

# Collection of Case Examples of Renewable Energy Utilization in School Facilities

**-Thermal Utilization-**  
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School Facility Environments

# Introduction

Global warming is one of the most important issues that require all-out efforts of countries around the world; it is necessary to further promote measures to create a low-carbon society.

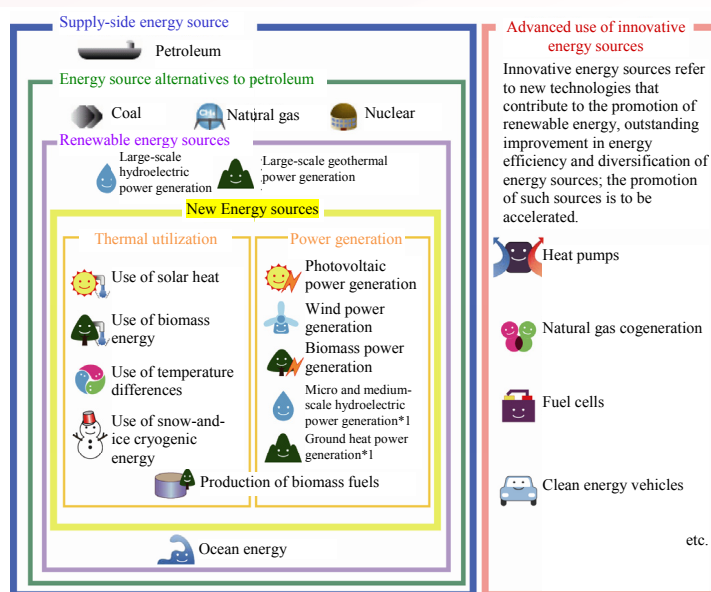
Against this backdrop, the Great East Japan Earthquake occurred in March 2011 and the electricity supply was greatly reduced after the disaster. Because greater energy-saving efforts are required also in school facilities, it is necessary to further promote the equipping of environmentally-conscious school facilities (eco school), including existing facilities.

In this collection we studied combinations of various renewable energy technologies that would enable the use of school facilities as an emergency evacuation center even when the commercial power supply stops due to power outage in time of disaster, and then we organized renewable energy technologies for thermal utilization. In addition to the outline, features and necessary points, we indicated in case examples the amount involved in the development, maintenance, management, etc. as well as evaluation of effects including improvement in CO<sub>2</sub> emissions and the indoor environment. We hope that this collection will be a useful point of reference for all those involved in establishing schools, when they work on utilization of renewable energy in the future.

## Definition of renewable energy

Definition of renewable energy is defined in the Act on the Promotion of New Energy Usage (hereafter the “New Energy Act”) as shown in the figure on the right.

Among renewable energy technologies, this collection introduces thermal utilization, including the use of ground heat (temperature difference), snow-and-ice cryogenic energy, biomass energy, and solar heat.



Note 1: The only ground heat power generation system that is categorized as a New Energy source is the binary cycle power system; the only hydroelectric power generation systems that are categorized as New Energy sources are those that use waste hydraulic recourses and have an output of 1,000 kW or less.  
Source: NEDO

## Renewable Energy Uses

Type (thermal utilization)			Method of uses
	Use of ground heat	P2	Ground heat energy is used for air-conditioning with heat exchangers or heat pumps, or for ventilation by transferring indoors the air that is warmed or cooled at shallow depths underground.
	Use of snow-and-ice cryogenic energy	P5	Cryogenic energy derived from snow or ice is used for air-conditioning.
	Use of biomass energy (pellet stove)	P8	Wood pellets made from waste wood, forest trimmings, etc. are used as fuel for heating.
	Use of solar heat	P11	Solar heat is accumulated by rooftop collectors, etc. for use in water heating and air-conditioning.

# Facilities using ground heat

## Outline

Methods using ground heat include: a method to send outside air to an underground space and heat or cool the air before introducing it to indoor spaces, and a method to use circulating water or ground water as a heat source or sink for a heat pump.

Considering possible use in time of disaster, the first method, which is less dependent on equipment, has an advantage. This system employs a cool/heat trench (underground trench), etc. using an underground beam space to let outside air pass underground, where the temperature is stable throughout the year, and supply the facilities with cooler air in summer and warmer air in winter.

## Features/Necessary points

For use of ground heat, it is necessary to maximize the area of contact between the underground space and the introduced air in order to reduce frictional resistance and fan capacity, while at the same time lowering the air speed to maximize the time of contact. Iwate Prefectural University has installed a cool/heat trench of 1.8m (w) × 1.2m (h) × 60m (l) for 3,600–7,800m<sup>3</sup>/h of introduced air.

The temperature of ground deeper than 10m is roughly the same as the annual mean outdoor temperature of the area. Use of ground heat is more effective in areas with large temperature differences throughout the year and in areas with a continual supply of ground heat from other places through underground water, for example.

If the ground-water level is high, introduction of humid ambient air to an underground space might cause dew condensation and germination of mold. It is necessary to ensure humidity measures, hygiene control in the trench and regular services throughout the year, which may include installation of bactericidal lamps, drainage of condensation water and use of charcoal.

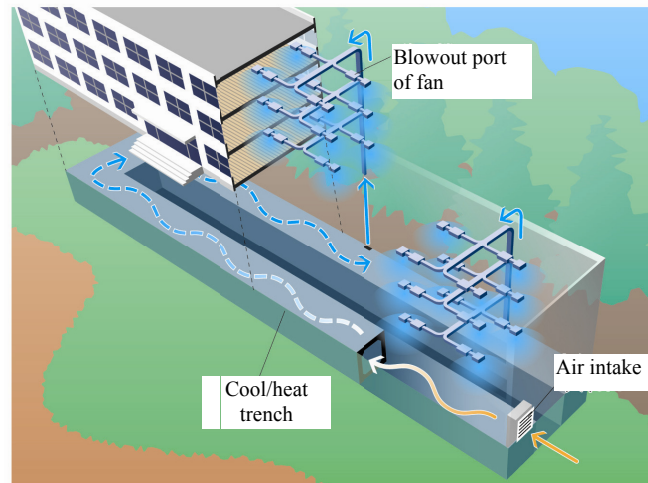
## Necessary planning points considering operation in time of disaster

In order to make ambient air pass through at a low speed using a cool/heat trench that utilizes an underground beam space, it is necessary to operate a fan. To ensure the supply of ambient air through the cool/heat trench even when the commercial power supply stops in time of disaster, etc., it is necessary to install photovoltaic power generators, storage battery, etc. to supply power to the fan.

Furthermore, because it is required to reduce electricity consumption at times of normal use, it is also important to plan and design a system that generates air movement throughout the entire building through ventilation caused by temperature difference by installing a solar-assisted natural ventilation system\* for example. The method of solar-assisted natural ventilation is effective also in time of disaster because it does not need a fan.

