.

□When applicable, a business trust agreement has been made with the local safety inspection association or the power company for entrusting safety management to the association or the company.

Conclusive confirmation

□The construction works were executed adequately. (The adequateness of the photovoltaic power generation system was verified by completion inspections.)

□An application has been filed for approval of the appointment of a licensed electrician or for exemption from this, and operational safety programs have been submitted to the authorities concerned.

□Appropriate programs for maintenance and safety management are in place.

10. Various Photovoltaic Power Generation Facilities at School

10

(1) Installation of photovoltaic power generation facilities for the benefit of environmental education

Environmental education promoted in everyday life

(Kanamachi Elementary School, Katsushika Ward, Metropolitan Tokyo)

An outline of the photovoltaic power generation facilities at school

- School size: 12 classes
- Installed photovoltaic power generation capacity: 2.3 kW
- Installation site: roof
- Orientation and tilt angle: Due south, 30°
- Year of installation: Fiscal 2006
- Characteristics:

In addition to photovoltaic power generation facilities, wind power/ photovoltaic hybrid power generation facilities, a biotope and a lawn-covered schoolyard are effectively utilized for environmental education. Photovoltaic power is consumed in a limited area in the school, and pupils can see on a display how much purchased power and generated power are consumed in that area.

Solar cell module facing south, fixed at a tilt angle of 30°

Wind power/ photovoltaic hybrid power generation facilities: Wind power is used on cloudy/rainy days.

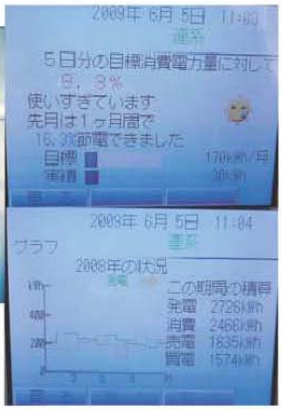
Use of photovoltaic power generation

The power lines in this school are divided between those for purchased power and those for photovoltaic power. The latter is consumed by lights installed in the main entrance and the corridors on the first and second floors on the north side of the building. The power consumption of the lights in these places is shown regarding both purchased energy and generated energy. Because the number of lights involved is limited, pupils can tell easily how many fluorescent lamps are being powered by the energy generated at school.

Efforts for environmental education

Because information and reports on environmental efforts are posted at various places in the school, both pupils and teachers have become more interested in natural energy, being more aware of the importance of energy/resource saving. As part of the continued efforts for encouraging children to learn more extensively about environmental issues as well as for fostering children who are considerate and value natural environment, a brochure for environmental education was prepared and the school has been working together with pupils' families in promoting environmental education.

Purchased energy and generated energy are shown.

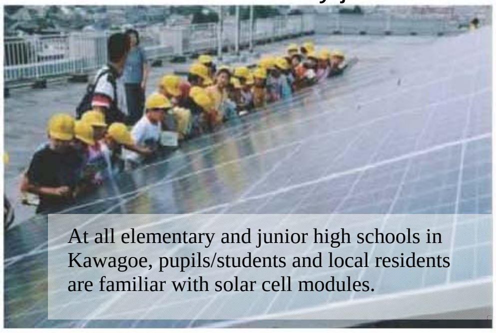


A brochure is available, and information on the environment is posted at many places in the school.

(2) Installation at every municipal elementary/ junior high/special needs school in a city

Municipal cooperation and coordination
(The City of Kawagoe, Saitama Prefecture)

An outline of the photovoltaic power generation facilities at all elementary/junior high special needs schools in the city



At all elementary and junior high schools in Kawagoe, pupils/students and local residents are familiar with solar cell modules.

- ●Number of schools in the city: 33 elementary, 22 junior high, 1 special-needs
- ●Installed generation capacity:
  3 kW: 31 elementary schools and 22 junior high schools
  10kW: 1 elementary school and 1 special-needs school
  30kW: 1 elementary school
- ●No. of schools installed: FY 1998: 1; FY 1999: 1; FY 2000: 10; FY 2001: 16; FY 2002: 15; FY 2003: 12; Fiscal 2006: 1
- ●Characteristics:

Most of the schools that installed a 3-kW system used their existing buildings for installation. 10-kW systems were installed concurrently with renovations of buildings at two schools. A 30-kW system was installed in a school when it was rebuilt as part of a complex, which was built also for a community hall and a library that were relocated from elsewhere. The small 3-kW systems were installed in large numbers because their capacity, being the same as that of the system used at home, was considered to be useful for providing environmental education to children and for raising local residents' awareness of photovoltaic power generation.

