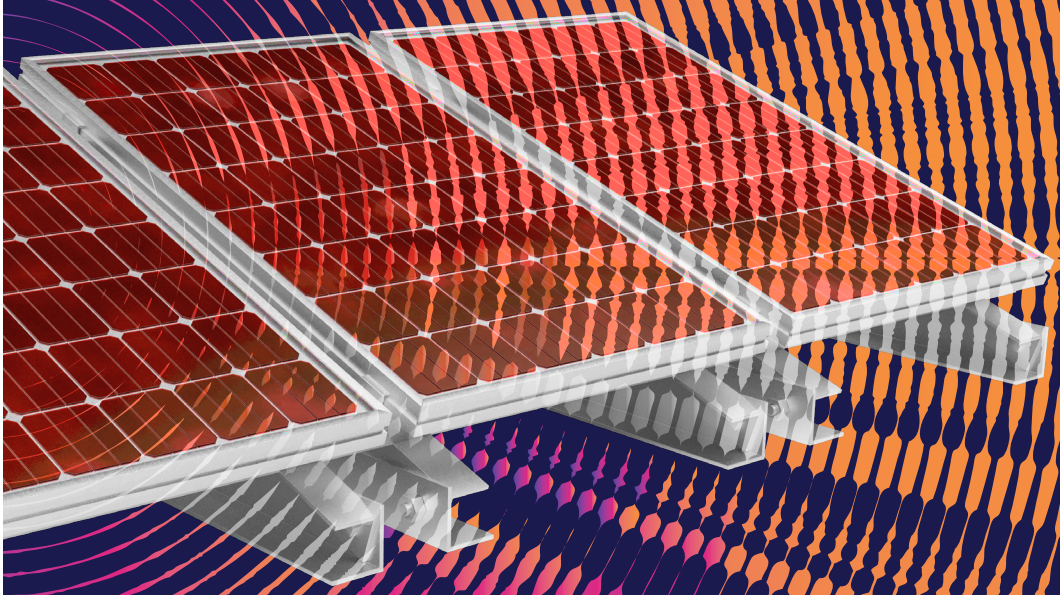
POWERING OUR TOMORROW

A Practical Guide to Installing and Using Renewable Energy in Schools



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www.greenschoolsprogramme.org

We are grateful to MISERIOR for their support.

Published by
Centre for Science and Environment
41, Tughlakabad Institutional Area, New Delhi 110 062
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Fax:1-11-29955879 | E-mail: cse@cseindia.org
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1 WHAT IS RENEWABLE ENERGY?

WHAT IS SOLAR ENERGY AND WHY IS IT IMPORTANT TODAY?

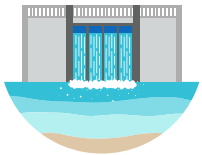
The term **'renewable energy'** refers to energy sources that can be replenished naturally and that are virtually inexhaustible. These sources do not deplete the Earth's finite resources. One of the key forms of renewable energy is solar energy.

Solar energy is derived from the sun's radiation. It is abundant, clean, and widely available. The sun's rays contain photons, which can be captured by solar panels or solar cells to generate electricity.

Today, our climate change-challenged world is moving away from fossil-fuel derived energy towards renewable sources. Climate change has become the biggest threat that confronts the world, and unchecked use of fossil fuels (like coal) to produce energy is adding to global warming. Most countries, including India, have realised this and are rapidly adapting renewable sources.

India, for one, plans to increase its renewable capacity to 500 gigaWatt (gW) by 2030 (in June 2023, our current installed capacity stood at 173.6 gW). The country also aims to meet 50 per cent of its energy requirements from renewable sources.

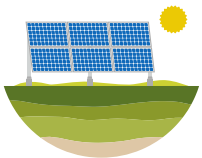
2 WHAT ARE THE RENEWABLE AND NON-RENEWABLE SOURCES OF ENERGY?