\*A system of natural ventilation to create an updraft in a passage of air such as chimney using solar heat

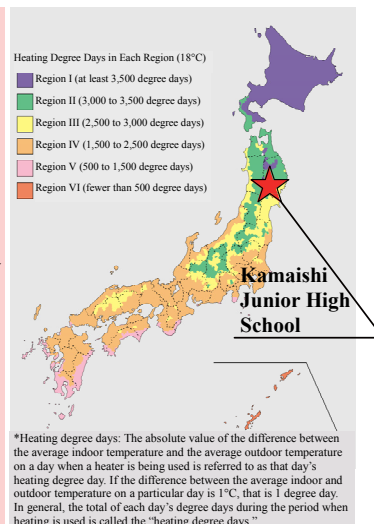
Main application	New construction	Refurbishment
The method is suitable for new construction because the installation of underground trenches requires extensive work and it requires a plan involving the entire building, considering ventilation caused by temperature differences.		



Schematic of the standard cool/heat trench method

## Installation example

School name: Kamaishi Junior High School, Kamaishi City, Iwate Prefecture  
 Major equipment: Ground heat utilization system  
 Number of classes: 14 including 2 special-needs classes  
 Number of students: 426 including 6 special-needs students  
 Capacity: Air volume: approx. 10,000 m<sup>3</sup>/h; ventilation rate: 0.7 times/h  
 Use of devices: For air-conditioning and ventilation of the classrooms on the 2<sup>nd</sup> to 4<sup>th</sup> floors of the school building, Media Garden, a multipurpose space, management offices on the 1<sup>st</sup> floor, a lounge, a memorial hall, an arena, a martial arts training space (3,870 m<sup>2</sup>), etc. (total area of the school buildings: 6,392 m<sup>2</sup>; gymnasium: 1,556 m<sup>2</sup>)  
 FY of installation: FY2006  
 Time for completion: Review: November 2002 to June 2003  
 Design: October 2003 to March 2004  
 Construction: September 2004 to March 2006  
 \*The time for completion includes the time for new construction.



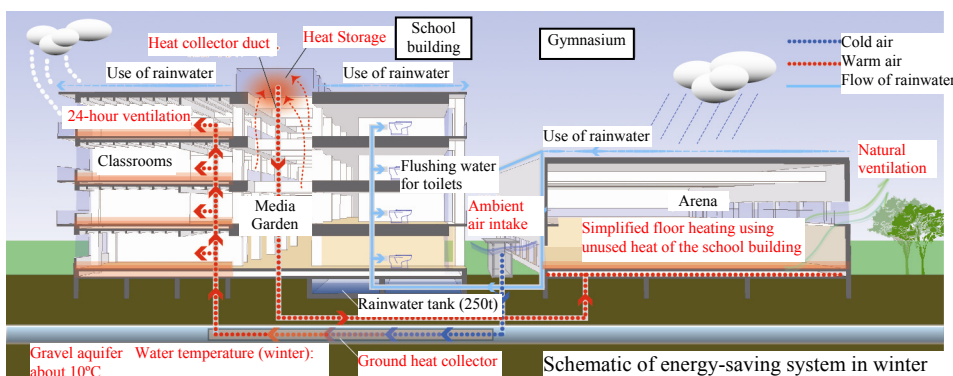
## Outline of the systems

The system is to collect ground heat by laying spiral ducts (imperforated drainage pipes for civil engineering) in a gravel aquifer. The classroom system supplies the ambient air that passed through a 190m-long duct of 60cm diameter to the underfloor of the classrooms through a concrete duct passing through the 1<sup>st</sup> to 4<sup>th</sup> floors. During winter, the exhaust of the system is sent to the underfloor of the gymnasium and the martial arts training place for their floor heating. In summer, the system for the gymnasium and the martial arts training place supplies the ambient air that passed through a 120-long duct of 30cm diameter to the underfloor of the spaces for simplified floor cooling.

Excluding some special classrooms, the systems are secondary heating installations of classrooms. They are primarily heated by heat storage type electric heaters using night-rate power in winter, whereas no other system is needed for cooling in summer thanks to the climate of Tohoku.

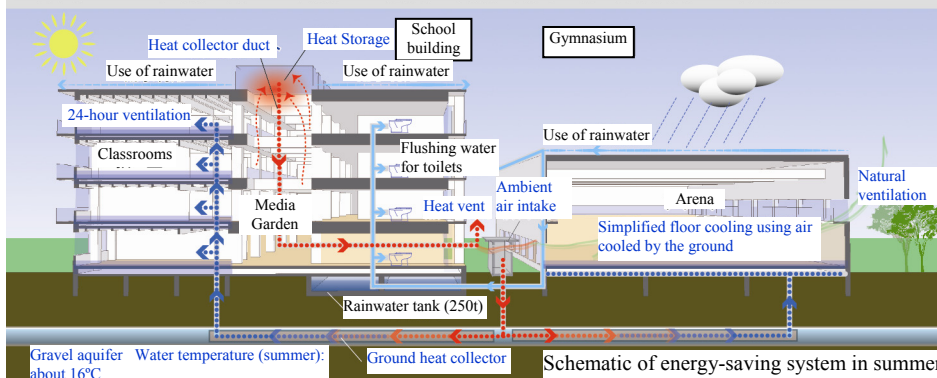


Outside Kamaishi Junior High School



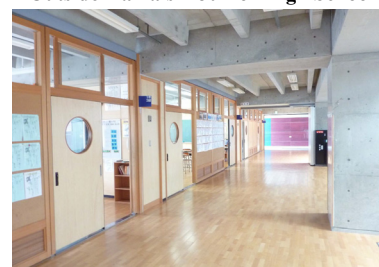
“Ecosystem for winter”

Ground heat (around 10°C) that is higher than the outdoor temperature is used to warm outside air for floor heating



“Ecosystem for summer”

Ground heat (around 16°C) that is lower than the outdoor temperature is used to cool the outside air for heating through the floor



Air warmed by ground heat flows under the floor of the corridor.



Blowing slits on the floor surface



The duct under the floor of the gymnasium (Fabric duct: air blows evenly out of the fabric part)

## Background of actions

Kamaishi City had been working on the formulation of a new energy vision since fiscal 2001 and positioned school construction in its concrete project to address global environmental problems as a city-wide effort. Against this background, the city decided to introduce facilities using ground heat as part of an Eco School with the aim of implementing education that raises interest in environmental problems and energy conservation through school facilities as familiar learning material.

## Method of maintenance and operation

The system introduced to Kamaishi Junior High School does not require everyday maintenance but does need switching of the operation mode when the seasons change. In this process, the operation program is checked once a year through the monitor board.

Because the standard cool/heat trench is a simple system, it requires no special maintenance work.

## Utilization for environmental education

Because the use of ground heat can lead to saving of heating and cooling costs, the student council reads usage registers every day, announces power consumption of the day and carries out a study to reduce power usage.

## Utilization in time of disaster

The original purpose of introducing the ground heat utilization system to Kamaishi Junior High School was to use renewable energy for improvement of the everyday classroom environment.

When the Great East Japan Earthquake occurred, the school accepted evacuated residents from March 11 to August 5, 2011. Its gymnasium was used as their evacuation site but the system to use ground heat did not function during the power outage just after the earthquake. After the restoration of power, the system played an accessory role as a cooling/heating facility, contributing to the improvement of the indoor environment of the gymnasium where 270 people lived at the peak.

Because the system cannot rotate fans for blowing air during power failure, it is necessary to have photovoltaic power generators, storage batteries and other devices that can supply the power necessary for fan operation for emergency preparedness.

