HOW GREEN IS YOUR SCHOOL?

REthink Energy

GSP MANUAL FOR ENERGY AUDIT

ANIL AGARWAL 1947–2002

'Environmental literature being generated for schoolchildren is, with some exceptions, in the genre of nature education. It is very important to expose young children to the beauties and wonders of nature. But as they grow older, it is important they begin to understand how human beings and human societies interact with their environment for their survival and their growth, how these human–nature interactions become a part of a society's culture, and why it is important to rationalize our relationship with our environment.'

Anil Agarwal
Founder-director, CSE

GREEN • SCHOOLS • PROGRAMME

A manual to assess the energy performance of your school

www.greenschoolsprogramme.org

CSE

CENTRE FOR SCIENCE AND ENVIRONMENT

GREEN SCHOOLS PROGRAMME
A manual to assess the energy performance of your school

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This publication is completed under the project 'Solar on Schools' (SOS) financed by GiZ commissioned by the Government of the Federal Republic of Germany.

Published by
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Printed at Multi Colour Services, New Delhi

Preface

We started the Green Schools Programme (GSP) with a simple idea.

We know that environmental challenges are growing; we also know that the challenge, however enormous, will need each one of us to get involved. It will need us to change the way we manage natural resources—to alter our consumption patterns so that we can do more with less—and innovate with current technologies so that we can improve the environment around us.

We wanted to develop a programme that would help us learn. Not just the idea but the practice of making change 'work'. We believe that it is always best to learn by doing. It is always best to do by learning.

It is this simple idea we converted into the Green Schools Programme (GSP).

CSE's GSP goes beyond nature education to get children to evaluate and precisely measure their school's environmental footprint through the GSP Audit.

The GSP Audit provides students an opportunity to learn about the environment not by memorizing yet another textbook, but by 'doing'. Students, under the supervision of their teachers, leave the classrooms to engage in various activities outside—counting, weighing, measuring, exploring, investigating and analysing—to help them understand the impact their actions and inactions have on the environment. Participating schools have learnt that what they know is not enough to protect the environment and what they preach is often not easy to practise. But they have also learnt the rationale of what they should do that will make a difference in the world.

This is the idea in practice. We know people all over the world are learning, to their horror, that they have no idea of what it means to be 'sustainable'. That in spite of all they did and thought they did, the disaster of climate change is real, and definitely happening. They are realizing that combating this global challenge means reinventing what is considered to be good environmental management.

For us, this is not a rating programme for ranks, marks or awards. It is a learning programme for building a new generation of people who are prepared to change the future. The consumers of tomorrow will have even less of a chance to correct the mistakes they will inherit from us. We are leaving behind a pretty bad world for them. But we know that they can make a difference if they can distinguish between the different shades of green—believing but not practising and practising but not making a difference.

We hope that our idea will work. We hope you will be engaged with us in being the change we believe in.

Sunita Narain
Director General, CSE

Contents

What is the Green Schools Programme?

A green school is a resource-efficient building—one that uses water efficiently, optimizes energy efficiency, minimizes waste-generation, catches and recycles water, and provides healthier space for its occupants as compared to a conventional building.

Participating in the GSP Audit will:

- Spur the growth of a more environmentally aware and responsible generation of citizens;
- Equip resourceful teachers to foster environmental literacy;
- Help the school community understand the scope and significance of their role in the sustainable use of natural resources within the school campus;
- Nudge everyone to get on with the job.

WHY RENEWABLE ENERGY?

With continued economic expansion and urbanization, India's demand for energy rises by 5 per cent every year. Rapid growth in electricity consumption and carbon footprint is expected, as coal production is set to increase from the current 453.10 million tonnes to a staggering 1.5 billion tonnes by 2020.

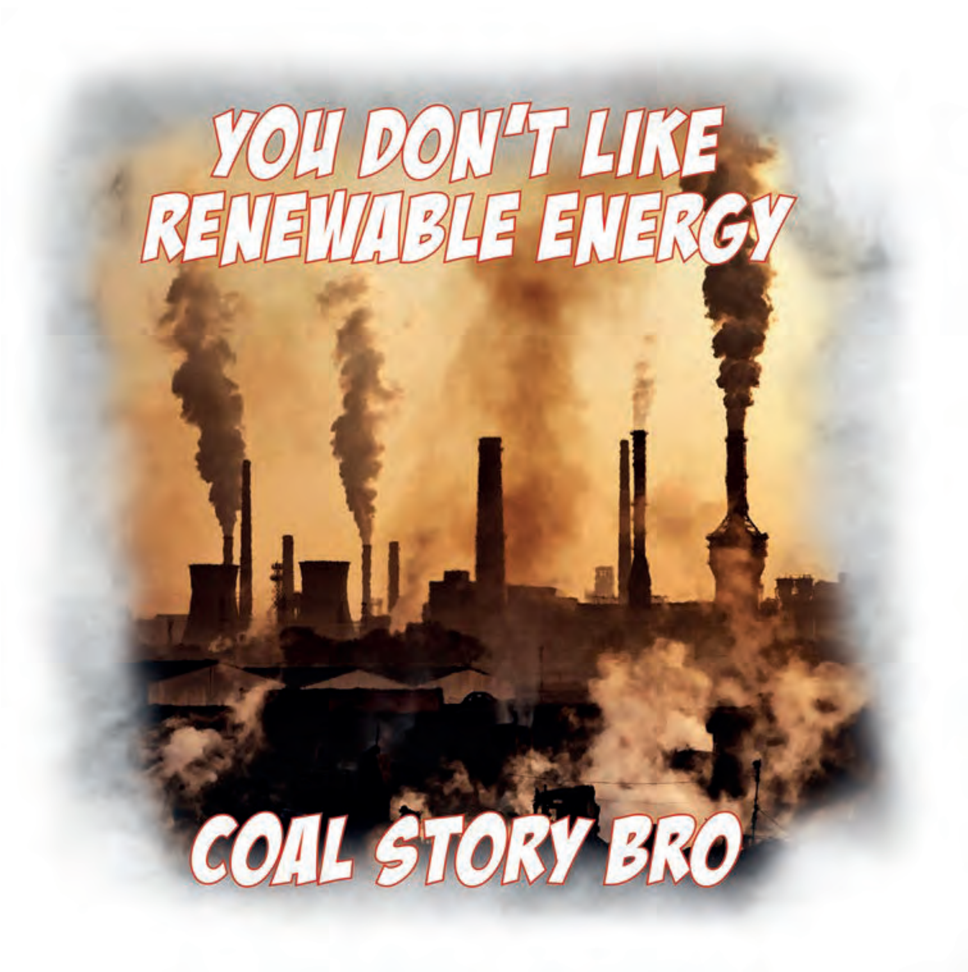
To offset emissions from polluting sources, transition to renewable energy (RE) is urgently required.

Schools depend on conventional sources to meet their energy requirements and a shift to RE will go a long way in providing environmental and economic benefits. The examples included here demonstrate that changes in energy consumption such as transitioning to solar, using bio-pellets or switching to light-emitting diodes (LEDs) helps in energy management and conservation. In fact, an environmental audit of 1,700 schools done by GSP in 2018 revealed that only 13 per cent of schools operate on solar energy, indicating that the huge potential of solar rooftop at educational institutions remains untapped.

This publication aims to educate students about sustainable practices regarding, and conservation of, energy to help create a better future. It contains tools to assist students in performing an energy audit of their schools to find out what sources of energy are used and whether this energy comes from renewable or non-renewable sources. For schools where solar panels have been installed, additional questions have been included to enhance the students' understanding of the value of the solar installations. Case studies, short stories and comic strips have been included to enhance the understanding of energy management and the need to move away from non-renewables.

We hope that the GSP manual for energy audit will be instrumental in bringing about a change in the way energy is consumed and managed.

Should you have any questions, please feel free to write to:
support@greenschoolsprogramme.org



Section I: Profiling and audit

General questions (GQ): All questions in this section are compulsory. The school contact details should match with the details provided during the time of registration with the GSP.

1. UDISE Code of the school: ____________________

____

(Unified District Information System for Education)

2. Name of the school: ____________________

3. Address of the school/institution: ____________________

City/district: ____________________

State: ____________________

Pin code: ____________________

Country: ____________________

School's landline/telephone (STD): ____________________

School's email: ____________________

4. Name of principal (Ms/Mr/Mrs/Dr): ____________________

Principal's email: ____________________

Principal's mobile number: ____________________

5. GSP co-ordinator's name/name of teacher responsible for GSP: ____________________

GSP co-ordinator's email: ____________________

GSP co-ordinator's mobile number: ____________________

6. Please select the appropriate category for your school.

- ☐ Day scholar (6 hours)
- ☐ Day boarding (8 hours)
- ☐ Residential (24 hours)
- ☐ Day scholar + Day boarding
- ☐ Day boarding + Residential
- ☐ Day scholar + Residential
- ☐ Day scholar + Day boarding + Residential

(*If 60—or 75—per cent of your school's population belongs to one category and the balance to another, select the category to which the majority of students belong. For example, if 75 per cent of the students are day boarders and 25 per cent are residential, select 'Day boarding'.*)

7. How many shifts does your school have?

- ☐ Morning
- ☐ Evening
- ☐ Both

Not applicable in the case of residential schools.

8. How many levels does your school have?

(*Please choose what is applicable*)

Lowest level of grade: ______________________________

Highest level of grade: ______________________________

9. Is your school single gender or mixed gender?

- ☐ Only boys
- ☐ Only girls
- ☐ Mixed/co-education

10. Which board of education does the school follow?

(*Please choose what is applicable or select 'Other' and specify*)

- ☐ State Board of Education (*please specify your state*)
- ☐ Central Board of Secondary Education
- ☐ Indian Certificate of Secondary Education
- ☐ International Baccalaureate (IB)/International General Certificate of Secondary Education (IGCSE) combination
- ☐ Other (*please specify; e.g., school-specific curriculum board of education, open learning*)

11. What is the total population of the school?

1.	Students	(M) __________	(F)__________
2.	Teachers	(M) __________	(F)__________
3.	Non-teaching staff (*housekeeping, support staff, management staff*)	(M) __________	(F)__________
	Total	(M)__________	(F) __________ = ______________

11a. How many members of families stay on the campus: ______________________

(*This question is compulsory for residential schools and any combination where residential services are provided by the school. Count all families and write a consolidated number. Children of families staying on-campus but studying in the same school should be part of students' population.*)

11b. How many visitors does the school receive?