Hydro

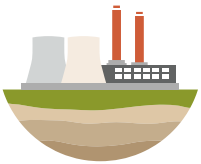
Oil

Solar



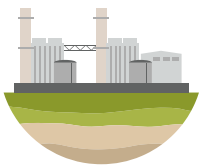
RENEWABLE

Coal



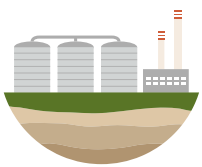
Wind

NON-RENEWABLE

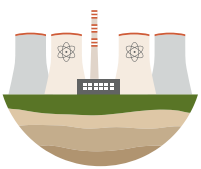


Gas

Biofuels

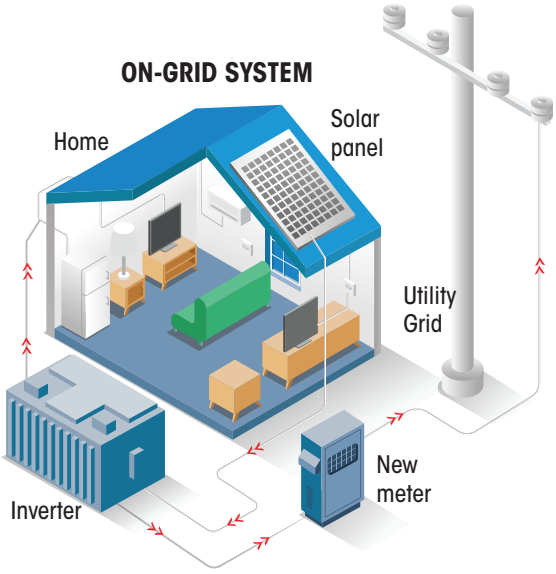


Nuclear



Note: Nuclear energy is usually considered non-renewable, but it is obtained from non-fossil fuel sources.

3 HOW DOES RENEWABLE ENERGY REACH OUR HOMES AND SCHOOLS – HOW DOES THE TECHNOLOGY WORK?



As said above, solar energy comes from the sun. The sun's rays contain photons, which can be captured by solar panels or solar cells to generate electricity. These panels or cells are typically made of semiconductor materials, such as silicon.

Semiconductor materials exhibit the 'photoelectric effect' – this means they can absorb photons (light particles) and release electrons. When sunlight (photons) strikes the semiconductor material, it excites the electrons present inside it, creating an electrical current. This direct current (DC) can then be converted into alternating current (AC) through an inverter, making it suitable for use in homes, schools and industries.

On-grid, off-grid and hybrid systems

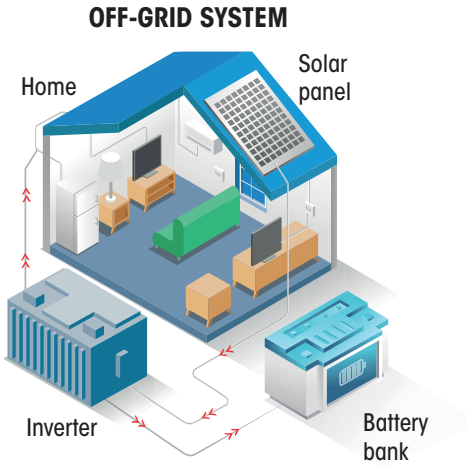
Solar power (photovoltaic or PV) systems can be categorised into three types: on-grid, off-grid, and hybrid.

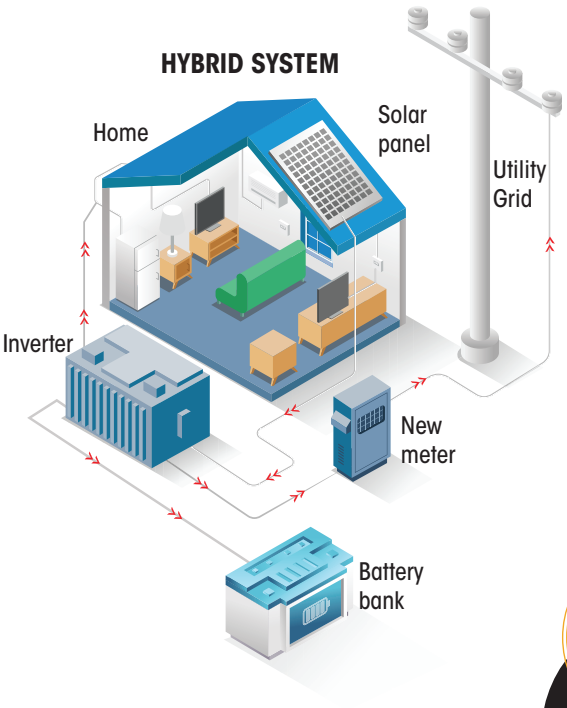
On-grid systems are connected to the electricity utility grid and rely on it for power supply. They export the excess energy that they generate back to the grid.