## Case of Kamaishi Junior High School

### (1) Initial cost (construction cost)

About **16.00 million yen** (2,000 yen/m<sup>2</sup>\*)

(Earthwork: about 0.6 million yen; ducts: about 13.00 million yen; fans: about 1.00 million yen; damper, etc.: about 1.40 million yen)

\*Amount per m<sup>2</sup> of the total floor area of the building where the system is installed

### (2) Running cost (maintenance and operation cost)

About **200,000 yen/year**

(Only the cost to check the operation program)

### (3) Annual energy-saving amount (amount of reduced heating and lighting expenses)

About **600,000 yen/year**

(Heating and cooling cost: 950,000 yen before the introduction; 350,000 yen after the introduction  
\*estimation at the time of planning)

## Evaluation of effects

### (1) CO<sub>2</sub> emissions

It is possible to reduce CO<sub>2</sub> emissions by about 20t annually compared with standard cooling and heating equipment

### (2) Indoor environment

February				August			
Earth temperature (gravel layer temperature)	Heat collection pipe inlet temperature (Outdoor temperature A)	Heat collection pipe outlet temperature (Room temperature B)	B-A	Earth temperature (gravel layer temperature)	Heat collection pipe inlet temperature (Outdoor temperature A)	Heat collection pipe outlet temperature (Room temperature B)	B-A
13°C	1°C	7°C	6°C	13°C	22°C	17°C	-5°C
The room temperature requires a supplemental heater but the system can be used as simplified floor heating that reduces heating cost.				In summer, the system using ground heat is enough for cooling the building, which greatly contributes to energy conservation.			

\*Estimated by Kamaishi Junior High School

## Status of introduction in Japan

**59 schools** (installation completed as of April 1, 2013)

Breakdown by region

(Schools)

Hokkaido	Tohoku	Kanto	Koshinetsu	Hokuriku
4	8	12	5	14
Chubu	Kinki	Chugoku	Shikoku	Kyushu
3	3	7	1	2

\*Including kindergartens, elementary, junior high, high, and special-needs schools  
Source: Survey on introduction of renewable energy facilities, etc. (MEXT)

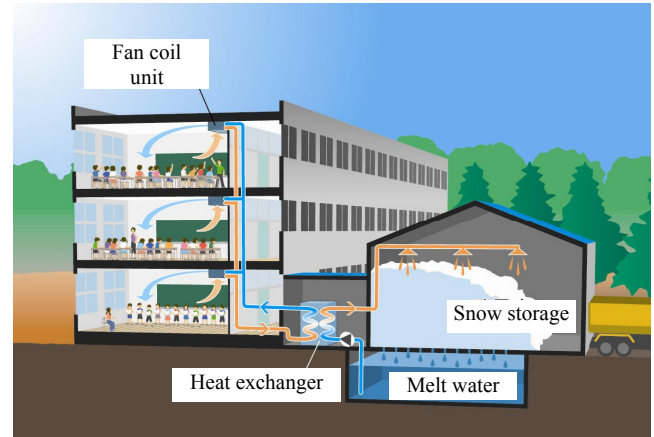
# Facilities using snow-and-ice cryogenic energy

## Outline

A commonly employed method using snow-and-ice cryogenic energy involves storing snow and ice frozen by open air in a highly insulation efficient storage and producing cold water for cooling using their cold energy through a heat exchanger.

Other systems using snow-and-ice cryogenic energy include: snow/ice houses that maintain low temperature through natural convection of stored snow/ice to store vegetables, etc.; ice shelters that maintain the low temperature of 0°C throughout the year using latent heat that is generated when water freezes and ice melts, and; artificial frozen ground system that freezes soil through a heat pipe using open air to use its cold energy.

Main application	New construction	Refurbishment
If there are spaces to install snow storage, a machine room for heat exchange, and other equipment, the system is suitable either to new construction or to refurbishment.		



Schematic of a standard snow-cooling system

## Features/Necessary points

A low-temperature and high-humidity environment can be created stably, easily and at low cost using snow and ice that are inexhaustible in cold snow zones. Cold energy of snow and ice is clean energy that does not emit CO<sub>2</sub>. Advantage: effective utilization of removed snow; economic effect through reduction of maintenance and operation costs, and; humidity-retaining ventilation cooling that does not contaminate interior air. Disadvantage: Greater distance between the snow storage and the facility to be supplied lowers the efficiency due to power necessary for carrying the energy, loss, etc.; high initial cost of snow storage; need of a space for a snow storage.

Installation of facilities using snow-and-ice cryogenic energy is appropriate for regions with a freezing index\* which exceeds -200°C. The system is effective for all parts of Hokkaido and some parts of Tohoku and Hokuriku, for example.

(\*Freezing index: annual total of the average temperatures that are below 0°C)

Snow and ice heat was explicitly positioned as a new energy source in 2002 when the Order for Enforcement of the New Energy Act was amended.

## Necessary planning points considering operation in time of disaster

The method commonly adopted in school is to store snow in snow storage and produce cool water using its cold energy through a heat exchanger while using the cold water for cooling. In this method, it is necessary to operate the fans to blow cool air to classrooms. For the system to operate in time of disaster, it is necessary to install a photovoltaic power generation system, storage battery, etc. to supply power to the fans.

## Installation example

School name: Yasuzuka Junior High School, Joetsu City, Niigata Prefecture

Major equipment: Snow cooling system

No. of classes: 4 classes including one special-needs class

No. of students: 65 including 3 special-needs students

Capacity: Snow storage capacity:  $660 \text{ t} (1,320 \text{ m}^3 \text{ (snow volume)} \times 0.5 \text{ t/m}^3 \text{ (density)})$

Photovoltaic power generation: 30 kW

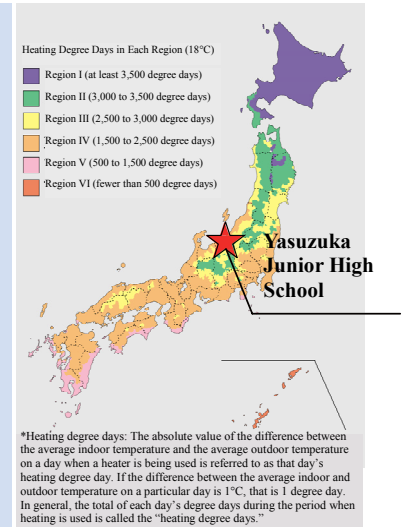
Use of devices: For cooling all rooms ( $1,792 \text{ m}^2$ ) in the building ( $3,182 \text{ m}^2$ )

FY of installation: FY2003

Time for completion: Design: September 2003 (one month)

Construction: November 2003 to February 2004

\*The time for completion includes the time for the building refurbishment.



## Outline of the systems

Along with major renovations, photovoltaic power generation and a snow cooling system were jointly applied in Yasuzuka Junior High School. The snow cooling system uses the snow that accumulates during winter as cryogenic energy for summertime cooling. Stored snow is melted by adding water, and the snow meltwater is circulated by pumps through a heat exchanger where water for air-conditioning is cooled. Another fan coil unit on the room side exchanges heat between the cold water and the room air for air-conditioning. The snow meltwater that is warmed at the heat exchanger between the snow meltwater and the circulating water is reused for melting stored snow and cycled as snow meltwater.