____

12. How many working days a year does the school have?

____

(*On an average, a regular school runs for 220–230 days annually. Residential schools can deduct the number of days of holidays/vacations for students.*)

13. Please select the month(s) in which the GSP Audit was carried out?

Months	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Response												

14. Where is the school located?

☐ Urban area
☐ Rural area

15. What type is your school?

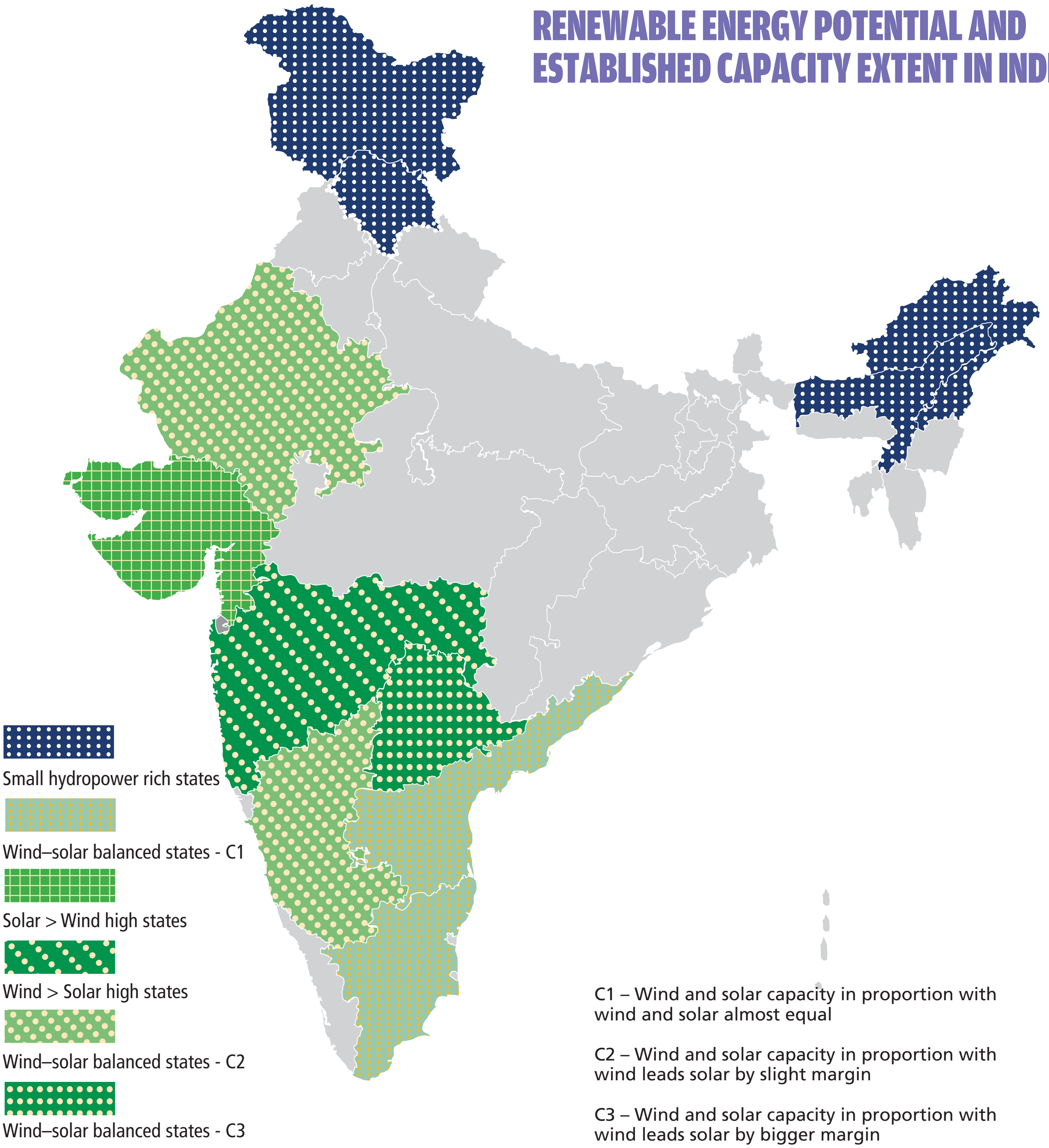
☐ Government
☐ Government-aided
☐ Private

According to the Census of India, an urban area has a municipality, corporation, cantonment board or notified town area, a minimum population of 5,000 and a population density of 400 per square kilometer or above. The conceptual unit for urban areas is a 'town', whereas for rural areas it is a 'village'. The classification of an area as an urban unit in the Census of India 2001 is based on the following definition:

- All places declared by the state government under a statute as a municipality, corporation, cantonment, cantonment board or notified town area committee, etc.;
- At least 75 per cent of the male working population engaged in non-agricultural economic pursuits.

As in the past censuses, well-defined outgrowths (OGs) of statutory towns have also been included in the extended urban area. Any area which is not covered by the definition of urban is rural.

RENEWABLE ENERGY POTENTIAL AND ESTABLISHED CAPACITY EXTENT IN INDIA



C1 – Wind and solar capacity in proportion with wind and solar almost equal

C2 – Wind and solar capacity in proportion with wind leads solar by slight margin

C3 – Wind and solar capacity in proportion with wind leads solar by bigger margin

Source: Enincon Research and Analysis

Energy audit

Mission GSP

GSP focuses on auditing consumption of non-renewable sources of energy in school premises. This section establishes the current consumption levels and practices of schools in the context of various sources of energy. The teachers will get an opportunity to educate students about sustainable practices and the students will learn how saving energy can help us reap a better future.

Task 1 Choose your energy audit team.

Task 2 Find out how much energy your school consumes.

Task 3 Find out how much energy the school derives from each type of energy source.

Task 4 Ascertain whether your school is using renewable sources of energy.

TASK 1 CHOOSE YOUR ENERGY AUDIT TEAM

The school administrative staff must be member(s) of your team as you would require electricity bills, fuel consumption bills, etc. Other support staff members, such as generator attendant and electricians, are also important contacts. It would be a good idea to rope in a physics or science teacher as well and, most importantly, a team of five to 10 of your schoolmates in your energy audit team.

REMEMBER TO METER ALL SOURCES OF ENERGY. THIS IS THE FIRST STEP TOWARDS SAVING ENERGY.

Teacher: ____________________

Administrative staff: ____________________

Students: ____________________

____

____________________ Date: __________

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THE UNIT OF MEASUREMENT TO BE USED IN THE ENERGY SECTION: MEGAJOULE (MJ).

TASK 2 FIND OUT HOW MUCH ENERGY YOUR SCHOOL CONSUMES

- Before answering these questions, please collect all the bills that your school receives for its energy consumption, e.g. electricity, fuel and gas bills. If the frequency of any energy consumption bill is fortnightly, bi-monthly, quarterly or half yearly, try to convert them into monthly averages.
- Take an average of the bills for a minimum of four months, e.g. January to April.
- **Electricity:** The audit team will have to get in touch with the administrative staff in the school office to procure the electricity bills.
- **Diesel:** Ask the generator attendant to show you the log book of fuel consumption and find out how many litres are being used. If diesel is being used for transport, the transport in-charge will have the register or log book with details about the amount consumed and cost paid. Remember the energy output of a generator would be taken only in terms of input, i.e. fuel used.
- **Liquefied petroleum gas (LPG):** Ask the mess or canteen staff how many cylinders are used in one month on an average. Remember, each gas cylinder generally weighs 14.2 kg.
- **Piped natural gas (PNG):** If the school has a PNG connection, ask the mess or canteen staff for a copy of the PNG bill, which is usually raised once or twice in a quarter-year.
- Make similar estimates for other fuels.

REMEMBER TO METER ALL SOURCES OF ENERGY. THIS IS THE FIRST STEP TOWARDS SAVING ENERGY.

Does your school get electricity bills? Yes ◯ No ◯

Does your school have its own vehicles? Yes ◯ No ◯

In 1878, Thomas Edison invented the light bulb after trying more than 1,600 different filaments, including hair from an assistant's head!

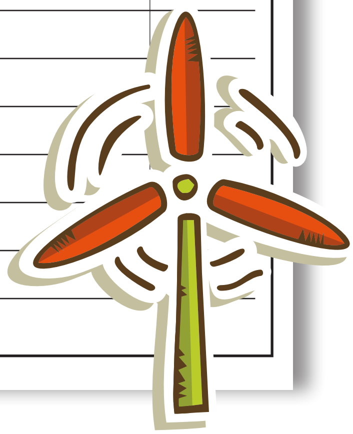
ONE HOUR'S WORTH OF ENERGY FROM THE SUN COULD POWER THE EARTH FOR A YEAR

TASK 3 FIND OUT HOW MUCH ENERGY THE SCHOOL DERIVES FROM EACH TYPE OF ENERGY SOURCE.

TABLE 1: Total energy consumed by the school

Source of energy	Quantity consumed or monthly average	Energy consumed Megajoules (MJ)*	Use
Electricity from the board	kwh		
Electricity from generator (diesel)	litres		
Petrol	litres		
Diesel	litres		
CNG	kg		
Kerosene	litres		
Coal	kg		
Wood	kg		
Animal waste	kg		
Solar	kwh		
Wind	kwh		
LPG	kg		
PNG	litres or standard cubic meter		
Bio-fuel	litres or standard cubic meter		
Others (specify)			
Total			

Note: *For conversion tables, please see Annexure; in the online GSP Audit, conversion calculation will be done automatically



Tooltip: *Mention the use in the above table:- 1. Lighting 2. Housekeeping 3. Cooking 4. Transport 5. Teaching or learning aid 6. Burning or incineration of waste. If your school does not use a particular source of energy, write 0.*

BURNING FOSSIL FUELS PLAYS HAVOC WITH OUR HEALTH AS WELL AS THE HEALTH OF THE PLANET. EXPOSURE TO POLLUTANTS RELEASED CAUSES HEADACHES, NAUSEA AND CARDIOVASCULAR AND RESPIRATORY DISORDERS.

TABLE 2: Appliances used by your school

Item	Number	BEE star rating	Size	Working	Non-working
ETVs					
VCR or DVD players					
Refrigerators and freezers					
Washing machines					
Air conditioners					
Heaters					
Microwaves					
Ovens					
Toasters					
Electric kettles					
Personal computers (CPU, mouse, screen and keyboard included)					
Laptop computer (CPU, mouse, screen and keyboard included)					
Notebook computers					
Notepad computers					
Printers					
Photo copying equipment					
Projectors					
Whiteboards					
Electrical and electronic typewriters					
Fax machines					
Telex					
Mobiles					
Answering systems					
Induction cookers					
Geysers and water heaters					

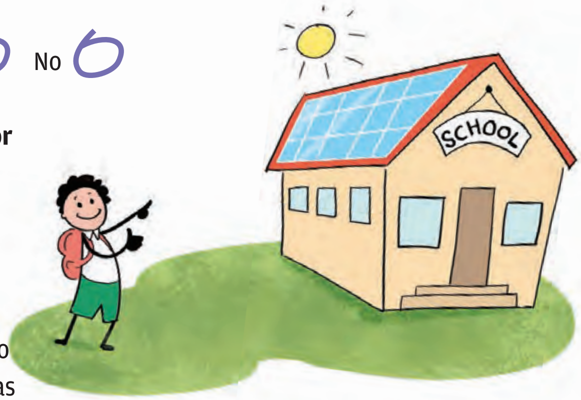
TASK 4 ASCERTAIN WHETHER YOUR SCHOOL IS USING ANY RENEWABLE SOURCES OF ENERGY

What is the average number of sunny days in your area? ____________________

Does your school use solar water heater(s)? Yes ◯ No ◯

Have any alternate sources of energy been employed or installed at your school?

Yes ◯ No ◯



If yes, do you use:

- ☐ Solar
- ☐ Wind
- ☐ Hydro
- ☐ Combination of solar and wind
- ☐ Biogas

Tooltip: *Do not add solar water heater(s) here. Consider only solar panels providing electricity.*

In case your school uses renewable source of energy, please answer the following questions.

TASK 4.1 ADVANCED QUESTIONS FOR THE ENERGY SECTION

Did your school avail any state subsidy for installation? Yes ◯ No ◯

(A) Solar rooftop systems

What is the installed capacity of solar photovoltaic (PV) panels on the school rooftop (in kW)?

____

Tooltip: *Installed capacity is rated (full-load) generation capacity of a power plant. A solar rooftop plant's capacity, being small, will be expressed in terms of kilowatt (kW). The information on installed capacity will be available on the solar rooftop plant's online performance monitoring system. Alternatively, it would also be mentioned in the order for installation placed with the solar rooftop installer or vendor.*

What is the connected load of the school (kW)?

____

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

Penetration of RE is defined as share of RE installed capacity in the connected load

What is the size of invertors associated with the solar photovoltaic panel (kVA)?

____

Tooltip: *Inverters are required to convert the direct current (DC) output generated by solar rooftop systems or batteries to alternating current (AC) for further use. In general, inverter wattage (expressed in kilo-volt-amperes or kVA) is 20–25 per cent more than the installed capacity.*

> Note: For a 1 kW solar rooftop system, inverters of about 1.2 kVA are required

What operational model has been adopted for the solar rooftop system?