Background of the installation at all elementary and junior high schools

In fiscal 1996, the City of Kawagoe launched a 1% power saving campaign with the aim of using the financial resources that were saved through the campaign for the benefit of the citizens. Since then, the city has been working on various measures and policies for curbing global warming. For the purpose of enhancing local residents' awareness of environmental conservation and of promoting environmental education to school children, the city decided to install photovoltaic power generation facilities at a greater number of public facilities, and finally established a policy of "installing photovoltaic power generation facilities at every newly built public facility as well as at all public elementary and junior high schools because of the importance of such facilities for environmental education." The plan for installing the facilities in all schools was implemented successfully and was completed in 2006.

The four-year plan and priorities for installation

The city formulated the "plan for promoting regional introduction of new energy." Based on the plan, photovoltaic power generation facilities were intensively built at all municipal elementary and junior high schools in the city over the four years from fiscal 2000 to 2003. To implement the plan efficiently, it was decided that i) photovoltaic power generation facilities would be installed concurrently with the repair and waterproofing works that had been separately planned, and ii) installation would take place at various places in the city within each fiscal year, so that local residents would be exposed to and informed of the photovoltaic power generation facilities.

Installation costs

The costs were borne solely by the city only for the facilities installed at the two schools in fiscal 1998 and 1999. The installation of 3-kW systems at the other 51 schools was approved as a regional project that ensured scheduled installation in the entire city area; thus, it was implemented under a grant from the NEDO Project for Promoting the Local Introduction of New Energy.* The two schools that installed the facilities concurrently with relocation or renovation of school buildings were certified under Eco-school Pilot Model Project, and they were subsidized by the NEDO Field Test Project on New Photovoltaic Power Generation Technology. In fiscal 2003 and 2006, subsidies were also available from the Green Power Fund of Greater-Kanto Industrial Advancement Center (GIAC).

*In fiscal 2009, subsidies were provided by the New Energy Promotion Council.

Cooperation and coordination among the municipal government's departments

Roles were shared by multiple departments in the municipal government to make all-out efforts for promoting the installation project. For example, the board of education made various arrangements with each school and took budgetary measures, the Construction Department was responsible for installation works, and the Environment Department applied for subsidies/grants.

Left:Tsukigoe Elementary School, Kawagoe, Saitama Prefecture (A 10-kW system was installed when the building was renovated.)

Right:Kasumigaseki-Kita Elementary School, Kawagoe, Saitama Prefecture (A 30-kW system was installed when the school was relocated and renovated.)

(3) Efficient use of the roof of a gymnasium for installation

(Senrigaoka Elementary School, Tsu, Mie Prefecture)

- School size: 20 classes
- Installed photovoltaic power generation capacity: 10.4 kW
- Year of installation: Fiscal 2005
- Annual output: 12,200 kWh
- Characteristics:

The solar cell modules installed on the roof of the gymnasium are made of amorphous silicon, and no glass is used on the surface. This material fits well with the vaulted roof and is superior in visual appearance.

The electric energy generated is displayed at conspicuous places in the shoe locker area for pupils and at the entrance for visitors, so that the effects of environmental education using the photovoltaic power generation facilities will spread to local residents.

Solar cell modules on the roof of a gymnasium

(4) Effective use of an open area on the roof of a parking lot

(Tomari Elementary School, Yurihama, Tottori Prefecture)

- School size: 10 classes
- Installed photovoltaic power generation capacity: 20 kW
- Year of installation: Fiscal 2004
- Annual output: 15,700 kWh
- Characteristics:

The open space on the roof of a parking lot is effectively used for installing solar cell modules.

The electricity generated is used to power fluorescent lamps and is displayed on a unit placed beside the school gate; thus, pupils can tell at a glance that electricity is generated each day and that they benefit from it.

Solar cell modules on the roof of a parking lot

(5) Solar cell modules serving as eaves

(Kobayashi Elementary School, Kobayashi, Miyazaki Prefecture)

- School size: 23 classes
- Installed photovoltaic power generation capacity: 5 kW
- Year of installation: Fiscal 2006
- Annual output: 6,000 kWh
- Characteristics:

Solar cell modules serve as eaves. They help to curb a rise in the indoor temperature by protecting classrooms from direct sunlight in summer; thus, they improve the school environment.

A unit for displaying the electricity generated is placed in the entrance and used for environmental education for pupils.

Solar cell modules serving as eaves were installed on an existing school building.

(6) Installation without mounting frames

(Nakajima Junior High School, Matsuyama, Ehime Prefecture)

- School size: 4 classes
- Installed photovoltaic power generation capacity: 10 kW
- Year of installation: Fiscal 2006
- Annual output: 13,500 kWh
- Characteristics:

Installation of the solar cell modules on a roof without mounting frames helped to reduce the load on the roof.

