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CHAPTER I

INTRODUCTION

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INTRODUCTION

The world is facing climate crisis at an unprecedented rate. Our globe is warming at a rate which is higher than it was at any point in the recorded history. This phenomenon is changing earth's climate and we have floods, hurricanes, wildfires, draughts. The fossil fuels are mostly responsible for this. Fossil fuels, when burned to produce energy, cause harmful greenhouse gas emissions, such as carbon dioxide among other gases, which is mostly responsible for climate crisis.

This situation still avoidable- if we all work together towards the goal of restricting the globe's temperature to 1.5°C above pre-industrial levels. The way to achieve this is to reduce emission of greenhouse gases, including carbon-di-oxide. This can be done by doing away the burning of the fossil fuels. To achieve the target of 1.5°C, the world needs to cut emission by 42% by 2030. We need to cut carbon-di-oxide equivalent emissions by 22 billion tonnes per year, if we want to achieve this target. This is possible if we leave or reduce our dependence on fossil fuels and switch to renewable energy sources.

Renewable energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. Sunlight and wind, for example, are such sources that are constantly being replenished. Renewable energy sources are plentiful and all around us. The deployment of renewable energy sources is one of the main enablers of keeping the rise in average global temperatures below 1.5°C. In the scenario of Net Zero Emissions of greenhouse gases by 2050, renewable energy sources allow electricity generation to be almost completely decarbonised.

Generating renewable energy creates far lower emissions than burning fossil fuels. Transitioning from fossil fuels, which currently account for the lion's share of emissions, to renewable energy is key to addressing the climate crisis. Renewable energy sources, such as biomass, the heat in the earth's crust, sunlight, water, and wind, are natural resources that can be converted into several types of clean, usable energy.

The sources for renewable energy are abundantly available around us. Water for hydropower, sunlight for heat and electricity, wind for electricity, biomass for heat energy, oceans for electrical energy etc. are abundantly available and non-exhaustible sources of renewable energy. With a global market potential of 350 GW by 2050, these sources can provide clean, local, predictable electricity to the world.

Renewables, including solar, wind, hydropower, biofuels and others, are at the centre of the transition to less carbon-intensive and more sustainable energy systems. Renewable energy sources have a large potential to displace emissions of greenhouse gases from the combustion of fossil fuels and thereby to mitigate climate change. If implemented properly, renewable energy sources can contribute to social and economic development.

Hydropower has been used since ancient times. Greeks used hydro power to grind flour and perform other tasks. By the end of 19th century, the electrical generator was developed and coupled with hydraulics, was used to generate electricity. At the beginning of the 20th century, many small hydroelectric power stations were constructed. By the end of twentieth century, advanced and efficient hydropower generators were built. Hydro generation is expected to be eventually overtaken by wind and solar power.

Onshore wind is a proven, mature technology with an extensive global supply chain. Onshore wind has evolved over the last five years to maximise electricity produced per megawatt capacity installed to unlock more sites with lower wind speeds. Wind turbines have become bigger with taller hub heights, and larger rotor diameters. Offshore wind is expected to grow rapidly in the coming years as deploying turbines at sea takes advantage of stronger winds.

Wind and solar are the predominant sources of power generation in the Net Zero Emissions by 2050 Scenario. Solar photovoltaics (PV) is a very modular technology that can be manufactured in large plants, which creates economies of scale, but can also be deployed in very small quantities at a time. This allows for a wide range of applications, from small residential roof-top systems up to utility-scale power generation installations. The exceptional growth in PV deployment in recent years will need to continue and scale up to follow the Net Zero Emissions by 2050 Scenario, requiring continued policy ambition.

Bioenergy is produced from organic material, known as biomass, which contains carbon absorbed by plants through photosynthesis. When this biomass is used to produce energy, the carbon is released during combustion and returns to the atmosphere. As more biomass is produced an equivalent amount of carbon is absorbed, making modern bioenergy a near zero-emission fuel. Modern bioenergy is an important source of renewable energy - its contribution to final energy demand across all sectors is currently five times higher than wind and solar PV combined, even when the traditional use of biomass is excluded.

Oceans are a source of abundant renewable energy potential, capable of driving a blue economy. Energy harnessed from oceans, through offshore renewables, can contribute to the decarbonisation of the power sector and other end user applications relevant for a blue economy (e.g. shipping, cooling, water desalination).

Renewable energy offers numerous economic, environmental, and social advantages. These include:

- Reduced carbon emissions and air pollution from energy production
- Enhanced reliability, security, and resilience of the power grid
- Job creation through the increased production and manufacturing of renewable energy technologies
- Increased energy independence
- Lower energy costs
- Expanded energy access for remote, coastal, or isolated communities.

Many goals in the UN's Sustainable Development Goals relate to the development of renewables. Action taken by the various countries on that may result in the Net Zero Emission goal. Various organizations and various governments are working in this direction and doing their efforts to achieve this goal.

Bureau of Indian Standards (BIS), on its part, has also contributed in achieving the goal of net zero emission by 2050 by developing the standards for making renewable and their systems standardized. Many departments in BIS are working on various topics of renewables and developing Indian Standards on these topics. The contributions for developing these standards come from various experts and organizations, which are members of the various BIS committees. These specialized committees are associated with different departments in accordance with their subjects. Mechanical Engineering Department (MED), through its committee MED 3, have developed many standards in the field of renewable energy. Electro-technical Engineering Department (ETD), through its committee ETD 46, has developed many standards in safety of distribution equipment for electrical energy. Also, through its other committee ETD 28, ETD has developed standards for use and development of photovoltaic cells. Another committee, ETD 42, deals in the generation, safety and equipment of wind turbines. ETD 54 deals in marine energy conversion systems. Water Resources Department has worked extensively in the field of Hydro energy, through its committees WRD 1, WRD 6, WRD 12, WRD 13, WRD 21, WRD 22 and WRD 23.