The system uses snow for cooling about  $1,800\text{m}^2$  classrooms and other spaces. The power generated by the photovoltaic panels on the roof of the gymnasium is used to drive devices necessary for the system operation. Snowmelt can be used also for washing school buses, flushing toilets and emergency water. This way, the system can help energy conservation and reduction of CO<sub>2</sub> emissions while contributing to saving tap water by supplying snowmelt as needed (up to 10t/day) through cooling operation in summer (dry season).



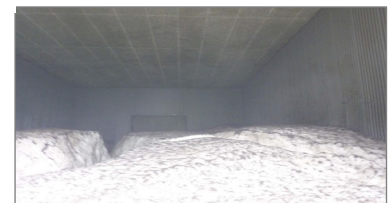
Outside Yasuzuka Junior High School



Outside the snow storage



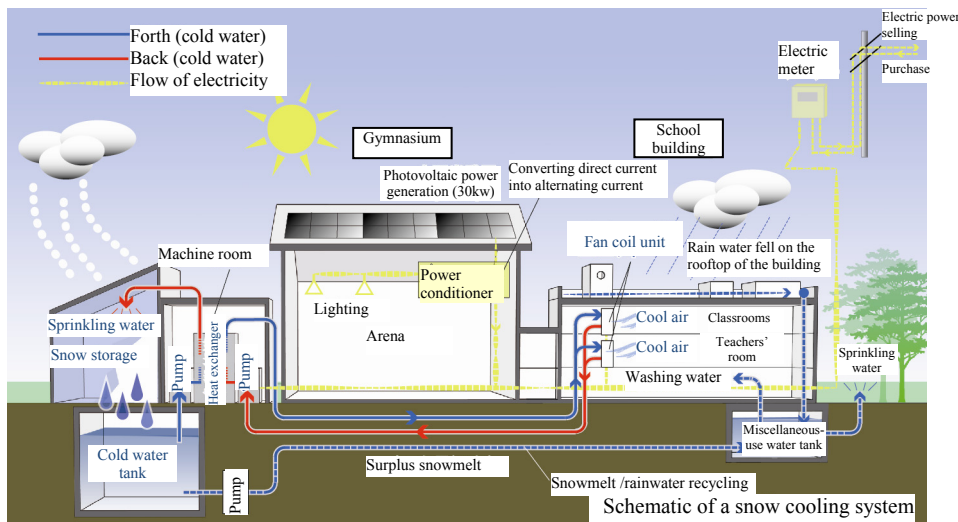
Storing snow in storage (capacity: 660t)



Stored snow (early August)  
About half of the stored snow still remains.



Fan coil unit



## Background of actions

It was decided to introduce a snow cooling system with the aim of contributing to conservation of the environment and existing energy resources through the use of snow that is a natural resource, and of creating a comfortable learning environment not only to improve the scholastic ability of students but also to use the system as educational material for hands-on experience so that students can take the first step in building a human society in harmony with the earth.

## Method of maintenance and operation

- Storing snow into the snow storage around February (conducted by the city)
  - Switching the piping to snow cooling mode in late June\*
  - Cleaning of the snow storage around September (conducted by janitors of the school)
  - Switching the piping to heating mode in early November\*
- \*Conducted by a professional service



Studying snow (1)



Studying snow (2)

## Utilization for environmental education

Comprehensive energy and environmental education, including that on the snow cooling system, has been provided during individual subject classes and comprehensive learning classes. Collaboration with parents, local residents and experts has been made proactively, which has led to the establishment of a unified community scheme for environmental education.

## Utilization in time of disaster

The power necessary for operating the system of Yasuzuka Junior High School (ex. snow melt water circulation pump, blast fan) is supplied by a photovoltaic installation (30kW) enabling autonomous operation during a power outage.

However, because photovoltaic power generation is not possible on a cloudy day and at night, an isolated power unit, storage battery, etc. are necessary to supply power matching the capacity for the system operation for emergency.

## Case of Yasuzuka Junior High School

- (1) Initial cost (construction cost)**  
**About 47.50 million yen (15,000 yen/m<sup>2</sup>\*)**  
 (Snow storage: about 28.00 million yen; insulation pane: about 7.50 million yen; piping: 3.80 million yen; other equipment: about 3.70 million yen; construction cost: 4.50 million yen)  
**Photovoltaic power generator installation cost: about 30.00 million yen (24,000 yen/m<sup>2</sup>\* including photovoltaic power generator)**  
\*Amount per m<sup>2</sup> of the total floor area of the building where the system is installed
- (2) Running cost (maintenance and operation cost)**  
**About 130,000 yen/year**  
 (Annual maintenance and inspection costs including pipe switching. Dumping of snow into the snow storage is excluded because this is done as part of snow removal work)
- (3) Annual energy-saving amount (amount of reduced heating and lighting expenses)**  
**About 0.70 million yen/year**  
 (Heating and cooling cost: 1.20 million yen before the introduction → 0.50 million yen after the introduction)  
\*estimation at the time of planning

## Evaluation of effects

- (1) CO<sub>2</sub> emissions**  
**It is possible to reduce CO<sub>2</sub> emissions by about 13t annually compared with standard cooling equipment**
- (2) Indoor environment**

During summer			
Outdoor temperature	Room without cooling	Room with snow cooling	Temperature difference
33°C	32°C	26°C	-6°C
Because the snow cooling system alone can maintain a room temperature appropriate for class activities, it greatly contributes to energy conservation. The system that allows free temperature control on the side of the fan coil unit in the room is as user-friendly as ordinary air-conditioners. However, wasteful use, such as excessive cooling and out-of-hours use, would consume much snow and lead to depletion.			

\*Observation result in summer

## Status of introduction in Japan

**6 schools** (installation completed as of April 1, 2013)  
 Breakdown by region (Schools)

Hokkaido	Tohoku	Kanto	Koshinetsu	Hokuriku
2	2	0	2	0
Chubu	Kinki	Chugoku	Shikoku	Kyushu
0	0	0	0	0

\*Including kindergartens, elementary, junior high, high, and special-needs schools  
 Source: Survey on introduction of renewable energy facilities, etc. (MEXT)



# Facilities using biomass energy

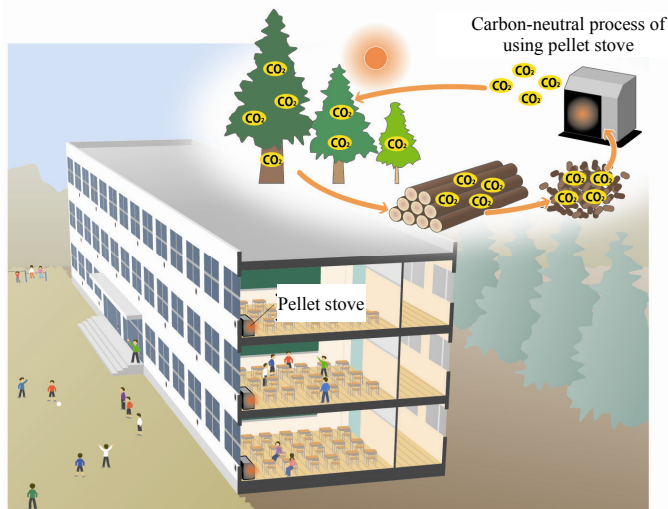
## Outline

A pellet stove may be a common method to use biomass energy in school facilities.