- ☐ Off-grid
- ☐ On-grid net metering
- ☐ On-grid gross metering

Tooltip: *Solar rooftop systems can either be standalone (off-grid) or grid-connected.*

A standalone system is wired only to a house and requires a battery back-up to store any excess power generated, or to meet power deficits. Example: Standalone solar street lights, solar lamps, rooftop panels.

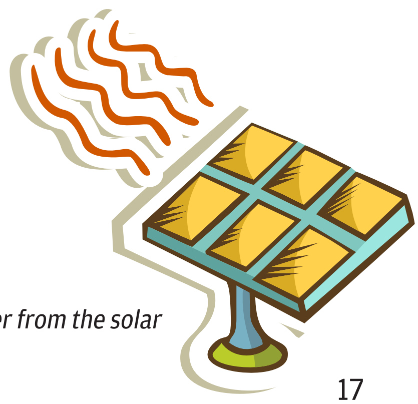
Grid-interactive systems, on the other hand, utilize the grid for storing and extracting electricity, as per the requirement. For example, solar rooftop panels, on-ground solar panels, etc. Interactions with the grid can be facilitated either via gross or net metering.

Under gross metering, all generated electricity is sold to the grid at a feed-in-tariff determined by the state electricity regulatory commission. The consumer continues to procure the required power from the distribution company, as per their tariff bracket. The bills are either settled individually or as net billing.

Under net metering, the consumer uses all the energy produced by the solar rooftop (SRT) system and relies on the grid for any excess energy required. The consumer is only charged for the excess energy they consume, as per their tariff bracket. Any surplus generation can be fed back to the grid.

This information will also be reflected in the electricity bill of the school as a net-metering billing would only be for net consumption.

Generally, on-grid systems have the benefit of transferring surplus power to the grid, while in off-grid systems surplus power may get wasted if there is not enough battery storage available.



What is the power generated by the solar rooftop panel in a year (kWh)?

____

Tooltip: *Information on power generation by the solar rooftop system can be sourced either from the solar rooftop plant's online performance monitoring system or from the electricity bill.*

Select the operation and maintenance (O&M) practices that have been adopted for the solar plant:

☐ Wet cleaning at least once a week
☐ Dry cleaning daily
☐ Annual maintenance contract with the vendor for maintenance of electrical and other technical components
☐ Regular monitoring of the integrated software and real-time tracking of performance (*usually through a smart phone or computer*)

Tooltip: *Solar rooftop systems require periodic cleaning as accumulation of dust can lead to significant decline in performance.*

If your school uses non-solar renewable sources of energy, please answer the following questions.

TASK 4.2 ADVANCED QUESTIONS ON OTHER RENEWABLE ENERGY SYSTEMS

What is the non-solar source of renewable energy (RE) at the school?

- ☐ Bio-fuel
  - ☐ Biogas
    - ☐ For electricity
    - ☐ For cooking
  - ☐ Biomass
- ☐ Wind
- ☐ Small hydro
- ☐ Other

  Provide details: ______________________________
- ☐ Not applicable

What is the installed capacity of non-solar RE system in your school (kW)?

____

Tooltip: *Installed capacity is rated (full-load) generation capacity of a power plant.*

What is the connected load of the school (kW)?

____

Tooltip: *The connected load of a consumer is the load in kilowatt (kW) which the power distribution company has agreed to supply to the consumer.*

What is the size of invertors associated with the non-solar RE system (W)?

____

How much power is generated by the non-solar RE system in a year (kWh)?

____

Tooltip: *Information on power generation by the non- solar RE system can be sourced from the performance monitoring system or from the bill.*

Select the operation and maintenance (O&M) practices that have been adopted for the RE plant:

- ☐ Annual maintenance contract with a vendor for maintenance of electrical and other technical components
- ☐ Regular monitoring of the integrated software and real-time tracking of performance (usually through a smart phone or computer)

If your school uses bio-fuels, please answer the following questions.

TASK 4.3 ADVANCED QUESTIONS ON BIO-FUELS

What are the different types of biomass used by the school?

- ☐ Food waste
- ☐ Animal solid waste (cow dung, etc.)
- ☐ Wood chips and pellets
- ☐ Grass, straw and dry leaves
- ☐ Others

How much waste is utilized by the biomass plant in a day (in kg)?

____

For what purpose(s) is the energy from bio-fuel generated in school, used?

- ☐ Electricity
- ☐ Heating
- ☐ Cooking

IF BIOGAS IS BEING USED FOR COOKING, ANSWER THE FOLLOWING QUESTIONS:

What is the approximate capacity of the biogas unit (in terms of m^3/day)?

____

Tooltip: *Likely to be mentioned on the gasifier itself or the order placed with the vendor.*

Do you add water in the biogas unit? Yes ○ No ○

If yes, what is the quantity of water (in litres) added per kg of waste?

____

What are the components of the biogas unit?

- ☐ Inlet pipe
- ☐ Drum or chamber
- ☐ Outlet pipe
- ☐ Scrubber
- ☐ Gas outlet
- ☐ Gas pump

How many hours of cooking are done per day using biogas?

____

What other fuel sources are used for cooking (LPG or PNG, etc.)?

____

How many hours of cooking are done per day using other sources?

____

Section II: Important information

SOURCES OF ENERGY

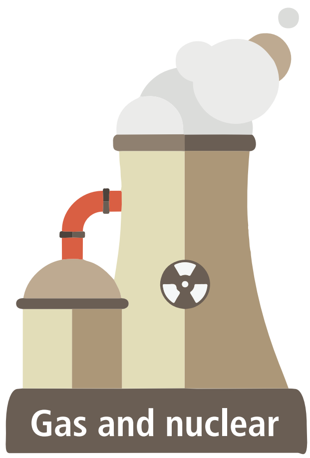
Human civilization has been made possible through the channelling of natural materials and energy. We need energy to survive and thrive. Broadly speaking, the energy we utilize has been classified into two categories:

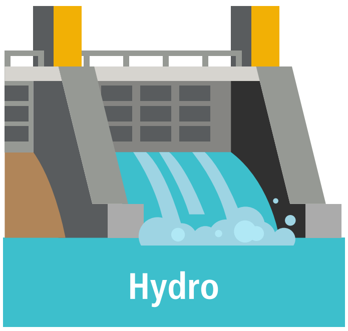
- Renewable energy is inexhaustible and includes the energy harnessed from such sources as the sun, wind and water. Garbage (such as dead trees, branches, and leftover crops), and gobar or cow dung, along with other forms of livestock manure—resources collectively called 'biomass'—can also be sources of renewable sources.

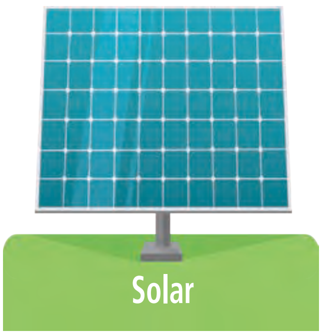
- Non-renewable energy is derived from fossil fuels—oil, coal and natural gas. These fuels were made through a special natural process over millions of years and we are fast depleting them in a matter of years. At present production levels, India has oil reserves only for 19 years, gas for 28 years and coal for about 230 years. Once they are gone, they are gone for good.[1]

Not only are fossil fuels exhaustible, they are also very harmful to human health. The burning of fossil fuels release a complex mixture of gaseous emissions including particulate matter (PM), oxides of nitrogen (NO_x), oxides of sulphur (SO_x), carbon monoxide (CO), surface ozone (O_3) and carbon dioxide (CO_2). Exposure to most of these gases causes both acute short-term effects like nausea as well as chronic long-term diseases such as cardiovascular and respiratory disorders, and lung cancer.

Burning fossil fuels has also contributed greatly to climate change. The impact of 'global warming' has already reached scorching levels and is spreading and deepening rapidly. If we do not cut the use of fossil fuels now, it will bring our civilization to a sudden, shocking halt.







TIPS TO SAVE ENERGY

- In many homes in India, the incandescent light bulb—the one invented by Thomas Edison in 1879—is still used. But compact fluorescent lights (CFLs) and now LEDs are fast taking over because they consume less energy and last longer; hence they are cost-effective. The best way to save energy is to keep your lights off when not in use.
- What about refrigerators, ACs and many other such equipment that we use quite unthinkingly every day? Refrigerators can significantly impact the electricity bill (up to 15 per cent of our power bills could be accounted for by a refrigerator). But they are necessary in every modern home. How can we ensure we make optimal use of a refrigerator? Simply by using it carefully. Place the refrigerator in a place where it gets adequate, well-ventilated space to increase its cooling efficiency. Do not keep the refrigerator door open unnecessarily.
- Ceiling fans consume more electricity compared to light bulbs, but are not paid enough attention when we think of saving power. A regular unrated ceiling fan can consume 75 watts of power, whereas the thickest tubelights consume 40 watts.
- The thickness of a tubelight is directly proportional to its power consumption. The thicker a tubelight is, the more electricity it consumes. Ultra-slim tubelights are not only stylish, they also consume less power.
- We waste about 7–10 per cent of electricity through appliances that are in the standby mode. We can save this amount of power simply by turning off the switch once the device is no longer being used.
- If the flame of a cooking stove in your house burns yellow, it means there is impartial combustion and this produces gases that are harmful for your health. Cleaning the stove regularly can help save energy and lessen emissions.

Energy Matters, Gobar Times, August 2016, p 68

UNEQUAL DISTRIBUTION OF ENERGY

Energy, like everything else, is not equally distributed all over the world and between people. While sections of the society in some countries use large amounts of energy, others hunger for even a light bulb. For example, in 2013–14, the per capita consumption of electricity in India was 957 units; in the US it was 12,954 units. As per government data, over 30 lakh homes in India continue to be in the dark (as they are not electrified). As the world moves towards 'cleaner' forms of energy (RE), we cannot expect the poorest to make that shift without making the distribution of energy more equitable. A poor villager using fossil fuels for cooking cannot be blamed for greenhouse emissions and squandering away precious resources unless and until she is given an affordable, easy-to-use alternative. A rich businessman flying a private jet for a vacation cannot make the same excuse.

In addition, access to energy opens up millions of opportunities for the underprivileged—economic, educational, cultural, etc. It is, therefore, fitting that conservation of energy and fighting climate change be combined with the dream of 'energy for all'.[2]

INDIA'S ENERGY SCENARIO

Coal-based power has the largest share (57 per cent) in India's total electric power capacity (which is 360 GW), while large hydroelectricity plants and gas and nuclear power plants contribute only about 13 and 10 per cent to this capacity respectively. In total, renewable energy contributes about 20 per cent of the country's total electricity capacity.[3]

Although wind, solar, biogas and water are all renewable energy sources of power, solar energy is considered the most affordable alternative to polluting fossil fuel-based power. Easy installation and electricity generation also make solar energy the best bet among renewables. India has a target of setting up 100 gigawatts (GW) of installed capacity from solar by 2022. According to a 2018 study published by the University of Technology (LUT), Finland, India has the capacity to operate entirely on renewables by 2050.

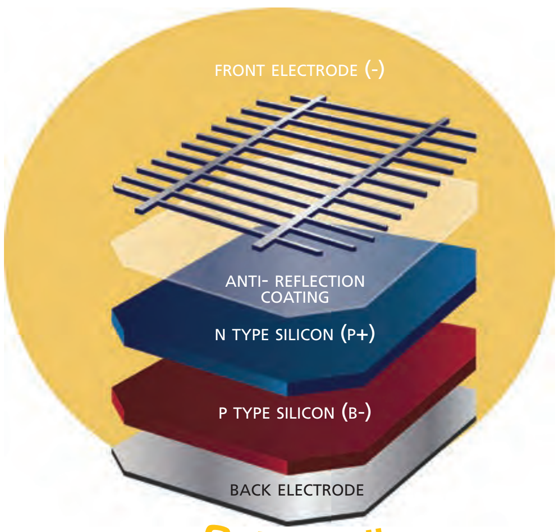
A country like Scotland has gone a step ahead and now two-thirds of its electricity needs are fulfilled by renewable sources of energy. Ireland, too, has stopped investing in fossils! If they can do it, so can we.