A 1 kW solar panel system can generate about 1,600 units of electricity in a year.

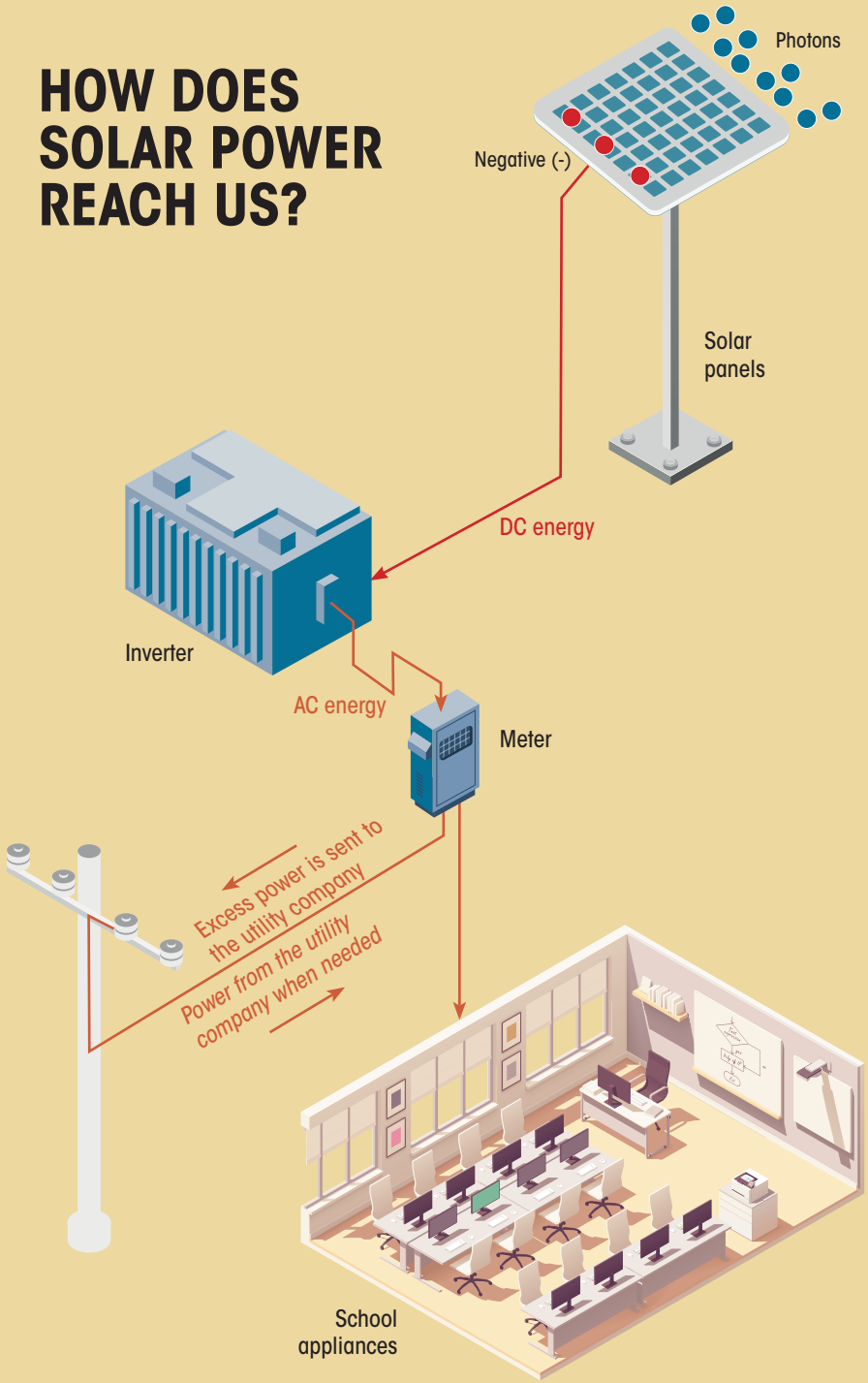
Off-grid systems operate independently and use batteries to store the energy they generate – this stored energy is used when solar generation is insufficient (such as during night-time). They are commonly found in remote areas where the grid has not reached.

Hybrid systems combine features of both on-grid and off-grid systems, enabling them to operate connected to the grid while also providing back-up power during grid outages through battery storage.