There are two types of pellet stove: a radiant heat type, which heats a room by raising the temperature of the stove itself, and a convection type, which blows out hot air.

Pellet stoves can be installed if there is a space for installation of air supply/exhaust pipes in the wall and of a chimney in the existing building

Main application	New construction	Refurbishment
The system that needs only a space for installation of air supply/exhaust pipes in the wall and that for a chimney can be incorporated either in new construction or refurbishment		



Schematic of equipment using biomass energy

## Features/Necessary points

Biomass energy is derived from organic matter, i.e., matter from organisms, such as the cellular tissues of plants and animals and animal excreta. The use of plant-derived biomass energy is gaining attention, because it is considered carbon-neutral\* energy. Carbon emissions from biomass are viewed as part of the natural carbon cycle, in which the carbon is found in different molecules but carbon dioxide absorption and emissions are in balance. Therefore carbon emissions from biomass are not regarded as adding to atmospheric concentrations of carbon dioxide.

The fuel of pellet stoves is wooden biomass called pellets, which are bar-shaped particles created by compressing woodchips (from timber, branches, tree bark and leaves.)

Advantage: relatively low initial cost for installation; use of storable wooden pellets; generating less carbon monoxide, ash and smoke; does not get dirty or smell like kerosene; contributing to the promotion of use of thinned wood, and, if a certain amount of wood consumption is expected and it is supplied in the region, promotion of local production for local consumption.

Disadvantage: It takes time to warm the room compared with stoves using other fuel such as kerosene; pellets are highly moisture absorbing and require a storage place. Furthermore, if a distribution system for stable supply of pellets is not established, this may lead to problems for operation such as high cost of fuel procurement and long delivery time.

(\*A condition in which the amount of CO<sub>2</sub> emissions from combustion/decomposition of plant-derived fuel and raw materials equals the amount of CO<sub>2</sub> absorbed by the original plants in their growth process.)

## Necessary planning points considering operation in time of disaster

Because most pellet stoves use electricity for their operation, they cannot be used during power outage. Therefore, it is necessary to install a photovoltaic power generation system, storage battery, etc. to supply power to the stoves in order to use them in time of disaster.

## Installation example

School name: Mikata Junior High School, Wakasa Town, Mikata Kaminaka-gun, Fukui Prefecture

Major devices: Pellet stoves

No. of classes: 10 classes including one special-needs class

No. of students: 215

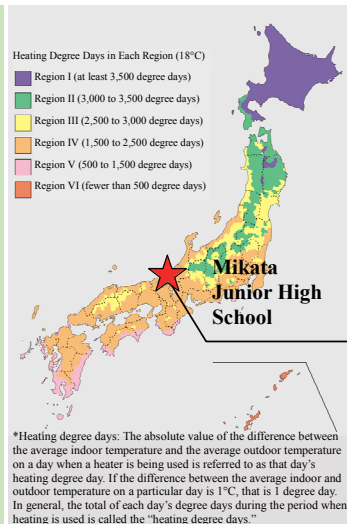
Capacity: 12.8kW × 12 units (for classrooms)

One 14.0kW unit (for a gallery floor heating system)

Use of devices: Special and regular classrooms, gallery (1<sup>st</sup> floor)

FY of installation: FY2005–FY2008

Pellet delivery time: About 1 month (if in inventory) or 2 months (if to be produced)



## Outline of the systems

Mikata Junior High School of Wakasa Town has introduced pellet stoves. The stoves have two chambers: one for pellet storage and the other for combustion. A small amount of stored pellets is consecutively fed into the combustion chamber. Most pellet stoves use electricity, which also enables automatic ignition at the press of a switch. The ease of use of pellet stoves is quite close to that of coal-fired stoves and kerosene heaters. The combustion efficiency is around 85–90%.



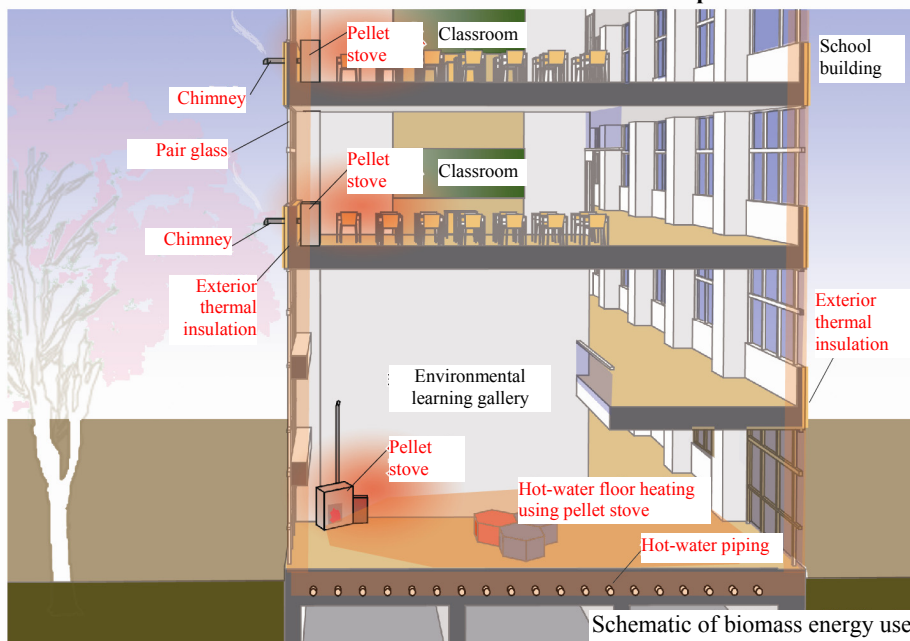
Outside Mikata Junior High School



A pellet production factory in the town  
(Pellets are sifted after production to obtain pellets of uniform size)



Produced pellets  
(One bag is about 10kg = quantity used by one stove to operate for one day)



A pellet stove installed in a classroom



Pellets in a stove

## Background of actions

Wakasa is a town surrounded by mountains, scenic Five Mikata Lakes and the beautiful sea. In order to pass down the rich nature, the town government adopted the “Biomass Town” plan in 2006. The entire town is promoting activities aiming for a recycling-oriented society. As part of the efforts the town introduced pellet stoves to all municipal elementary and junior high schools and other public facilities in the town, set up a pellet production factory in the town and has been providing children with environmental education.

## Method of maintenance and operation

It is necessary to refill pellets and remove ash, etc. daily.

## Utilization for environmental education

Observations of actual equipment and experiences that provide for the physical sensation of heat generated from pellets can contribute to environmental education by themselves. Furthermore by cleaning and controlling the stove together with their teacher, students can develop interest in how to handle fire safely in daily living and learn the method and importance of organization and cleaning. Collaboration with the community is active, as seen in the fact that observation programs take place at a pellet plant in the town, where students can experience log splitting during pellet processing.

Environmental education sessions by experts are also actively offered, which shows the established awareness and framework in the entire community for environmental education.