SOLAR ROOFTOPS IN SCHOOLS

A one kilowatt (kW) rooftop system requires a shadow-free area of at least 10 square metres that can produce three to five units of electricity a day. Most parts of India receive enough solar radiation for 300–350 days a year. Therefore, even a school with a 5 kW solar rooftop can easily save money by reducing its dependence on the power grid. The less we consume from the grid, the more we save on the electricity bill.[4]

HOW DO SOLAR PANELS OPERATE?

Solar panels, each lined up with 60 or 72 photovoltaic (PV) cells convert sunlight into solar energy through a process called the photoelectric effect, which was discovered by Edmund Bequerel, a French physicist. He found that certain materials produce small amounts of electric current when exposed to light. When PV cells are exposed to sunlight, they displace electrons from atoms of the specific material used, generating a flow of electricity. A single PV cell can generate 4–4.5 watts of power, while an entire module can produce 320 watts of power. Tempered glass is placed on the top of the cells since a transparent layer traps more light.



Solar cell

BENEFITS OF GRID-CONNECTED SOLAR ROOFTOP SYSTEM

A. Monetary benefits

Installation of grid-connected solar rooftops requires an initial investment by the consumer, but it pays back soon enough. Here is how:

1. Benchmark cost of rooftop solar system: Rs 60,000/kW
2. Central financial assistance: Rs 18,000/kW
3. Net cost to consumer: Rs 42,000/kW
4. A 1 kW system usually generates about 1,200–1,500 units per year
5. Savings per annum: Rs 6,000–Rs 7,500 per year, considering that the average tariff is Rs 5 per unit
6. Payback period: Five–seven years (at the most)[6]

B. Environmental benefits

Globally, for every unit of power consumed (in kWh), 800 g to 1 kg CO_2 gets released into the atmosphere. Just ask for the electricity bill at home and check the units consumed. For example, if the monthly consumption is 450 units, it would add up to 450 kg of CO_2 emissions.

Now imagine that your house is operating completely on solar energy, you would prevent over 5,000 kg of CO_2 emissions in a year as solar energy does not emit CO_2.[7]

At the rear end, there is a sheet usually coated in white so that there is no loss of energy through heat radiation. Electricity generated from this solar panel is made to pass through an inverter first, and then distributed to different points for running appliances at home and elsewhere. In case energy produced by the solar panel exceeds usage, the surplus flows into the main power grid and an equivalent amount can be drawn back later from the grid.[5]

END OF LIFECYCLE

Solar panels are a boon, but after they reach the end of their lifecycle (approximately 30 years), they need to be disposed of. Constituents of solar panels include silicon solar cells, metal framing, glass sheets, wires and plexiglass (a kind of polymer), etc. Most of these components can be recycled and reused. Responsible disposal also prevents leakage of toxic heavy metals into landfills and dumpsites. While it is a good idea to install solar panels, it is equally important have a recycling plan ready.

Examples from GSP schools

Of the 1,700 schools that have so far participated in the GSP Audit across the country, only 13 per cent operate on renewable energy like solar and bio-fuel, etc. Here we list emulation-worthy practices at a few of them.

CASE STUDY 1: Birla Balika Vidyapeeth, Pilani, Rajasthan

A residential school with a population of 850, the average total monthly energy consumption of the school was 68,242 kWh. All of it was met by Rajasthan State Electricity Board (RSEB), Pilani. The sources of this energy were conventional (fossil fuel-based). Being in a state that receives abundant sunlight year round, the management planned to tap the power of the sun to meet the school's energy needs.

In 2017, the management of BET (Birla Education Trust) entered into an agreement with an agency, Sun Waves Infrapower, Jaipur to pay them Rs 4.40 per unit electricity generated for the next 25 years, since no payment was made to the company for installation of the rooftop solar.

Good news

Following the installation, the school's dependency on electricity supply from the power grid decreased by almost 35 per cent. The school's polluting diesel generators (three in number), which it used to supply electricity during power cuts, have been replaced by clean and cheap solar backup. The school also saved Rs 3,19,981 per month from their switch to solar!

Other than cost savings, schools are also finding that such systems provide a unique educational opportunity for students in terms of practical knowledge through live demonstrations, field work and science projects

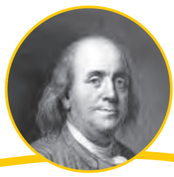
Bio-pellets used at the school

CASE STUDY 2: New Digamber Public School, Indore, Madhya Pradesh

The school used to cook midday meals for students using LPG that was expensive and consumed a substantial amount of the fossil fuel.

To deal with the high consumption of LPG—about 155–160 cylinders were used per month—the school partially shifted to biomass pellets in 2013, reducing the consumption of LPG to 105–110 cylinders a month. Biomass pellets are made from agricultural waste and the school buys them from First Energy Pvt Ltd, Pune.

A brief history of inventions related to electricity

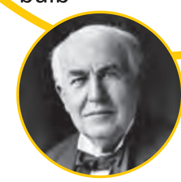


1752
Benjamin Franklin invented the lightning rod and demonstrated the connection between lightning and electricity

1800
Alessandro Volta developed a device for storing electricity, that is, battery. The 'volt' is named in his honour

1867
Michael Faraday invented the induction ring which eventually led to the invention of electrical transformers and motors

1879
Thomas Alva Edison invents the incandescent bulb



Good news

Since 2013, when the school started using bio-pellets, 3,000 LPG cylinders have been saved. Moreover, the cost of 1 kg of bio-pellets is Rs 18 while a kg of LPG costs Rs 76.3. Around 2.5 kg of bio-pellets provide the same energy as 1 kg of LPG. This means that the total yearly savings from use of bio-pellets is Rs 2,81,750.

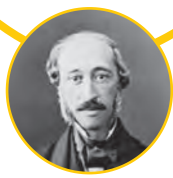
The impact and effect of these practices has also been seen on students as they have become more aware and sensitized about the benefits of saving energy.

For more such stories, read CSE's publication *Paving the Path: A selection of best environmental practices in schools across India*.

Schools recognize the importance of not only using renewable sources of energy but also of the efficient management of electricity. Conventional lights like incandescent bulbs consume six to seven times more energy compared to LEDs. Schools like **CMS LP School Ennooramvayal, Kerala** and many others that were winners in the energy category of the GSP Audit have put these basic practices in place.

1884
Nikola Tesla invented an electric generator that produced alternating current (AC). Until this time, electricity had been generated using direct current (DC) from batteries

1839
Alexandre-Edmond Becquerel discovered the photoelectric effect that would pave the way for PV technology used in solar panels



1954
Daryl Chapin, Calvin Fuller and Gerald Pearson of Bell Labs develop the first silicon photovoltaic (PV) cell

Gobar Times, June 2019, p 88–89

AUDIT CHAMPS!

The following GSP award winning schools have also shown exemplary improvements in energy utilization.

DAV International School, Amritsar, Punjab: A change-maker school; in 2018, it decreased its electricity consumption from 103,658 MJ to 45,810 MJ (that is 50 per cent reduction in bill amount) by going solar and through judicious use of energy at the school campus. This was a result of replacement of old appliances by new efficient ones—500 tubelights were removed; 74 hot cases each of 4,000 W were replaced by 2,000 W each hot cases; and 12 surplus LED and CFL lights were removed. Moreover, strict monitoring and reduction in the running time of the electric appliances allowed the school to save 15,000 units of electricity a month.

Kendriya Vidyalaya, New Majri, Maharashtra: The school received an award in the energy category in 2018. It installed solar panels in 2017 and since then the electricity demand—approximately 450 kWh (units) per month—is met by them. The school introduced LED lights (158), increased the number of CFL bulbs (15 to 21 from 2017 to 2018) and does not use conventional tubelights.

East Point School, Delhi: The school won the award in energy section after the GSP Audit in 2017. It meets more than half of its energy requirement by solar power.

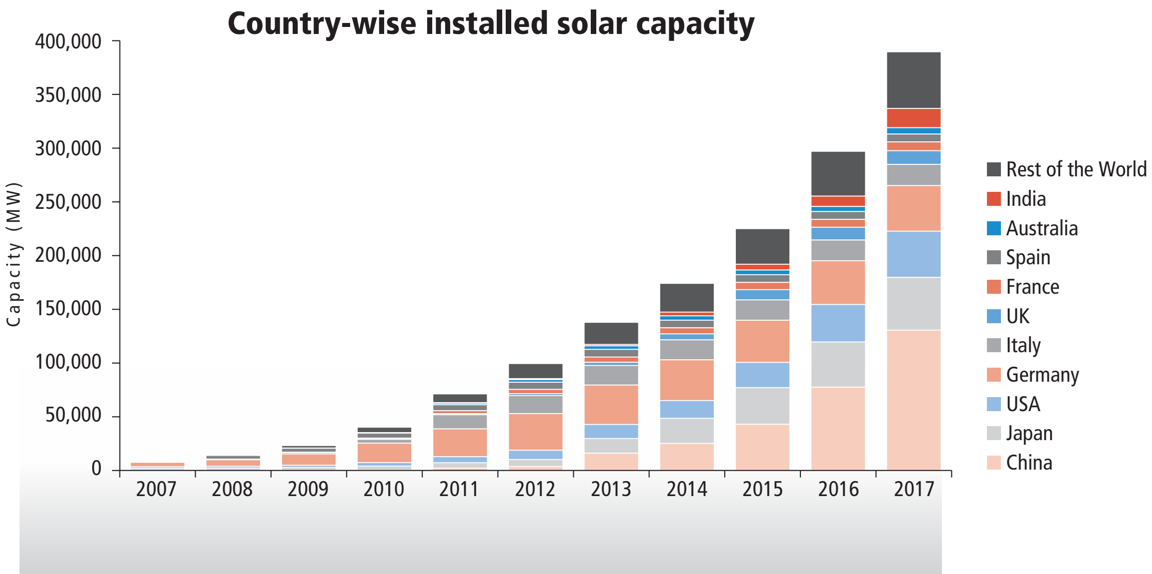
Kendriya Vidyalaya Ottapalam, Kerala: Another change-maker; it won the GSP award in 2017. The school uses both solar power and bio-fuel. The biogas plant at the school has a waste storage capacity of 50 kg and can produce upto 10 kg of gas. The plant is also used for experiments in the chemistry lab. The school doubled its solar capacity to 400 kWh in one year.

Fab India School, Pali, Rajasthan Yet another winner of the GSP Audit of 2017, it increased its solar power plant capacity from 3.5 kWh in 2016 to 13.5 kWh in 2017, thus meeting 90 per cent of the electricity demand.