HOW DOES SOLAR POWER REACH US?



4 WHY SHOULD MY SCHOOL OPT FOR RENEWABLE ENERGY INSTEAD OF CONVENTIONAL NON-RENEWABLE ENERGY?

There are many advantages for schools if they opt for renewable energy:

Helps reduce energy costs, brings down the power bills.

The money that is thus saved can be used for other activities/tasks.

Reduces the school's carbon footprint, makes the school truly environment-friendly – the school thus plays a role in stopping global warming.

TOP TIP

Along with using a renewable source of power, the school can switch to energy-efficient electrical appliances to make its energy policy 'greener' and more effective.

Solar energy has helped us reduce our carbon footprint and made our school more environment-friendly. We did not think it was possible until the solar panels were installed on our campus and we saw the difference they made. We have reduced our energy costs to a great extent -- it's almost zero now. We are happy to contribute to a more sustainable future.

RAKHI BALI
Government Senior Secondary School (GSSS),
Chamba, Himachal Pradesh

"The solar panels are a great teaching tool for our students. They are able to learn about renewable energy and sustainability in a practical and hands-on way. Our electricity bill is almost zero now, and we are utilising the saved funds for other activities for students in the school.

SAPNA KAMBOJ
GSSS-Dharampur,
Solan, Himachal Pradesh

5 DOES MY SCHOOL HAVE THE POTENTIAL TO INSTALL SOLAR PANELS?

Schools interested in assessing their solar power potential can use the following check-list to arrive at a decision:

Determine your location: The amount of sunlight your location receives is a crucial factor in calculating the solar potential. Consider the latitude, climate, roof orientation and tilt and shading factors (such as nearby buildings or trees).

Do you have a good number of sunny days (260 or more in a year)?

Space available: For 1 kiloWatt power (kWp) system, you will need at least 10 square meter (sq m) space on a rooftop or on the ground.

Check your monthly demand (maximum and minimum in kWh) of electricity for the last 12 months.

Find out the tariff rate or per unit charges of electricity in your area.

6 HOW MUCH WILL IT COST TO INSTALL AND RUN A SOLAR POWER SYSTEM IN MY SCHOOL?

If you are considering installing a solar plant with the latest technology, the average cost across India is approximately Rs 55,000 per kiloWatt (kW). Please note that prices may vary from state to state.

It is important to note here that the average cost mentioned above does not include the installation cost, service cost for five years and any other liaising fees. These costs will be separate and depend on various factors such as the size of the system, location, and specific requirements.

However, the mentioned average cost does include the benefit of a net metering facility. With net metering, you can efficiently manage your energy consumption by connecting your solar system to the grid and offsetting your electricity usage with the power generated by your system.

MNRE's solar benchmark cost 2022-23: Grid-connected rooftop solar power plan

Capacity	States other than special category (Rs/kWp)	Special category states (Rs/kWp)
1 kWp	51,100	56,210
Above 1 kWp-2 kWp	46,980	51,670
Above 2 kWp-3 kWp	45,760	50,330
Above 3 kWp-10 kWp	44,640	49,100
Above 10 kWp-100 kWp	41,640	45,800
Above 100 kWp-500 kWp	39,080	42,980

Notes: *MNRE – Ministry of New and Renewable Energy; kWp – kiloWatt power; special category states – Sikkim and the other northeastern states, Uttarakhand, Himachal Pradesh, UTs of Jammu & Kashmir, Ladakh, Lakshadweep, and Andaman & Nicobar Islands*

Sample quotation for a 5 kW on-grid rooftop solar system

Item	Warranty	Quantity	Rate	Total amount
520 W PV Module; 144 cells, half cut; DCR cell; efficiency – 20%	25 Years	10	₹20,000	₹2,00,000
5 kW on-grid inverter Features: Digital display Technology: MPPT Phase: 3Φ (three phase)	5 Years	1	₹45,000	₹45,000
Mounting structure (520 watts) GI structure, can be customised Adjustable: 15 degree to 40 degree	1 Year	10	₹3,000	₹30,000
1 panel connector, 1-in-1 wire out	1 Year	8	₹200	₹1,600
DC wire, 4 sq mm, 30 meters pair	1 Year	30	₹120	₹3,600
ACDB	1 Year	1	₹6,000	₹6,000
DCDB	1 Year	1	₹6,000	₹6,000
Earthing kit with chemical bag	1 Year	3	₹3,000	₹9,000
Lightning arrester	1 Year	1	₹3,000	₹3,000
Earthing wire, 90 mtr	1 Year	90	₹150	₹13,500
Net metering charges Sanctioned load must be 5 kW or above	NA	1	₹25,000	₹25,000
Installation area required - Avg 10 sq m/ kW shadow free area. Total area required – 300 sq ft approx. Civil work is not included.		1	₹20,000	₹20,000
Total cost without any subsidy				₹3,62,700