A unit for displaying the electricity generated is placed inside the school building for use in environmental education, and surplus power is purchased by a power company.

Mounting frames were not used, even though the roof is almost flat

(7) Installation with the roof pitch as the tilt angle

(Oshima Elementary School, Inagawa, Hyogo Prefecture)

- School size: 7 classes
- Installed photovoltaic power generation capacity: 10 kW
- Year of installation: Fiscal 2006
- Annual output: 11,300 kWh
- Characteristics:

The tilt angle of the solar cell modules is the same as the roof pitch. A unit for displaying the energy generated is placed in the entrance so that children are always aware of the power generation at school. They learn about the characteristics of solar cells, including seasonal changes in the power output, through year-round observation of photovoltaic power generation. Surplus power is sold to a power company.

Solar cell modules installed almost flat on a pitched roof

Topic Long-range outlook for CO_2 reductions according to different scenarios at school

The Action Plan for Achieving a Low-carbon Society approved in a Cabinet meeting on July 29, 2008, aims at reducing CO_2 emissions by 60-80% by 2050 as compared to the current emissions level. CO_2 emissions from school facilities in 2050 were estimated according to various scenarios. In comparison with the emission level in 1990:

a. CO_2 emissions will increase by 10% when only standard energy-saving measures are taken; and

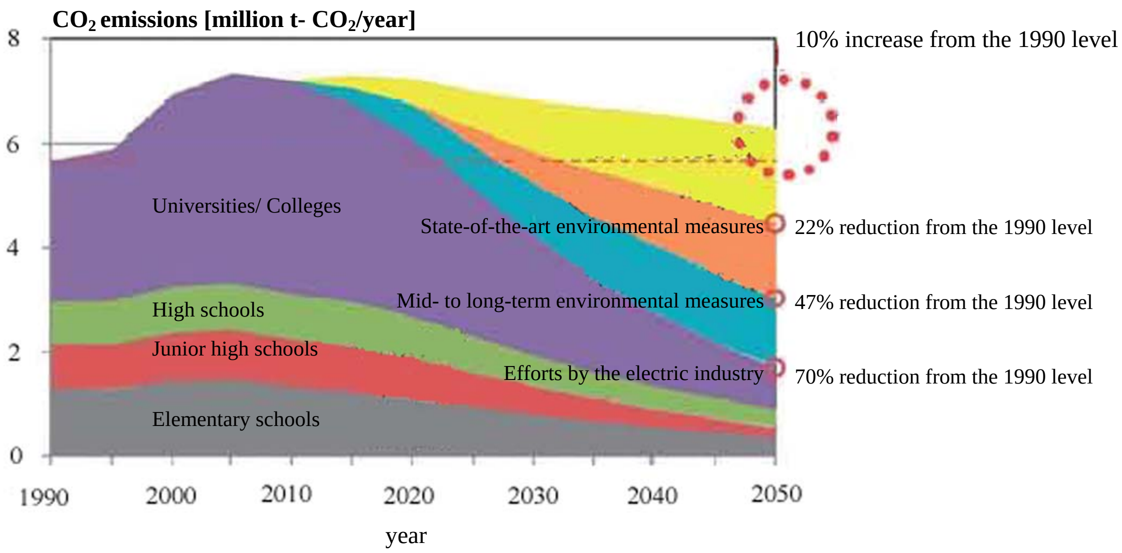
b. A significant reduction in the CO_2 emission will be possible when state-of-the-art environmental measures, future environmental measures which will be made available by technological innovations, and efforts by the electric industry are combined with energy-saving measures. (There are many factors, including cost, to consider.)

An outline of various environmental measures

	Scenario	Description
1	Maintenance of the Status Quo	Underuse of insulation, energy-saving devices, renewable energy, etc.
2	State-of-the-art environmental measures	Use of daylight, insulation, energy-saving devices, renewable energy, etc.
3	Medium-to-long-term environmental measures (facilitated by technological innovations in the future)	Use of daylight, super insulation and high-efficiency energy-saving devices, and increased use of renewable energy, etc.
4	Efforts by the electric industry	Reduction of CO_2 emissions per unit of output through efforts by power companies

To increase the use of renewable energy, it is critical to promote installation of photovoltaic power generation facilities in as many schools as possible.

・The estimates shown above are included in the *Policy regarding the Promotion of Environmentally Friendly School Facilities (eco-schools): The Role of Schools within a Low-Carbon Society* (final report prepared by Prof. Ikaga in March 2009) of MEXT.



Estimated CO_2 emissions from school facilities

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