Students visiting the pellet plant



Pellet stove in an evacuation site (gymnasium)  
\*Osu Elementary School, Ishinomaki City

## Utilization in time of disaster

About three weeks after the Great East Japan Earthquake, 43 pellet stoves were installed and operated at 21 evacuation sites in school and other facilities of Kesennuma, Minamisanriku, Ishinomaki and Kurihara cities with the support of pellet stove manufacturers, NPOs and others. Pellets that are easy to transport and store were donated and sent from pellet plants across Japan. In preparation for emergency, photovoltaic power generators, storage batteries, etc. that supply power matching the capacity to operate the pellet stoves are necessary.

## Case of Mikata Junior High School

### (1) Initial cost (construction cost)

About **0.50 million yen/unit** (for classroom)

About **1.50 million yen/unit** (for floor heating)

\*Including duct/electric works accompanying the installation

\***7.50 million yen in total for the project at Mikata Junior High School**

**(0.50 million yen × 12 units + 150 million yen × 1 unit)**

### (2) Running cost (maintenance and operation cost)

About **0.50 million yen/year**

**(Including the cost of kerosene for heaters used before full operation of the pellet stoves in addition to pellet cost)**

### (3) Annual energy-saving amount (amount of reduced heating and lighting expenses)

About **0.30 million yen/yea**

## Evaluation of effects

### (1) CO<sub>2</sub> emissions

It is possible to reduce annual CO<sub>2</sub> emissions by about **10t** compared with standard heating equipment

### (2) Indoor environment

March			
Outdoor temperature	Room without heating	Room with an operating pellet stove	Temperature difference
0°C	12°C	23°C	11°C
Heating with the pellet stove started at 7:30 and the room temperature reached 23°C at 10:00 when class starts. It showed a competent heating performance.			

\*Measuring result at 10:00, on March 3, 2011

## Status of introduction in Japan

**106 schools** (installation completed as of April 1, 2013)

Breakdown by region

(Schools)

Hokkaido	Tohoku	Kanto	Koshinetsu	Hokuriku
9	16	0	47	3
Chubu	Kinki	Chugoku	Shikoku	Kyushu
2	20	1	8	0

\*Including kindergartens, elementary, junior high, high, and special-needs schools  
Source: Survey on introduction of renewable energy facilities, etc. (MEXT)

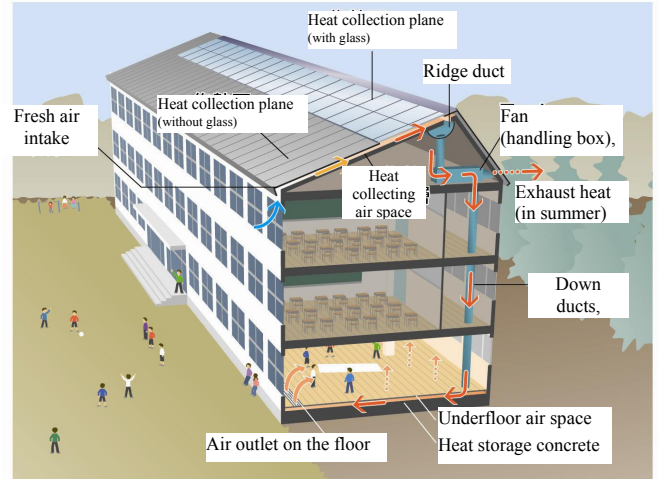
# Facilities using solar heat

## Outline

General systems use solar heat by raising the temperature of air, water or anti-freezing fluid using a heat collector on a roof to provide hot water or heating.

Considering the use in time of disaster, the best method may be the natural circulation system that uses movement of air caused by temperature difference. However, because the method is limited to sites with height difference enabling heat collection using slope, the forced circulation type that uses pumps and fans requiring only small power for operation combined with a photovoltaic installation is adopted in most cases.

Main application	New construction	Refurbishment
Suitable for either new construction or refurbishment if it is possible to install a pitched roof with an angle and direction for efficient collection of solar heat, double flooring for supply of hot air under the floor and the like		



Schematic of a generally used solar heat utilization facility

## Features/Necessary points

It is necessary to slope the surface for solar heat collection in order to ensure high heat collecting efficiency. Because generally heating is needed more than hot water in school facilities, use as a heating system should be prioritized.

A heating system collecting heat using water requires installation of a radiator in the space to be heated and has many problems including heat loss and water leak of hot water piping and larger pump capacity accompanying friction loss due to thin and long hot water piping.

A system collecting heat using air requires relatively large duct spaces. Because warm air is blown to the space to be heated in a low air velocity, fan of a small capacity may be sufficient for the system. As described in “Outline” a separated heat collection and natural circulation system can generate sufficient airflow if the conditions for the site are met. In summer, it is necessary to install a mechanism that enables switching of the duct route to exhaust hot air outdoors.

## Necessary planning points considering operation in time of disaster

In the assumption of a disaster, a heating system collecting heat using air is believed to be better than a system collecting heat using water that has a risk of secondary damages due to leak from piping, for example.

Fans are essential to supply hot air from the heat collection plane on a rooftop/roof to the space below to be heated. Therefore, it is necessary to have photovoltaic power generators, storage batteries and other devices to supply power necessary for fan operation in preparation for outage of commercial power.

## Installation example

School name: Futaba Elementary School, Kamaishi City, Iwate Prefecture

Major devices: Solar heat utilization system

No. of classes: 12 classes including two special-needs classes

No. of students: 258 including 4 special-needs students

Capacity: Air volume: approx. 13,000 m<sup>3</sup>/h; ventilation rate: 2-3 times/h  
solar power generation system: 3kW

Use of devices: For heating and ventilation of classrooms on the 2<sup>nd</sup> and 3<sup>rd</sup> floors, workspace, special-needs classrooms, a multipurpose hall on the 1<sup>st</sup> floor, a memorial hall, etc. (2,335m<sup>2</sup> of 4,941m<sup>2</sup>, the total floor area of the building)

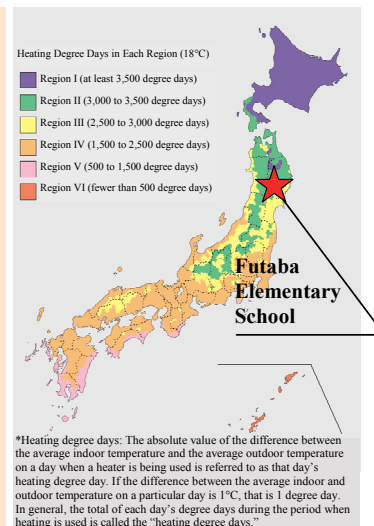
FY of installation: FY2003

Time for completion: Review: December 2000 to December 2001

Design: December 2001 to June 2002

Construction: October 2002 to October 2003

\*The time for completion includes the time for new construction of the building



## Outline of the systems

A one-way grade roof is placed on an RC flat roof of the school building. The placed roof structure has four air-heat collectors (total area: 507.4m<sup>2</sup>) and 12 fans (1,560m<sup>3</sup>/h). 12 vertical ducts (3 for the 1<sup>st</sup> floor, 1 for the special-needs classes on the 2<sup>nd</sup> floor and 8 for classrooms on the 2<sup>nd</sup> and 3<sup>rd</sup> floors) of 300mm diameter are installed down from the rooftop to supply air warmed by solar heat to the underfloor of classrooms; the air blows out through outlets on the floor near the window and heats the floor and the room while performing ventilation. During the daytime, the heat of the warmed air is stored in the concrete thermal mass built under the floor. In the evening the heat is naturally released to moderate the drop in air temperature.