7 WHAT KIND OF HELP DOES THE GOVERNMENT OFFER IF MY SCHOOL OPTS FOR RENEWABLE ENERGY?

In India, the government provides subsidies and incentives to promote solar panel installation. The Ministry of New and Renewable Energy (MNRE) offers Central Financial Assistance (CFA) under schemes like Rooftop Solar Power Plants and Off-grid Solar Applications. These programmes aim to reduce up-front costs and encourage renewable energy adoption. The CFA amount varies based on system size and installation type. These subsidies make solar panels more affordable, supporting the country's goal of reducing its carbon footprint.

Currently, the scheme offered by the Central government is for residential installations only. However, from time to time, state governments or national bodies like the SECI (Solar Energy Corporation of India) and the IREDA (Indian Renewable Energy Development Agency) also launch subsidy schemes specifically targeting educational institutions.

Plant capacity	Applicable subsidy for general category states	Applicable subsidy for special category states
Up to 3 kW	Rs 14,588 per kW	Rs 17,662 per kW
Above 3 kW and up to 10 kW	Rs 14,588 per kW for first 3 kW and thereafter Rs 7,294 per kW	Rs 17,662 per kW for first 3 kW and thereafter Rs 8,831 per kW
Above 10 kW	Rs 94,822 fixed	Rs 1,14,803 fixed

Notes: *Special category states – Sikkim and the other northeastern states, Uttarakhand, Himachal Pradesh, UTs of Jammu & Kashmir, Ladakh, Lakshadweep, and Andaman & Nicobar Islands*

8

WHAT ARE THE AGENCIES AND COMPANIES THAT I CAN TURN TO FOR INSTALLATION?

The Ministry of New and Renewable Energy (MNRE) has approved multiple agencies and distribution companies (DISCOMs) on a state-wise basis to facilitate the installation of rooftop solar panels. This initiative allows schools and individuals to easily connect with these approved agencies through a national portal dedicated to rooftop solar.

To find the approved agencies in your state, please visit the following link and select your state from the dropdown menu provided at ***solarrooftop.gov.in***

9 HOW AND WHERE SHOULD SOLAR PANELS BE INSTALLED?

The first step in the installation process is to determine the mounting method – whether the panels would be placed on a roof or on the ground.

✓ PRO ✗ CON

IF THE PANELS ARE PLACED ON A ROOF

✓ Uses up the space that otherwise might not be used for any purpose

✓ Typically, the installation cost is lower compared to a ground-mounted system

✓ Does not take up land that could be utilised for other activities

✓ Limits unauthorised visitors from accessing the panels

✓ Panels can protect the roof from exposure to certain elements

✗ Roof penetration is required

✗ School might require a new roof before installation

✗ In case repairs are needed on the roof, panels will need to be removed and reinstalled

✗ Adds weight to the roof -- in some cases, the roof could require additional support mechanisms

IF THE PANELS ARE PLACED ON THE GROUND

✓ They can be installed at multiple angles

✓ Can easily be accessed for maintenance

✓ Carports can be installed in existing parking lots -- providing shading, lighting, and protection to parked cars

✗ Typically, the installation cost is higher

✗ Limits the use of the land

✗ Takes up large areas

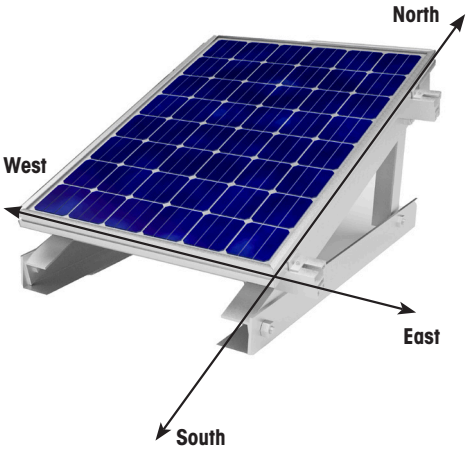
✗ Easier access for unauthorised visitors