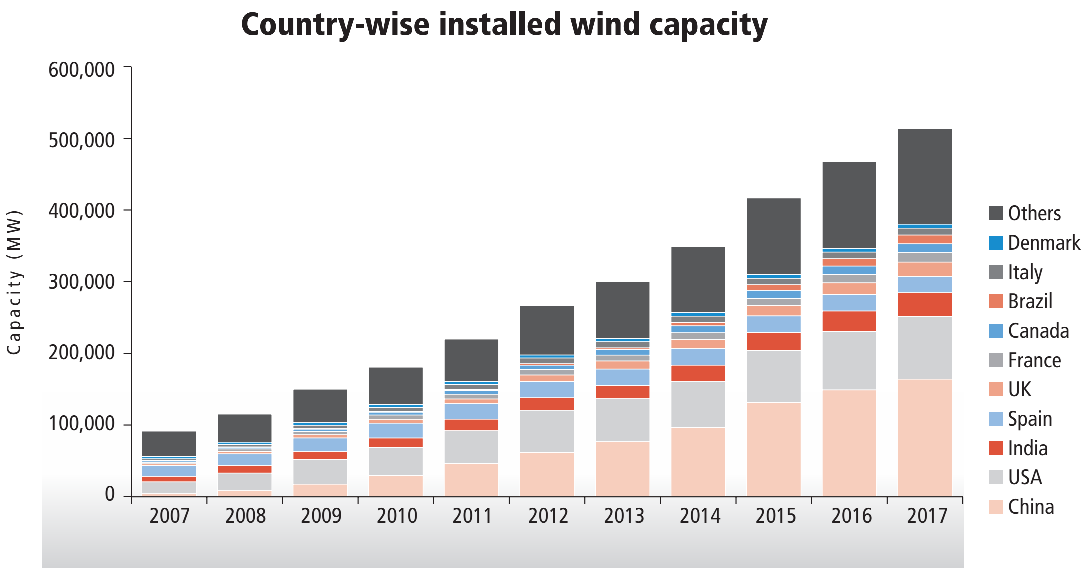
DID YOU KNOW?

- India currently has the world's third and sixth largest wind and solar installed capacities, respectively.[8]
- The first step towards saving energy is to meter all sources of energy used.
- Renewable capacity (wind, solar power—ground-mounted and rooftop—small hydropower, biomass, waste-to-energy, biomass gasifiers and SPV systems) in India has registered a sharp growth, and stands at 74.8 GW as of November 2018, up from 36.5 GW in March 2014.[9]
- While the push to expand renewable capacity has come from Central government-driven policies, the sector's growth has been unevenly distributed across states. The southern states are together home to almost 50 per cent of the installed capacity in the country, though their collective potential is only 8 per cent of the country's total. The western states—Gujarat, Madhya Pradesh, Maharashtra and Rajasthan—have some of the highest potential in the country.[10]
- Cleaner energy access encompasses fuel used for cooking; 63 per cent of India's population continues to rely on traditional biomass (firewood, crop residues and cow dung cakes) that cause indoor pollution and has serious health impacts. Studies have found women and children to be disproportionately affected.[11]
- Currently, the share of electricity—the cleanest cooking fuel—in the cooking mix is minimal, especially when compared to the large numbers still dependent on biomass-based cooking. The obvious advantage is to poor households that can get rid of indoor air pollutants if they switch to electricity-based cooking.[12]
- Grid-connected Rooftop and Small Solar Power Plants Programme under the National Solar Mission gives Central financial assistance (CFA) to private schools and educational institutions, of upto 30 per cent of the benchmark cost for general category states and union territories.[13]
- Eleven states that have been granted the special category status—Himachal Pradesh, Jammu and Kashmir, Uttarakhand and seven north-eastern states—can claim 70 per cent of the benchmark cost as CFA for solar rooftop projects.
- Burning fossil fuels releases a complex mixture of pollutants. Exposure to these pollutants causes acute short-term effects, such as irritation of the eyes and headaches, as well as chronic long-term diseases, like lung cancer.
- WHO estimates that 10–15 per cent of Indian children in the 5–11 age group suffer from asthma. It costs an average of Rs 300 per month to buy a child's asthma medicines.
- Ninety per cent of the electricity used by a standard incandescent light bulb is wasted as heat.[14]
- One bus load of people takes 40 vehicles off the road during the rush hour, saves 70,000 litres of petrol, and avoids over 175 tonnes of emissions every year.
- Bureau of Energy Efficiency (BEE) was set up in 2002 under the Energy Conservation Act, 2001 to create policies and develop strategies with a thrust on self-regulation and market principles to achieve energy efficiency. BEE sets the standards and label for marking star-rating of various appliances such as refrigerators, air-conditioners, ceiling fans, computers, televisions, LED lamps, etc.
- We waste about 7–10 per cent electricity to appliances in the standby mode. We can save this power simply by turning them off when they are not being used.
- Global energy consumption in 2018 increased at nearly twice the average rate of growth since 2010, said a recent report released by the International Energy Agency (IEA). The report titled *Global Energy and CO_2 Status Report*, reviewed the trends in energy and emissions in 2018. Its key findings are:
  - 33.1 gigatonnes or 1,012 kg of carbon dioxide was added due to a surge in the energy demand
  - 60 per cent of emissions increase was contributed by the US
  - 30 per cent of all energy-related emissions come from burning of coal for electricity
  - 85 per cent of the net increase in emissions was on account of world's top three energy consumers—China, India and the US

Solar and wind—India has a lot of catching up to do!



Source: International Renewable Energy Agency (IRENA), 2018



Source: International Renewable Energy Agency (IRENA), 2018

GREEN SCHOOLS PROGRAMME

ENERGY

Make your school energy literate

Section III: ACTIVITIES

ACTIVITY I

Ask your parents about the rate of petrol or diesel ten years ago.

Compare the rates and interpret the changes, if any. If your parents cannot give you a proper idea, talk to your teachers and neighbours who owned a vehicle in 2009. Better still, talk to a petrol pump owner.

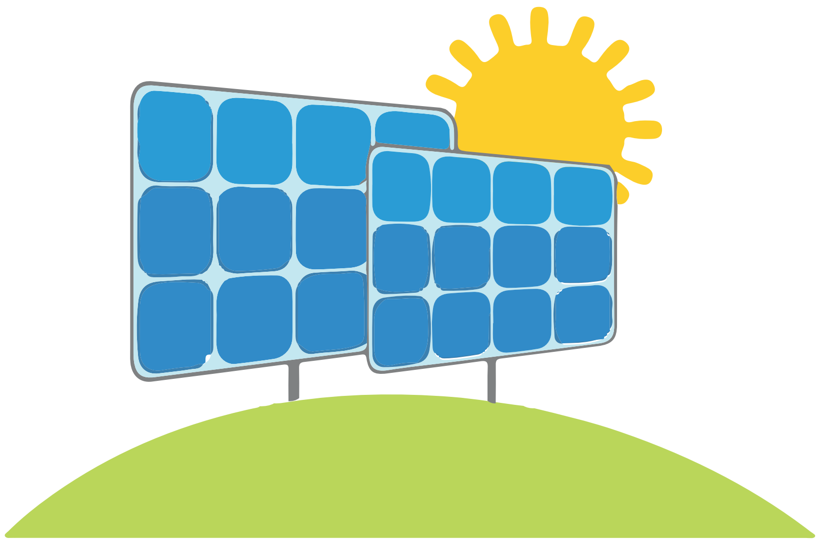
Fuel	Rate		Difference
	2009 (Rs/litre)	2019 (Rs/litre)	
Petrol			
Diesel			

What does the data from the table tell us?

Find out the major crude oil fields in India. Talk to your geography teacher, if you need help.

Find out how much crude oil India produces and how much it imports? Which countries do we import from? Gauge the transportation cost of crude oil from at least one country to India.

Do you think bio-fuels could be of help as far as import and transportation is concerned? How?



ACTIVITY II

In a city like Delhi, one of the main sources of air pollution is the growing number of vehicles. On an average, more than 200 new cars and 150 new two-wheelers are registered in Delhi everyday! Is there any system to monitor their emissions levels? You must have heard about the Pollution Under Control Certificate (PUCC). Ask your parents for the PUCC of the vehicles they own, if any. Else, try to get one from a vehicle owner in your locality. You can also check the PUCC of your school vehicles or the vehicle that drops one of your friends at school. Look for the following:

a. Which department of the government issues the certificate?
b. What are the permissible limits of each pollutant?
c. Go to the nearest petrol pump and locate the pollution-checking booth. Chat with the person who tests vehicles. Take a look at the monitoring machine. Where was it manufactured? Emissions of which pollutants does it check? Are the tests done properly?
d. Find out what happens to the vehicles that fail the test?
e. Look out for stickers with Euro Stage or Bharat Stage written on them. What do they mean?

ACTIVITY III

There are various forms of renewable energy, solar being just one of them. So what makes it the best renewable form of energy (that the future will mostly depend on)? The earth's atmosphere, oceans and land masses absorb approximately 3,850,000 exajoules (1 EJ = 10^{18} J) of solar energy per year. This implies that the sun provides the earth with as much energy in an hour as the human civilization uses every year. These numbers speaks for themselves.

Let's figure out how we can tap into the solar energy available to us.

Think about and list various applications of solar energy. Don't limit yourself to domestic use. Figure out its use in various industries, from cars to architecture. Also find out which applications use thermal and which use photovoltaic technology.

Discuss this in the class and create a representative chart and put it on the dashboard for all to see.

Domestic application	Architecture and urban planning	Agriculture	Water treatment	Industry X,Y and Z	Other categories
Example: Solar cookers	Example: Rooftop solar panels	Example: Solar water pumps			

Have you seen solar energy being harnessed in your vicinity? Where will you place that practice in this table (displayed on your dashboard)?

ACTIVITY IV

Do you know hydroelectricity is a form of renewable energy? So far only micro-hydroelectricty projects (less than 25 MW in capacity) were considered a part of renewable energy in our country; but recently large hydroelectricity projects have also been included in the list of renewable sources.[15] Can you think of the differences between micro- and mega-hydroelectricity projects?

According to the government, India has a hydro-power potential of 145,320 MW, of which only about 45,400 MW has been utilized so far. Only about 10,000 MW of hydro-power has been added in the last 10 years. The share of hydro-power in the total generation capacity has declined from 50.36 per cent in the 1960s to around 13 per cent in 2018–19, the government said in a release.[16]

How will you find out the electricity generation capacity of a river or stream near your town or locality?

It is actually very easy. Let's try!

The flow of the river, the head (length) of the stream or the river and gravity are major factors in generation of electricity.

Power is measured in watts, head in metres and flow in litres per second.

Acceleration due to gravity in metres per second per second.

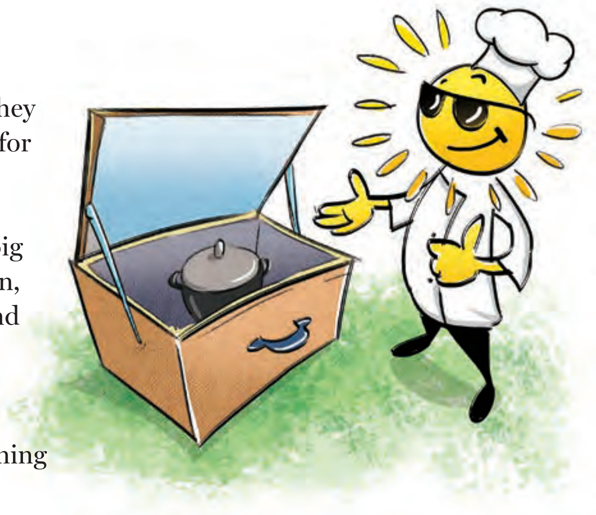
Gravity is approximately 9.81 metres per second per second, that is, each second an object falls, its speed increases by 9.81 metres per second (until it reaches its terminal velocity).

Equation Power (Watts) = Head (Metres) X Flow (Litres) X Gravity (9.81)

Calculate how much electricity a micro-hydroelectricity power plant can generate given a flow of 20 litres per second with a head of 12 metres.

The only concern with micro-hydroelectricity power is low-power generation during the summer months. Water crisis during the summer season is not new to us anymore. In many parts of the country, river and stream size fluctuates drastically between seasons. During the summer months, it is likely that the flow of a river will be less and, therefore, less power will be generated.