Power consumption of one fan is 230W. 24 photovoltaic power generation panels of 125W-26V are installed to operate the fans.

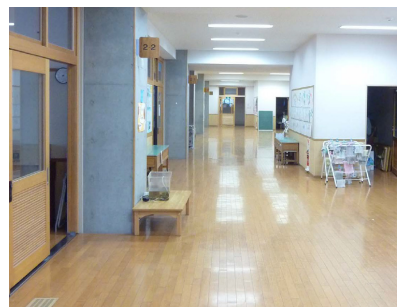
An oil-firing hot water boiler is used as an auxiliary heater and fan convectors blow warm air from underfloor through outlets near windows to the room.



Futaba Elementary School



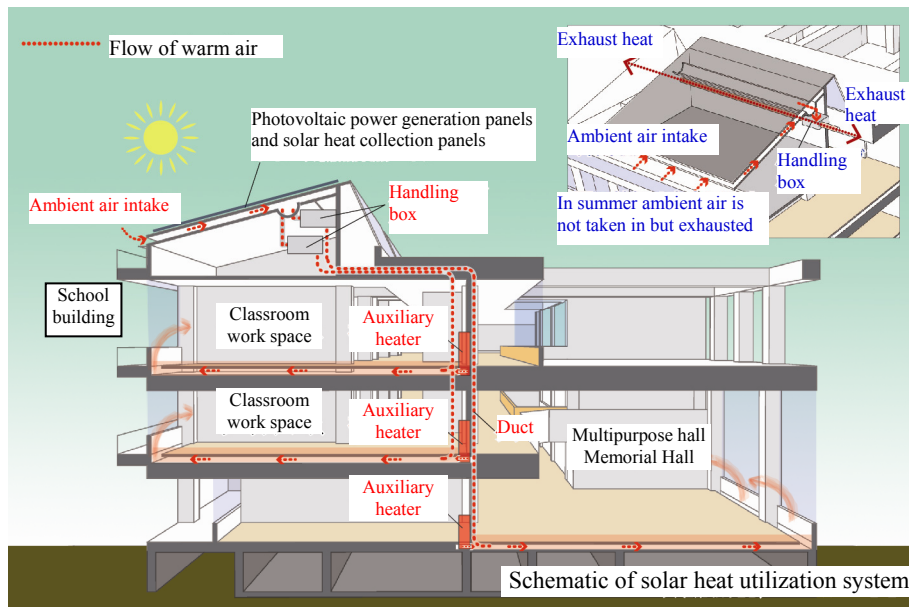
Heat collection panel (heat collection area: 507.4m<sup>2</sup>)  
Photovoltaic power generation panel on the top row



Hot-air outlets are installed also in corridors



Outlet on the floor



## Background of actions

The Kamaishi City Government started to work on the formulation of a new energy vision in 2001 and positioned school construction in its concrete projects to promote city-wide efforts addressing environmental problems. In line with this development, the city decided to introduce solar heat utilization facilities as part of Eco School for education to raise interest in environmental problems and energy conservation through familiar learning materials such as school facilities.

## Method of maintenance and operation

No regular maintenance work is required. Upon a failure or abnormality alarm, it is necessary to have investigation and confirmation carried out by personnel in charge of facilities at the education board.

## Utilization for environmental education

The school facilities themselves serve as learning material. For example, students make wind chimes as part of environmental education to check the flow of air in the school and understand how warmed air moves.

## Utilization in time of disaster

After the Great East Japan Earthquake, the school accepted evacuated residents from March 11 to April 17, 2011. The gymnasium was used as the main evacuation site while the school building was also used temporarily. At that time, the solar heat utilization facilities functioned as an auxiliary heating system contributing to the improvement of the indoor environment.

The air-blowing fans of the facilities can operate based on photovoltaic power generation: this is a self-sustaining system except on a cloudy day and during night.

## Case of Futaba Elementary School

### (1) Initial cost (construction cost)

About **30.00 million yen** (6,000 yen/m<sup>2</sup>\*)  
 (Photovoltaic power generation: about 2.40 million yen, Duct components: about 5.00 million yen, Fan components: about 15.00 million yen, installation cost: about 7.60 million yen)  
 Patented components at the time of the installation were used for the fans and their price was reflected on the amount.

\*Amount per m<sup>2</sup> of the total floor area of the building where the system is installed

### (2) Running cost (maintenance and operation cost)

About **0 yen/year**  
 (No maintenance and operation cost in principle)

### (3) Annual energy-saving amount (amount of reduced heating and lighting expenses)

About **0.9 million yen/year** (about 0.80 million yen/year)  
 (Heating cost: 2.10 million yen (190 million yen) before the introduction; 1.20 million yen (1.10 million yen) after the introduction)

\*Calculation assuming kerosene heating based on EHP in ( )

## Evaluation of effects

### (1) CO<sub>2</sub> emissions

It is possible to reduce CO<sub>2</sub> emissions by about 23t (12t) annually compared with standard heating equipment

\*Calculation assuming kerosene heating based on EHP in ( )

### (2) Indoor environment

January				April			
Ambient temperature	Room A	Room B	B-A	Ambient temperature	Room A	Room B	B-A
5.2°C	10.5°C	12.7°C	2.2°C	14.4°C	13°C	18.3°C	5.3°C
Floor surface temperature of Room B: 14.5°C				Floor surface temperature of Room B: 21.5°C			
The temperature requires auxiliary heating but the temperature of the floor surface is higher than the room temperature, which creates a warm feeling and helps to reduce heating cost.				The solar heat utilization alone can maintain a room temperature appropriate for class activities, which greatly contributes to energy conservation.			

\*1 Room A: without solar heat utilization system; Room B: with a solar heat utilization system

\*2 Average of 10 days per month with good insolation efficiency

\*3 Temperature at 14:00 (simulated values)

## Status of introduction in Japan

240 schools (installation completed as of April 1, 2013)

Breakdown by region

Hokkaido	Tohoku	Kanto	Koshinetsu	Hokuriku
1	21	108	25	9
Chubu	Kinki	Chugoku	Shikoku	Kyushu
19	18	22	3	14

\*Including kindergartens, elementary, junior high, and special-needs schools

Source: Survey on introduction of renewable energy facilities, etc. (MEXT)

Insolation of the areas of the case examples and expected annual power generation per 1kW of the respective photovoltaic power generation systems are in the table to the right.

Insolation is a little lower on the Sea of Japan side but the **annual average of 1,000kWh per 1kW of the photovoltaic power generation system** is obtained in general. When installing a photovoltaic power generation system for operation in time of disaster, it is necessary to determine the capacity necessary to operate the renewable energy system.