✗ Increased chance of accidental damage from rocks or other particles thrown from a mower or other equipment

✗ May require a fence, adding cost to the project

When mounting the panels, some factors should be kept in mind in order to maximise their output:

- **Orientation:** The panels should be positioned facing south to receive the maximum amount of sunlight.
- **Temperature and sunlight:** The panels will generate more power under full sun, but at lower temperatures.
- **Sun tracking:** Tracking the movement of the sun throughout the day increases the amount of power generated by the solar array.



A solar panel installation

During the installation process, it is important to position the solar panels in a way that allows them to receive direct sunlight without any shade from nearby buildings or trees at any time of the day.

Due to the Earth's rotation on its own axis and its revolution around the sun, the angle at which the sun's rays hit the Earth's surface varies throughout the year. This angle variation can be as much as 45 degrees at a particular location on Earth. Considering these facts, the following guidelines should be followed when installing solar panels:

- The panels should be installed at an angle of "LATITUDE of the place + 10 degrees" from horizontal. For example, if the latitude of a place is 26 degrees, the solar panels in that location should be installed at an angle of 26 + 10 = 36 degrees relative to the horizontal plane.

- In the Northern Hemisphere, the solar panels should face south, while in the Southern Hemisphere, they should face north. Since India is located in the Northern Hemisphere, solar panels in the country should always be installed facing south. The direction of north-south can be determined using a magnetic compass.

10 HOW CAN THE SCHOOL MAINTAIN THE SOLAR PANELS?

- Ensure proper roof drainage and check for water pooling near the solar panels. Keep the solar panels dry.

- Keep the solar panels clean to ensure maximum sunlight absorption. Depending on the location and environmental conditions, periodic cleaning may be necessary to remove dust, dirt, leaves, or other debris that could hinder performance.

- Maintain an optimum battery charge by using a voltmeter to measure it.

- A visual inspection of the modules should be done periodically to look for possible defects such as cracks, chips, de-lamination, fogged glazing, water leaks and discolouration.

- Keep the site clean, including the area around the inverter and panels.

- Confirm that any roof penetrations are sealed to prevent leaks. The roof should undergo leak testing after the mounting system has been connected to the roof and sealed, but before the modules are installed.

- Check for erosion around the footings of ground-mounted systems.

- Ensure that only authorised personnel can access the electrical enclosures.

- Inspect for corrosion on enclosures and the mounting system.

- Wiring installations should be regularly checked for any cracks, breaks or deterioration in the insulation.

- Check for any loose wires hanging in the panel array.

- Junction boxes must be inspected to ensure that the wires are not damaged by rodents or insects.

- Look for signs of animals nesting under the panels.

11 WHICH BATTERY WORKS BEST AND WHAT SHOULD BE TAKEN INTO ACCOUNT WHEN CHOOSING A BATTERY?

At any point in time, electric generation must equal consumption – unless there is a means of storing the excess energy that is generated. Storage offers the ability to preserve electricity generated at one point in time and use it at another point to balance variable generation sources and variable loads.
There are three main types of batteries used to store solar energy — lead-acid, lithium-ion, and nickel cadmium.

Let us deep dive into each of them.
Lead-acid: This is the oldest type of solar battery. Lead-acid solar batteries come in two different sub-types. Sealed lead-acid batteries are designed in a way that they can reduce the release of toxic gases into the atmosphere during their charging process. The other sub-type is the flooded lead-acid battery. This is like a bigger version of a traditional car battery.

Lithium-ion: We can call this sub-type 'the new kid on the block'. In recent years, lithium-ion batteries have seen improvements parallel to the developments in battery technology required for electric cars. These batteries are popular among residential home owners. There are three reasons for this:

- Their lifespan is longer.
- They require less maintenance.
- They are more lightweight and smaller compared to lead-acid batteries.

In addition, these batteries are able to easily handle deep discharges of 80 per cent or more – meaning, they have a higher usable capacity.

Nickel cadmium: As another tried and tested solution, nickel cadmium batteries – also called "nickel batteries" or "Ni-Cd" – have been in the battery technology scene for a while. They are known for the ability to operate at extreme temperatures without any complex battery management systems. That is why they are more popular among commercial-scale projects. But because of their high toxicity, these batteries have been banned in many countries.