Answer on page 50



ACTIVITY V

Do you think solar cookers have advantages? Well, they sure do. They are safe, free and cause no air pollution. Do you want to make one for yourself? Make sure to have adult supervision.

Materials you will need: A small square box that can fit inside a big square box (over two feet long), aluminum foil, newspaper for insulation, glass panel (the size of the top of the big box, a baking rack, tape and black paint.

Do it yourself!

1. Paint the inside bottom of the small box black and cover the remaining sides with aluminum foil. Can you guess why we use black paint?
2. Place the small box in the bigger box. Ideally, there should be a one to two inch gap between the two boxes. Crumble pieces of newspaper and stuff them in the gap (for insulation).
3. Now, with the help of an adult, put the glass panel on the top of the box. One of its sides should be attached to the box like a lid that can be opened to keep food containers inside. Make sure you find a good spot with maximum sunlight with the glass panel facing the sun.

ACTIVITY VI

ACROSS

2. Energy that passes spontaneously between a system and its surroundings in ways other than through work
5. A means to reduce the amount of energy required to provide products and services
6. Energy generated from natural resources—such as sunlight, wind, rain, tides and geothermal heat

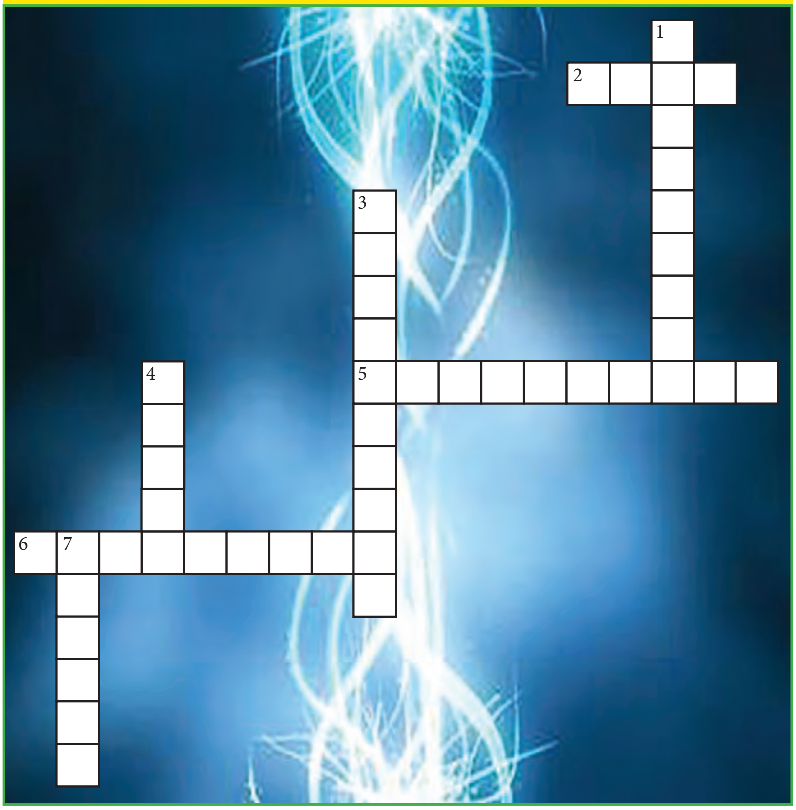
DOWN

1. The emission of energy as electromagnetic waves or as moving subatomic particles
3. A popular unit of energy
4. A unit of energy in the International System of Units, named after an English physicist
7. The capacity to do work

Answers on page 50

Gobar Times, August 2016, p 76

Scribble & Nibble



Section IV: GOBAR TIMES (GT) STORIES

Power cut

• Priya Muthukumar

ENERGY

Oh, no... The climb to the third floor was killing me! The lift was not working. Our security uncle said there had been a power cut.

My legs hurt. We had our inter-house football matches at school today. I was tired and famished. After much huffing and puffing, I reached home. My dad opened the door.

'Pa, the lift is not working. I had to climb up the stairs!' I said, as I dropped my heavy bag on the floor with a thud.

'Hmmm... power cut. Go, freshen up. I've made some sandwiches for you,' my dad answered, gorging on the cheesy sandwiches.

'It's so hot, Pa . . . no air conditioner . . . I feel like I am in an oven!' I yelled, frustrated.

My dad looked at me calmly and I knew what that look meant—end of the conversation.

'Take your sandwiches and the glass of mosambi juice. Sit in the balcony, beta. It's cooler there,' dad said, calmly. Absentmindedly, I picked up the TV remote and sank into our plush sofa only to be reminded of the power cut.

I went to the balcony. A tough day at school and things at home made it worse.

Dad told me that there's going to be load shedding for four hours for the next three days in our area. No TV, no air conditioner and I hadn't charged my cell phone or laptop... I was feeling lost!

Wait a minute, why wasn't anybody switching on the generator? I got up to remind the security uncle to switch it on.

'Varun! Would you like to join me for a jog in the park? It's quite breezy out there,' Pa asked.

I generally preferred to be left alone with my gadgets in my cozy air conditioned room, working on my Class 9 projects and homework. But Pa was different. He was a fitness freak.

I thought his idea of a jog seemed better than staying cooped up in our apartment in the concrete jungle without electricity. Dad was an excellent conversationalist, especially when it came to talking about his childhood, as all grown-ups are wont to do.

'In our time, we never had an air conditioner. After school, we would play cricket with the neighbourhood kids and reach home just in time to finish our homework, have dinner and sleep!'

I listened to him as he continued nostalgically. We jogged through narrow lanes, we tried to outpace each other, we spoke about Hindi films and then we stopped by to have chai at a local tea shop. I wiped the sweat trickling down my face.

The outdoors weren't as breezy as Pa had promised!

Pa seemed to have read my thoughts. 'Varun, do you know the total electricity demand of our city per day?' he asked.

I nodded my head disinterestedly. 'Seven thousand megawatt approximately' he continued. 'Generally, good rains during the monsoons result in sufficient inflow of water to the reservoirs that generate hydropower. This year, we did not have enough rains. Also, such scanty rainfall results in the reduction of wind energy.'

'Yes Pa, we do study about all of this—hydropower, thermal power, wind power, solar power and all of that,' I said.

'Also our consumption has increased over the years,' Pa continued, sipping his chai. 'We have so many gadgets and enjoy many more luxuries today! Sometimes I wonder whether our city has enough power to satisfy its hunger. In the past few months, we have seen more frequent scheduled power cuts.'

Demand versus supply. I was reminded of those words. I remembered how often we had forgotten to switch off the lights and fans in our classrooms when not in use.

As we walked back home, Pa continued, 'We must conserve electricity, and follow measures like turning off the refrigerator when not in use. Refrigerators account for 20 per cent of household electricity use. Also, turning off the TV and other entertainment devices and something as simple as switching off the main power button when not in use could save both energy and money!'

My dad beamed with pride when I said that replacing regular light bulbs with CFLs could save a lot of power. 'Those are wise words from my teenager! I'll change the light bulbs in our house,' he promised, patting my head. 'Do you know beta, I iron all our clothes at one time. That also saves electricity! And when I see streetlights left on, I make sure to inform the authorities.'

Hmm... we had reached home. Electricity was back. I was relieved that I needn't use the candle to do my homework.

I walked swiftly to open the windows to cool down our house instead of blasting the air conditioner. 'Dad, let's have dinner in the balcony today!' I said, proudly.

Planet Earth—Kolaveri style

Mridula Ramesh

'Archana! Archana!'

Tara ran up to Archana.

"Look—here's a contest! There's a huge prize and ... and..."

Archana smiled at her friend's excitement.

'Calm down, Tara! What contest?'

'The winners get to meet Rajnikanth!' Tara shrieked, unable to contain her delight.

Archana's heart seemed to stop for a quick second. Rajnikanth—wow!

'So what is this contest?'

'It's about making our homes earth-friendly. The best house wins.'

The excitement was replaced with apprehension. Earth-friendly? What did that mean?

'Have you heard? There's a contest! The winners get to meet Rajnikanth,' Alok was saying, running in.

Archana and Tara smiled at their friend.

'Yes, we heard, Alok. But what do we need to do?'

'That's easy. Let's search for "earth-friendly houses" on the Internet. We'll make a super-cool report on what to do, add catchy music...'

Archana stemmed his flow. 'That's what everyone else will be doing.'

'We could build a model,' Tara chimed in.

'Everyone will be building a model,' said Alok. He was peeved that Archana had dismissed his idea.

The bell rang, and the three friends went to class. They—and the rest of the school—talked about the project all day.

The next day was Saturday. Tara and Alok went to Archana's house. Sridhar Uncle was visiting from Chennai. He smiled on seeing the three heads huddled early morning around the computer.

'Good morning. What are you all doing? Not schoolwork, surely?'

Tara turned around. 'Hi Uncle! We have this huge contest at the school. There's a big prize and the winners get to meet Rajnikanth—we have to come up with ideas to make our home earth-friendly. So we are researching this on the net.'

Alok added, 'We are going to make a super video with the Kolaveri song and add a bit about ourselves talking about ways to make our homes earth-friendly.'

'What do you think, Archana?' asked Sridhar Uncle.

Archana hesitated. Her friends were a little struck about her lack of enthusiasm for their ideas.

'I don't know, Sridhar Uncle. I feel we should do more ... but..."

Alok cut in. 'Come on, Archana. The video is different—we'll change the lyrics but keep the tune.'

'I just feel it should be something that visitors can touch and feel,' Archana said.

'Which is why I think we should do a model,' Tara said.

Sridhar Uncle smiled and said, 'So why don't you do both?'

They looked at him and said in a chorus, 'What do you mean?'

'Build a model house with all the things you are talking about, and make a video to run in the background as well.'

Alok looked apprehensive. 'That'll be a lot of work,' he said.

Archana looked relieved. 'You're spot on, Sridhar Uncle! We'll build a small working model of a house. We'll get tiny LED lights, solar panels and all the stuff we've been reading about so the judges can see the house in action. We'll make a

video with us dancing and change the words to match the ideas.'

It would be a lot of work, but Archana, Tara and Alok were enthused. They felt that they had a real shot at winning. Over the next month, they spent every spare minute on the project.

Finally, the day of the competition arrived. The three friends, helped by their parents, loaded the house into Alok's father's car.

Alok's father looked at the three ragged but animated children.

'I'm very proud of you three,' he said. 'You have really worked hard and made something worthwhile.'

The gates of the competition venue opened. Visitors to the children's stall viewed the lovely white house surrounded by a vegetable garden and trees, with tiny drip lines running through. Small signs showed how much water was saved by using drips, rainwater harvesting and sewage treatment. The gardens were lit with working solar lamps. One half of the house was open, so that visitors could see inside. The other was covered with working solar panels. There was also a working windmill mounted on the roof.

Inside, the rooms were lit with working LED lights, and all the appliances had labels that showed they were five-star-efficiency rated. A small bathroom had a dual flush—that had a sign saying 'grey or used water'—with water that was filtered and reused.

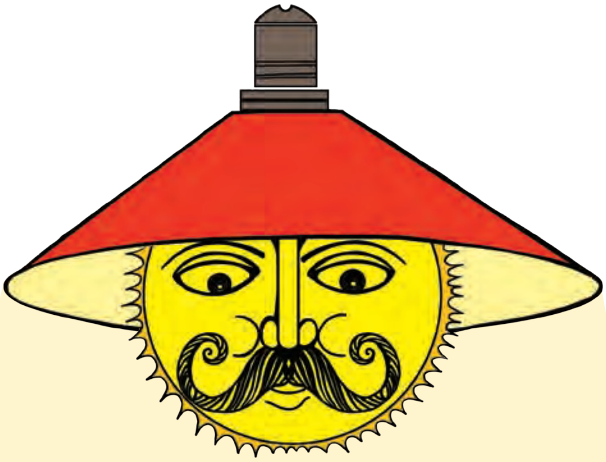
The 'family' used biodegradable products so that used water could be easily treated and fed into the garden. The house had plenty of natural light streaming and good ventilation that kept lighting and cooling costs low. The kitchen had two bins to segregate waste. A label above the gas stove indicated that the gas was made from a small biogas plant on the premises.