School	Data site in the neighborhood	Annual average insolation*1	Expected annual insolation*2
Kamaishi JHS, Futaba ES	Morioka	3.88	1,034
Yasuzuka JHS	Niigata	3.53	941
Mikata JHS	Fukui	3.56	949

\*1 Annual average insolation on a slope of 30 degrees facing due south (kWh/m<sup>2</sup>/day)  
\*2 Expected annual power generation per kW of the system capacity (kWh/year)

(Reference)

- "New Energy Guidebook"(New Energy and Industrial Technology Development Organization)
- Learning through the Use of Earth-friendly Energy— Guidebook on the Use of New Energy at School Facilities (Educational Facilities Research Center, National Institute for Educational Policy Research)

## Fundamental Study of School Facility Environments

October 24, 2007

Final revision on March 29, 2013

Decision by the Director General of the National Institute for Educational Policy Research

### 1. Aims

In recent years, environmental problems on a global scale have been raised as a common issue for the whole world, and the development of school facilities that take the reduction of the environmental burden and coexistence with nature into consideration is required. Moreover, since 2008, when the commitment period of the Kyoto Protocol started, the government and other bodies have been strengthening initiatives aimed at reducing greenhouse gas emissions. Based on this kind of situation, as well as grasping the current situation with regard to energy consumption in school facilities, the research group will carry out a study of policies for promoting environmental measures in existing school buildings and contribute to educational facility measures associated with the future development of school facilities.

### 2. Focus of the Study

- (1) Grasping the actual energy consumption situation in school facilities
- (2) Formulating model plans for environmental measures focused on existing school buildings
- (3) Develop tools for calculation of CO<sub>2</sub> emissions from school facilities
- (4) Other relevant matters

### 3. Implementation Method

With the cooperation of the academics listed in the annex to this document, research will be conducted into the areas listed in item 2. above. In addition, the research group will be able to seek the cooperation of other interested parties, as required.

### 4. Implementation period

The study will be carried out between October 24, 2007, and March 31, 2014.

(Annex)

### Fundamental Study of School Facility Environments: Cooperating Parties

(In order of the Japanese syllabary, ○: Project Leader)

#### (Commissioners)

Osamu Koizumi	Chief, Architectural Design Group 2, Architectural Design Division, NIHON SEKKEI, INC.
○Hiromi Komine	Professor, Department of Architecture and Civil Engineering, Chiba Institute of Technology
Jun Sakaguchi	Professor, Department of International Studies and Regional Development, University of Niigata Prefecture
Nobuyasu Terashima	Assistant Chief Engineer, City Planning and Development Promotion Department, Chodai, Co., Ltd.
Junta Nakano	Associate Professor, Department of Architecture and Building Engineering, School of Engineering, Tokai University
Etsuko Mochizuki	Professor, Department of Architecture & Civil Engineering, Chiba Institute of Technology

(Observers: Department of Facilities Planning and Administration, Minister's Secretariat, Ministry of Education, Culture, Sports, Science and Technology (MEXT))

Yoshio Mano	Deputy Director, Facilities Planning Division
Tomoyasu Shimada	Advisor Section Chief, Facilities Planning Division (until September 24, 2013)
Masanobu Noguchi	Advisor Section Chief, Facilities Planning Division (from September 25 to December 31, 2013)
Yasuo Iwai	Advisor Section Chief, Facilities Planning Division (from January 1, 2014)
Taishi Nishiki	Deputy Director, Local Facilities Aid Division (Until July 7, 2013)
Tetsuji Kimura	Deputy Director, Local Facilities Aid Division (from July 8, 2013)
Keiichi Ohgiya	Technical Section Chief, Local Facilities Aid Division

In addition, the following staff members at the National Institute for Educational Policy Research were involved in the compilation of the report.

Fukuei Saito	Director, Educational Facilities Research Center
Hirofumi Nishi	Senior Researcher, Educational Facilities Research Center
Yoshiyuki Habasaki	Specialist of Educational Facilities

## Financial Support for Introducing Eco-School

### <For Public Schools>

#### ○Super Eco School Demonstration Program

Description: Support for formulation of basic plans toward zero-energy facilities based on studies in workshops, etc. with participation of local residents, guardians, etc.

Eligible facilities: School buildings of public elementary/junior high schools for which refurbishment, etc. are planned (FY2014 public invitation period: January 24 to April 25, 2014 (plan))

	Basic plan	Design	Construction work
○Super Eco School demonstration program			
○Public school facilities expenditure Subsidy rate: Reconstruction/refurbishment: 1/3; new construction, extension, reconstruction, introduction of photovoltaic power generation, etc.: 1/2			*

\*Eligible for priority selection for public school facilities expenditure and addition to subsidy unit

#### ○Eco-School Pilot Model Program

Description: Support to building construction

Eligible schools: Public kindergartens, elementary schools, junior high schools and schools for special needs education

     Renewable energy subsidy programs relevant to the Collection of Case Examples

	Building construction works	Works related to environmental conservation						
		Thermal insulation of walls, windows, etc.	Improvement of lighting, air-conditioning, etc.	Use of wood	Photovoltaic/wind power generation	Hydropower generation, etc.	Solar heat utilization of ground heat, biomass energy, snow-and-ice cryogenic energy, etc.	Other eco-works
○MEXT: Public school facilities expense Subsidy rate: New construction/extension: 1/2; Reconstruction/refurbishment: 1/3								
○MEXT: projects to introduce photovoltaic energy generation Subsidy rate: 1/2								
○Forestry Agency: Building of Wooden Public Facilities <Subsidy for the Creation of a Forest, Forestry, and Lumber Industry> Subsidy rate: 1/2								
○METI: Subsidy for local renewable energy production for local consumption Subsidy rate: Up to 1/2								
○METI: New Energy Introduction Support Project at the Local Level Subsidy rate: Up to 1/2								
○MLIT: Housing/Buildings CO <sub>2</sub> Reduction Leading Project Subsidy rate: Up to 1/2								

\* When certified as an Eco-school Pilot Model Program, Projects of MEXT are eligible for addition to subsidy unit and area for their eco-works, while projects of other ministries/agencies certified are eligible for priority adoption and other support measures. Check the application guideline of the respective program for detail.

You may select and combine subsidy programs of the ministries/agencies as long as there are no overlaps.

#### (Reference)

Example of using a subsidy program concerning eco-school

Main construction works	Works related to environmental conservation			
	Thermal insulation of walls, windows, etc.	Photovoltaic power generation	Use of wood	Use of ground heat
MEXT subsidy (Subsidy rate: 1/2 or 1/3)	MLIT subsidy (up to 1/2) *If the subsidized works can be clearly separated from the main construction work	MEXT subsidy (1/2)	Forestry Agency subsidy (1/2) *The amount of difference with the main construction work is provided	METI subsidy (up to 1/2)

#### ○Renewable energy promotion fund (Green New Deal Fund) program

Description: Support for local governments' introduction of renewable energy to their disaster prevention bases

Eligible facilities: Public facilities including schools that are owned by a local government and serve as local disaster prevention bases

Subsidy rate: 10/10

\*Prefectures and designated cities authorized to grant the fund by the MOE decide which municipalities will be subsidized in the eligible area.

### <Private schools>

#### ○Eco-Campus Promotion Project

Description: Facility remodeling necessary for furthering the equipping of environmentally-conscious school facilities

Eligible schools: Private kindergartens, elementary schools, junior high schools, secondary schools (first phase), high schools, schools for special needs education

Eligible projects: Photovoltaic power generation, environment-focused renovation of the schoolhouse, greening inside and outside the schoolhouse, remodeling of schoolhouse facilities for use of rainwater, reuse of wastewater, etc.

Subsidy rate: Up to 1/3