CHOOSING A SOLAR BATTERY

Every battery type comes with some advantages and disadvantages. This is why it is important to take into account six important factors when choosing a solar battery for yourself.

- Battery size/kWh
- Energy capacity/kW
- Round-trip efficiency
- Depth of discharge
- Battery life
- Safety

12 ARE THERE EXAMPLES OF SCHOOLS THAT HAVE OPTED FOR RENEWABLE ENERGY AND MADE A DIFFERENCE?

Government Model Senior Secondary School, Nalagarh, Himachal Pradesh

The Nalagarh-based school is a perfect example -- it sources its power entirely from solar energy, thus reducing its carbon footprint. This has also helped the school bring down its electricity costs to zero!

The school has implemented energy-saving measures and replaced traditional lighting with energy-efficient LED lights. The success of the initiative has gained recognition at the local, state, and national levels, inspiring other schools to adopt renewable energy.

Centre for Science and Environment (CSE), in association with its state partner, has provided support to the school throughout its solar installation and maintenance process. Workshops and seminars have been organised to raise awareness.

> The implementation of solar energy has not only reduced our carbon footprint, but has also transformed our school into an eco-friendly institution. By harnessing solar energy, we have successfully powered all our lighting and electrical appliances, resulting in reduced energy costs. Moreover, the substantial savings we have achieved are being utilised to support various other initiatives.
>
> **RANJAN LATA**
> GSP Coordinator,
> G.B.S.S.S. Nalagarh, Himachal Pradesh

GLOSSARY AND ABBREVIATIONS

ACDB: Alternating Current Distribution Box -- an electrical enclosure that houses the necessary components for distributing the AC electricity generated by the solar system to various loads or appliances.

BIPV: Building Integrated Photovoltaics. It refers to the integration of solar panels into the design and structure of buildings, enabling them to generate electricity.

Connected load: It is the load, in kiloWatt (kW), that a power distribution company has agreed to supply to a consumer. The electricity bill of the consumer (i.e., a school) will contain this information, mentioned as connected load or just load.

DCDB: Direct Current Distribution Box. Similar to ACDB, it is an electrical enclosure that contains the components for distributing the DC electricity generated by the solar panels to the inverter or other DC loads.

DCR Cell: Double-Sided Cell Reflectance. DCR cells are designed to minimise reflection of sunlight from the rear side of the solar cell, thereby improving the overall efficiency of the module.

DISCOM: An electricity distribution company

Efficiency: Efficiency refers to the ability of the solar PV module to convert sunlight into usable electricity.

GI structure: GI stands for galvanized iron, which refers to the material used in the structure. It can be adjusted to different angles, specifically between 15 degrees and 40 degrees, to optimise the orientation of the PV modules for better sunlight exposure.

GW: GigaWatt. It is a unit of power equal to one billion Watt. It is often used to express the capacity of large-scale solar or renewable energy installations.

kWh: KiloWatt-hour. It is a unit of electrical energy equivalent to one kiloWatt of power sustained for one hour. It is commonly used to measure electricity consumption or production.

Mounting structure: The mounting structure is the framework or support system used to install and secure the solar PV modules. In this case, it is designed to accommodate PV modules with a power output of 520 Watt.

MPPT: Maximum Power Point Tracking -- a technology used in solar inverters to optimise the output power from the solar panels by

continuously tracking and adjusting the operating point to the maximum power point.

MW: MegaWatt. It is a unit of power equal to one million Watt. It is commonly used to describe the capacity of medium- to large-scale solar or renewable energy projects.

NEM: Net Energy Metering. It is a billing arrangement where the excess electricity generated by a solar system is fed back into the grid, and the owner receives credits that can be used to offset future electricity consumption.

O&M: Operation and maintenance -- all services that ensure maximum efficiency and maintenance of the solar photovoltaic system.

On-grid inverter: A device used in grid-tied solar systems to convert the direct current (DC) electricity produced by the solar panels into alternating current (AC) electricity that can be fed into the utility grid.

PV: Photovoltaic. It refers to the technology that converts sunlight into electricity using solar cells.