Visitors who couldn't push through the crowd to view the house were reading the attractive posters that depicted the room-wise actions that made the earth-friendly house. A crowd had also gathered to watch the video that showed Alok, Tara and Archana dancing and singing.

(Sung to the tune of Kolaveri)
Build a house-u,
Solar power-du,
Waste-u ellam clean-u,
LED light-u, dual flush-u,
Garden full-a green-u,
Green-u, green-u,
So-u green-u.
Planet-full-a cheer-u,
Cheer-u cheer-u,
Planet cheer-u,
Namma life clear-u,
Green this, green this,
Let us all do this now!
Green this, green this,
Let us all do this now!

Archana, Tara and Alok were thrilled to see the response. And then, the judges were there along with Rajnikanth! Real-life Rajnikanth was peering into their house, moving the tiny wastepaper baskets, touching the lights. He saw the video and a slow smile spread over his face.

'I think there can be no doubt who the winners are,' he said. 'Come, let's dance!'



Energy of the future

Renewable energy can be a viable power source for our airports, stadiums & homes.

Sorit Gupto

Piu entered the house panting one summer afternoon and said, 'I have no energy to do anything.' She had come back from school and was completely exhausted. Her mother came to her rescue and handed her a glass saying, 'This should energize you.'

It was glucose. Piu drank it all up and felt better.

'In some time, you will feel better,' said Piu's mother.

And it was true! Piu did feel better in a while. She was ecstatic that things had sprung back to normal. She went up to Pom and said, 'The drink had some magical quality Pom! I wonder what's that?'

'The magic was because of the glucose in that drink. Glucose is our main source of instant energy,' explained Pom. 'I didn't quite understand. Can you explain it to me?' said Piu.

Pom nodded in agreement and said, 'Let me tell you a story and it goes like this...'

'All living organisms need energy, but only plants have the ability to produce it. A plant produces its food using sunlight through the process of photosynthesis. Now, since animals can't produce their food, they have to depend on others. Animals that get their food solely from plants are called...'

"Herbivores!" replied Piu.

"That is right, Piu," Pom confirmed.

Piu smiled and then continued, 'Animals that get food from other animals are known as carnivores and those that get food from plants and animals are known as omnivores, like us. Am I right, Pom?'

'Smart kid! The flow of energy from one organism to the other is what is referred to as the food cycle,' said Pom.

Piu had slipped into a reflective mode, so Pom broke the silence saying, 'But you know Piu, food is not the only form of energy exchange in the world. The bulbs in our homes, our smartphones, cars, aeroplanes and industries do not eat food but they also need energy to carry out their tasks and activities.'

Feeling a little puzzled, Piu asked, 'So, where do we, humans, get this energy to run our machines?'

'Simple, from other animals. First we used to get it from horses, elephants, camels, cows and even humans,' said Pom.

'What! Even humans?' asked Piu, to which Pom replied, 'Yes, Piu. Even humans. Slaves used to haul wagons, cut crops and do all kinds of work for their "masters". But soon this changed.'

'How did things change, Pom?' asked Piu again. Pom took a deep breath and said, 'With the industrial revolution, beginning from the late 1700s, the world took a big leap in technology. The discovery of fossil fuels like coal, petroleum (oil) and natural gas paved the path for large-scale consumption of energy for electricity, transport, agriculture, industries, space research and so on.

'But there was one side effect.'

'What was that?' asked Piu.

'These fossil fuels, when burnt, released carbon dioxide (CO_2), a greenhouse gas responsible for increasing global temperature.'

'Industrialization has led to increase in atmospheric concentrations of CO_2, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. And with rising global temperatures came erratic weather events, rapid melting of snow and rising sea levels,' said Pom, and then the two fell silent.

After a while, Piu said, 'But tell me something. What is the alternative? Don't tell me that we must stop using electricity and go back to the cave-dwelling days!'

Pom chuckled at Piu's innocent question and then said, 'Not at all, Piu! Scientists have already taken up this challenge of finding an alternative energy source that can power our appliances and gadgets without releasing CO_2. And in 1839, French physicist Alexandre-Edmond Becquerel found one such source and guess what it was?'

'The sun?' replied Piu with a quizzical expression on her face.

'Exactly! It was the sun,' replied Pom excitedly, and then proceeded to say, 'And that's how the story of renewable energy began. Well, we are still in the nascent stage but we have travelled a long distance in a very short time. For example, harnessing solar energy was at best a science fiction plot a few decades ago but today it is as common as the newspaper! From trains to cars to street lights and toys, everything runs on solar energy.'

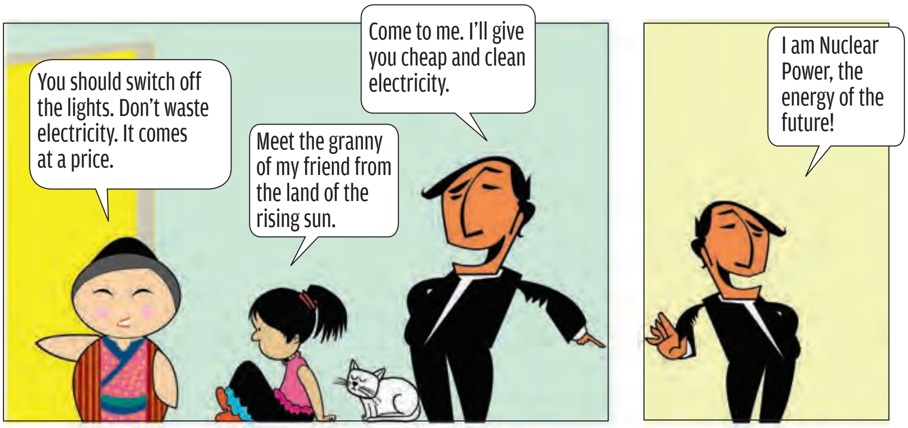
'Yes! Finally, I know how my friend's toy dinosaur was walking without batteries. You just have to put it in a sunny place and that's it,' said Piu.

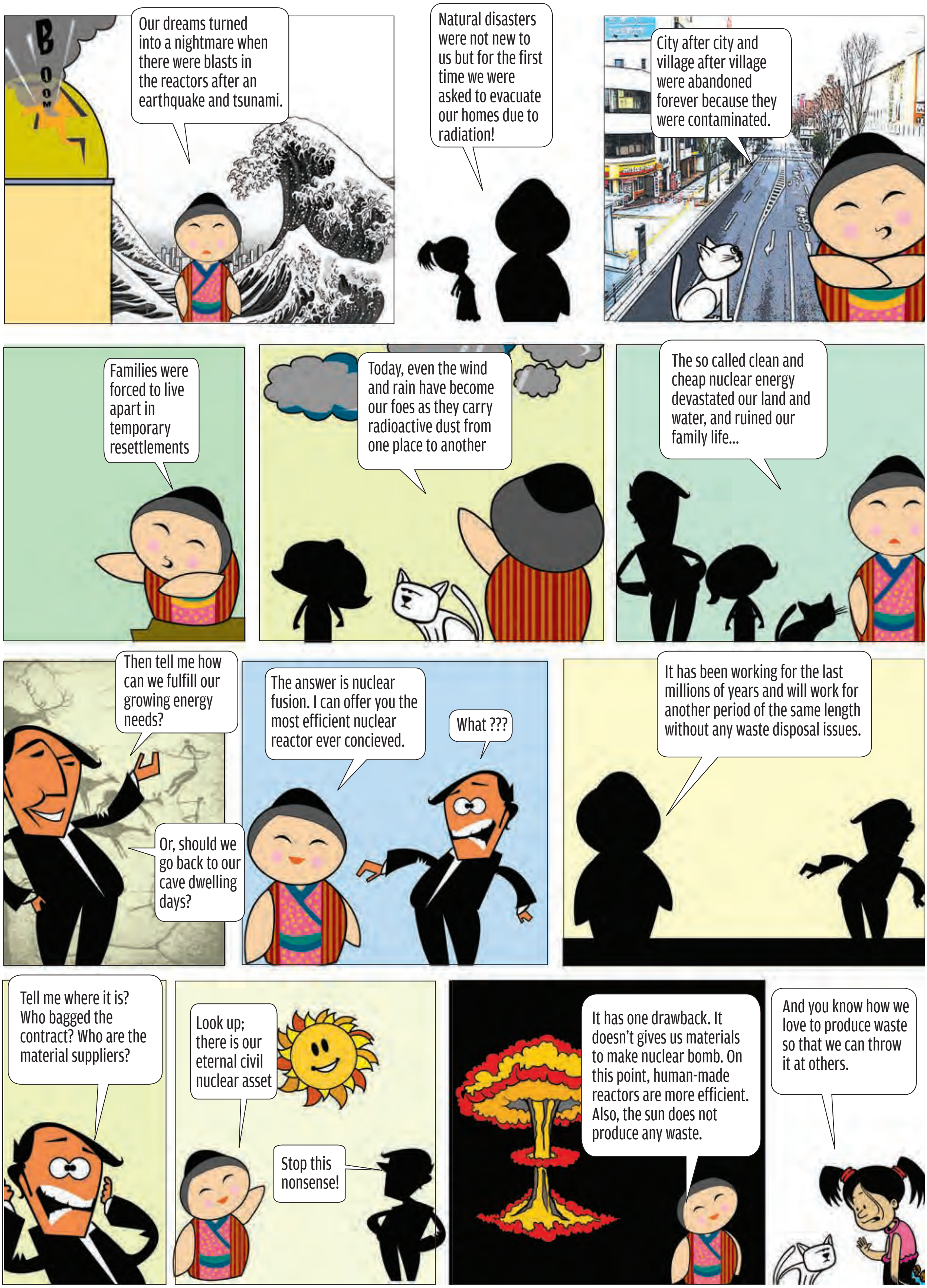
Pom replied, 'You are right, Piu. And the most important aspect of solar power is that it does not emit CO_2. It is absolutely pollution-free!'

Piu could not hold back her excitement at this and blurted out saying, 'That's great Pom! Now, I will ask my parents to get appliances and gadgets that run on solar energy.'

NUCLEAR ENERGY

Sometimes the danger of the things you have created exceeds their usefulness




BOOM
Our dreams turned into a nightmare when there were blasts in the reactors after an earthquake and tsunami.
Natural disasters were not new to us but for the first time we were asked to evacuate our homes due to radiation!
City after city and village after village were abandoned forever because they were contaminated.
Families were forced to live apart in temporary resettlements
Today, even the wind and rain have become our foes as they carry radioactive dust from one place to another
The so called clean and cheap nuclear energy devastated our land and water, and ruined our family life...
Then tell me how can we fulfill our growing energy needs?
Or, should we go back to our cave dwelling days?
The answer is nuclear fusion. I can offer you the most efficient nuclear reactor ever concieved.
What ???
It has been working for the last millions of years and will work for another period of the same length without any waste disposal issues.
Tell me where it is? Who bagged the contract? Who are the material suppliers?
Look up; there is our eternal civil nuclear asset
Stop this nonsense!
It has one drawback. It doesn't gives us materials to make nuclear bomb. On this point, human-made reactors are more efficient. Also, the sun does not produce any waste.
And you know how we love to produce waste so that we can throw it at others.

Formulae

- Besides schools, students can now check the cost and size of solar rooftop that can be installed at their homes as well. Domestic houses are a huge untapped market for solar power in the country. Enter the pin code of your area and see the solar energy plant potential.