RESOURCES AND LINKS THAT MIGHT HELP

Technical specifications for rooftop solar plants.
https://solarrooftop.gov.in/pdf/Technical_Specifications_np.pdf

Young Environmentalist - energy section
https://young.downtoearth.org.in/category/renewable-energy

Energy Managers: environmental toolkit on renewable energy
https://young.downtoearth.org.in/category/renewable-energy

Down To Earth videos
https://www.youtube.com/@D2E/videos

Renewable energy factsheets, reports and other products
https://www.cseindia.org/topics/renewable-energy?type=reports

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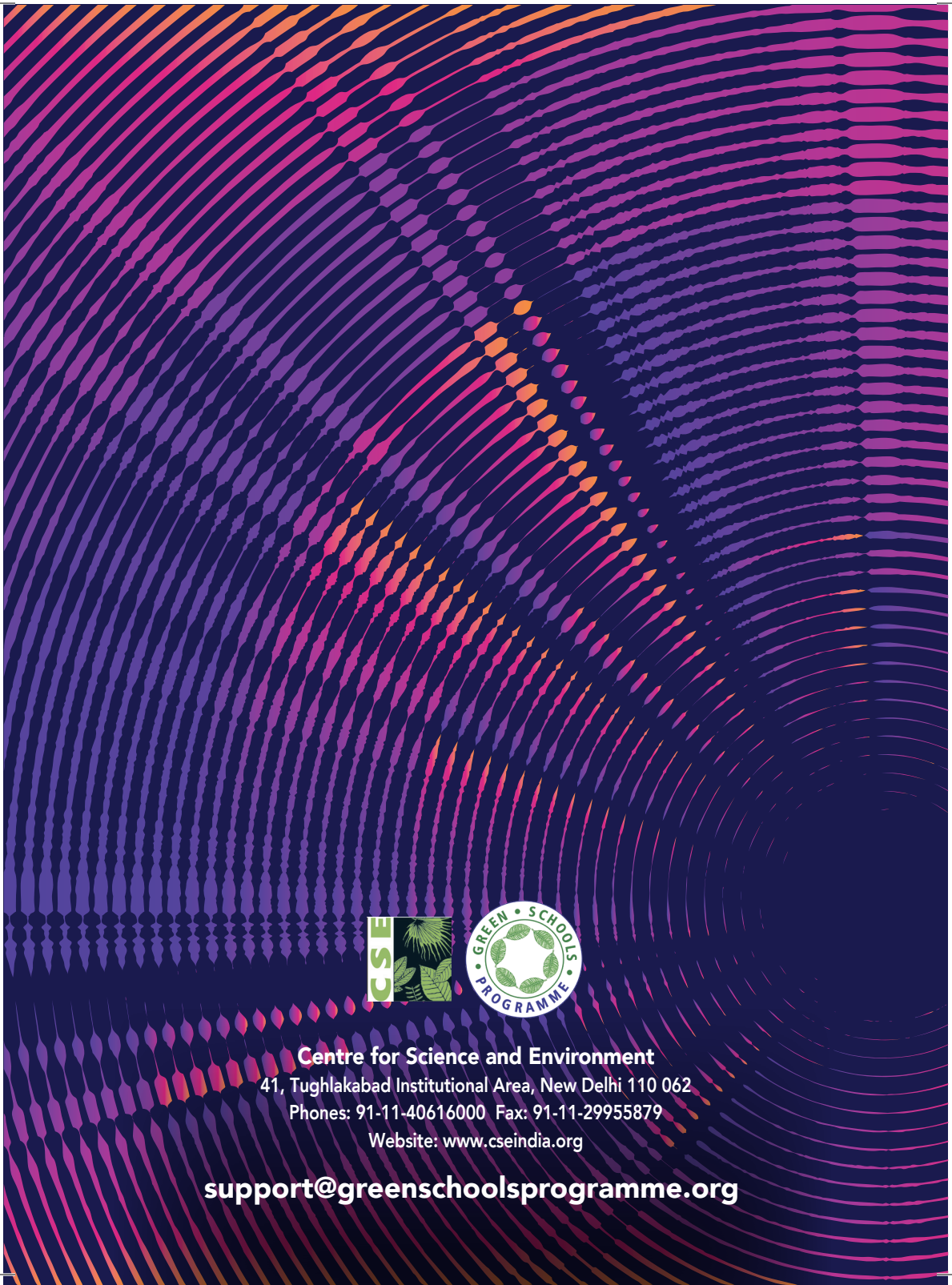

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