  Just go to this link - http://solarmyroof.cseindia.org/NewPage.aspx#kk

- Plant load factor (PLF) can be calculated to determine the efficiency of operations and schools can be rewarded accordingly.

  Plant load factor = Actual generation in a year / (Installed capacity x 24 x 365) x 100

- Capacity utilization factor (CUF) gives the measure of performance of a solar PV power plant.

  CUF of a solar plant can be calculated as = Actual generation in a year / (Installed capacity x 24 x 365) x 100

  Where 24 is hours in a day, and 365 is days in a year.

  Maximum possible CUF for a solar plant is 19–20 per cent, but it can drop to 10–11 per cent if the system is not maintained properly. A CUF above 20 per cent is not possible for solar rooftop PV.

Annexure

Gross calorific value of some materials

Energy source	Calorific value in megajoules (MJ)
Electricity from the board (kWh)	3.60
Electricity from generator (Diesel) (kWh)	44.80
Petrol (litres)	43.93
Diesel (litres)	44.80
CNG (kg)	37.24
Kerosene (litres)	43.09
Coal (kg)	20.92
Wood (kg)	13.28
Animal waste (kg)	13.77
Solar (kWh)	3.60
Wind (kWh)	3.60
LPG (kg)	45.19
PNG (kg)	13.77
Biogas (kg)	13.77

Daily energy consumption at a school

Category	Per capita per day energy consumption
Day scholar	46.2 MJ
Day boarding	49.8 MJ
Residential	24.6 MJ
Scholar + Boarding	48.0 MJ
Scholar + Residential	49.8 MJ
Boarding + Residential	46.2 MJ

Glossary

- **Alternating current (AC):** It is a type of electrical current in which the direction of the flow of electrons switches back and forth at regular intervals or cycles. Current flowing in power lines and normal household electricity that comes from a wall outlet is alternating current. The standard current used in the US is 60 cycles per second (i.e., a frequency of 60 Hz); in Europe and most other parts of the world it is 50 cycles per second (i.e. a frequency of 50 Hz). One advantage of alternating current is that it is relatively cheap to change the voltage of the current. Furthermore, the inevitable loss of energy that occurs when current is carried over long distances is far smaller with alternating current than with direct current.

- **Connected load:** It is the load, in kilowatts (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.

- **DISCOM:** Electricity distribution companies.

- **Direct current (DC):** It is electrical current which flows consistently in one direction. The current that flows in a flashlight or another appliances running on batteries is direct current.

- **Grid-interactive systems:** Systems that utilize the grid for storing and extracting electricity, as per requirement. For example, solar rooftop panels, on ground solar panels, etc. Generally, on-grid systems have the benefit of transferring surplus power to the grid. Interactions with the grid can be facilitated either via gross or net metering.

- **Gross metering:** Under this type of metering, all electricity generated is sold to the grid at average cost of supply (ACoS), as determined by the regional DISCOM. The consumer continues to procure all the power they require from the DISCOM, as per their tariff bracket. The bills are either settled individually or as net billing.

- **Installed capacity:** It is the rated (full-loaded) generation capacity of a power plant. A solar rooftop plant's capacity, being small, will be expressed in terms of kilowatts (kW). The information on installed capacity will be available on the solar rooftop plant's online performance monitoring system. Alternatively, it will also be mentioned in the order for installation placed with the solar rooftop installer or vendor.

- **Kilowatt (kW):** A kilowatts is a unit of energy equal to the 3.6 megajoules.

- **Net metering:** Under this type of metering, a consumer utilizes all the energy produced by the solar rooftop (SRT) system they have installed, and relies on the grid for any excess energy required. The consumer is only charged for the excess energy they consume, as per their tariff bracket. Any surplus generation of electricity by the SRT system can be fed back to the grid. This information will also be reflected in the electricity bill of the consumer as under net metering, billing would only be for net consumption.

- **O&M:** Operations and maintenance; this abbreviation includes all services that ensure maximum efficiency and maintenance of your photovoltaic system.

- **Solar photovoltaic (PV) panels:** Photovoltaic (PV) devices generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of materials called semiconductors. Electrons in these materials are freed by solar energy and can be induced to travel through an electrical circuit, powering electrical devices or sending electricity to the grid. PV devices can be used to power anything from small electronics such as calculators and road signs up to homes and large commercial businesses.

- **Standalone system:** It is a system wired only to the house and requires a battery backup to store any excess power generated, or to meet power deficits. For example, standalone solar street lights, solar lamps and rooftop panels. In these off-grid systems, surplus power may get wasted if there is not enough battery storage available.

- **Subsidy:** The money given as part of the cost of something, to help or encourage it to happen. Ministry of New and Renewable Energy (MNRE) website (https://mnre.gov.in/solar-rooftop-grid-connected) provides information about several subsidies available for institutions (including schools) to reduce the cost of solar installation.

- **Tariff bracket:** Per unit electricity rates on the basis of consumption.

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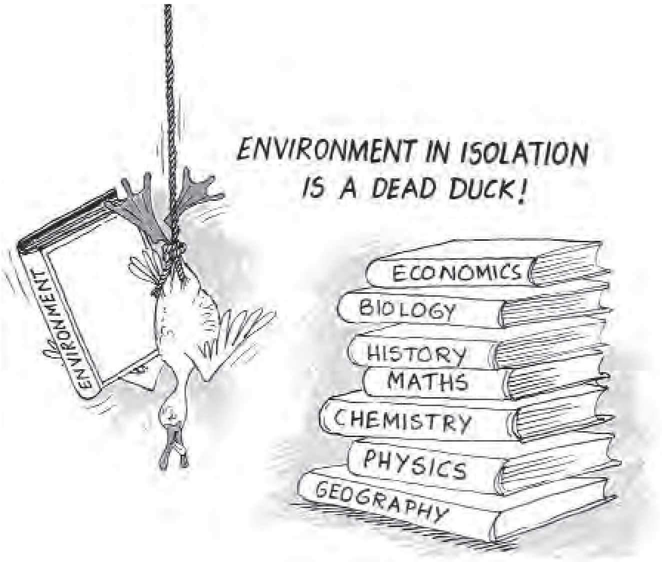
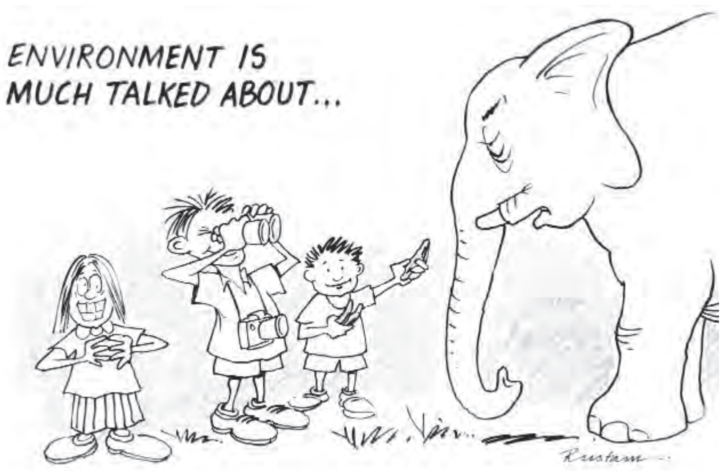
Answers

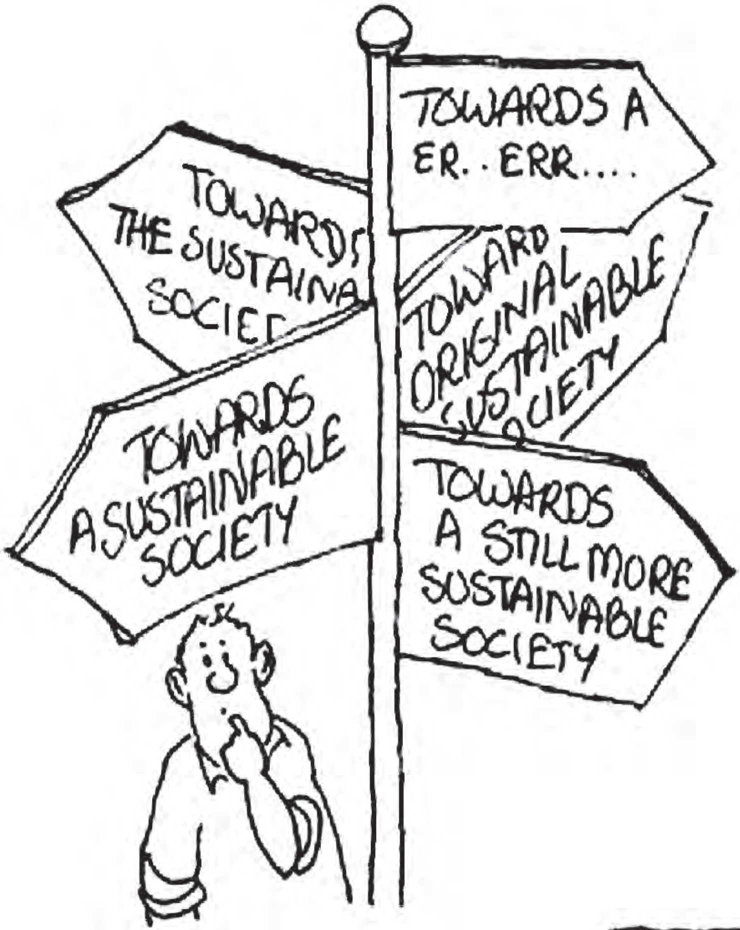
Answer to activity IV: *2,354 W*
Answers to activity VI: *1. Radiation 2. Heat 3. Horsepower 4. Joule 5. Efficiency 6. Renewable 7. Energy*

What is environment education?





Environment cannot be taught as just another subject yet every subject can help us understand it better


TOWARDS A
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THE
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ORIGINAL
TOWARDS
A SUSTAINABLE
SOCIETY
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A STILL MORE
SUSTAINABLE
SOCIETY


PROTECTING THE
ENVIRONMENT –
WHAT ONE
PERSON CAN DO
CONSERVE
ENERGY

CSE SCHOOL BOOKS ON ENVIRONMENT ISSUES

1. Paving the path
2. How Green is Your School? An Environmental Audit for Schools (Bonus: Teachers Handbook inside)
3. How much do we know about climate change (Quiz book)
4. Climate Change Now
5. Getting to Know About Environment (comic book series)
6. Climate Change for the Young and Curious (comic book series)
7. The Crow Honey Hunter and the Kitchen Garden (comic book series)
8. Bioscope of Piu & Pom (comic book series)
9. Water Plus: Is My School Water Wise?
10. Be Waterwise: GSP Manual for Water Audit
11. Junk Food Busted
12. Is My School a Junk-Food-Free Zone?
13. Climate Change in South Asia
14. Excreta Matters – A Students' Special Edition
15. How Green is My Neighbourhood
16. Climate Change & Natural Resources

For further details, please visit: ***https://bit.ly/2DwXpaK***

Please write to Ramachandran if you have any queries at - rchandran@cseindia.org

If you really think about it, civilization is merely an orderly arrangement of matter and a harmonious flow of energy. We use energy for everything—from the food we eat to the clothes we wear. Energy powers our homes, schools and offices. We use it to transport us from one place to another. All our gadgets run on energy.

In the last three centuries, humankind has progressed beyond imagination. Our energy needs have also skyrocketed. These needs are largely met by fossil fuels, which pollute our environment with toxic emissions that also cause climate change. It is clear that our dependence on fossil fuels is unsustainable.

With this clarity has come a burning desire to find better alternatives. Renewable sources of energy, like the sun, wind, water and biomass, present a viable and long-term solution.

But do we have enough information about our energy needs and these alternatives? This GSP manual on energy helps gauge energy-consumption patterns in schools, and educates us about the ways in which we can improve the overall scenario of electricity use in schools.

CSE

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