These committees sometimes adopt some standard with are already made by ISO or IEC and can also be used in the country. Adoption saves efforts of making the standard again. As a lot of work is already being done in the field of renewables already, ISO and IEC have formulated standards in the field of renewables. These standards are made by the committees at international level, in which India also participates as member. So, we can say that the input for making a standard at international level comes from every member country, including India. We call such international committees liaison committees of our sectional committees.

This handbook contains list of all such standards made by BIS for renewables. This also contains a list of liaison committees of ISO/IEC, so that the reader can search and correlate detailed work being done by these international committees. The details of work being done by these ISO/IEC committees is not in the scope of this handbook. Anybody interested to have more information about these committees, can search in any search engine online.

The purpose of this handbook is to make the students aware about the standards in the renewables field. The other most important purpose is that the students should know about the standards. The information available in this handbook has been compiled from many sources, including information available on internet on various sites.

CHAPTER II

RENEWABLE ENERGY SOURCES AND USES

CHAPTER II

Renewable Energy Sources and uses

Renewable energy is clean energy. It is obtained from a natural source. The natural source is self-replenishing; it is replenished at a faster rate than it is consumed. These natural sources have provided energy to the mankind for thousands of years- in the form of solar heat, wind power for sailing the sea ship, water flow power to grind the grain. With the development of technology, we can now harness these sources of natural energy in various other forms. Though there are many ways to harness this energy, we will discuss about the most common uses of these natural resources. The main uses are:

- Solar energy from sun
- Wind energy from wind
- Hydro energy form water
- Bio energy from biomass
- Marine energy from the sea.

Bureau of Indian Standards (BIS) has formulated many standards on renewables. These standards detail about the way the renewable is used, the requirements for its usage, safety and performance requirements of renewables etc.. These standards are a great source of information about the processes, requirements, tests needed for renewable systems, in line with national and international requirements. BIS has made many standards indigenously, using expertise available locally in the country. However, many standards have been adopted from International Standards Organization (ISO) and International Electrotechnical Commission (IEC) standards. As on date, more than 22500 standards have been formulated by BIS. The following list contains the standards related to the renewables and renewable energy, formulated by BIS. The list contains the Indian Standard number, its title and the committee which has formulated it. Then the brief about the standard. The details about the title are available inside the standard itself:

CHAPTER III

SOLAR ENERGY

CHAPTER III

Solar Energy

Solar Energy is radiation from the Sun capable of producing heat can be used for generating electricity. The total amount of solar energy incident on Earth is vastly in excess of the world's current and anticipated energy requirements. If suitably harnessed, the solar energy has the potential to satisfy all future energy needs. In the current century solar energy has become increasingly attractive as a renewable energy source as it is abundant in supply and non-polluting in character, in contrast to the finite fossil fuels coal, petroleum, and natural gas.

Though solar energy itself is free, the high cost of its collection, conversion, and storage still limits its exploitation in many places. Solar radiation can be converted either into thermal energy (heat) or into electrical energy, though the former is easier to accomplish. It is the **3rd largest renewable energy resource**, after wind and hydropower. Solar energy's economic viability along with vast availability contributed to its unprecedented growth in recent years.

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Installed capacity for solar energy in 2022:

World 1053.12 GW

China 393.03 GW

India 63.15 GW

Brazil 24.08 GW

Spain 20.52 GW

Mexico 9.02 GW

Chile 6.05 GW

Capacity for solar energy in 2023-24:

China 430 GW, the country is the largest producer of solar energy in the world.

The USA is at 141.8 GW the USA stands second in the list of top solar countries. From a measly capacity of 0.34 GW in 2008, the nation has come a long way in the solar domain.

Presently, 3% of the US's electricity is sourced through solar power plants. The solar market in the US is also growing at a rapid rate. Sources claim that solar jobs have increased by 167% in the nation.

Japan is third at 84.9 GW. A few years ago, Japan stood 4th in terms of solar power capacity. Now, with a cumulative capacity of 84.9 GW, the nation is occupying the 3rd spot.

The nation is considered the fastest growing in terms of promoting Solar PV. Further, with 45% of the world's photovoltaic cells manufactured in Japan, the country leads the world in the photovoltaic market.

Germany is fourth and leads the European countries in renewable energy. As of 2021, the nation's solar capacity was 69.1 GW. In 2021, solar power accounted for 10% of the country's electricity consumption.

The Ukraine war has created tension between many European nations and Russia. Germany is also facing the consequences of this friction in the form of a shortage of gas. To manage this energy crisis, the German government is striving to introduce policies and expand the renewable energy capacity.

India is fifth with installed capacity at 68 GW. The country has vast solar potential, as most states of India receive sunshine for more than 300 days a year.

How to capture solar energy?

Among the most common devices used to capture solar energy and convert it to thermal energy are flat-plate collectors, which are used for solar heating applications. Because the intensity of solar radiation at Earth's surface is so low, these collectors must be large in area. Even in sunny parts of the world's temperate regions, for instance, a collector must have a surface area of about 40 square meters (430 square feet) to gather enough energy to serve the energy needs of one person.

Solar cookers concentrate sunlight onto a receiver such as a cooking pan. The interaction between the light energy and the receiver material converts light to heat and this is called absorption. The conversion is maximized by using materials that absorb, conduct, and retain heat.

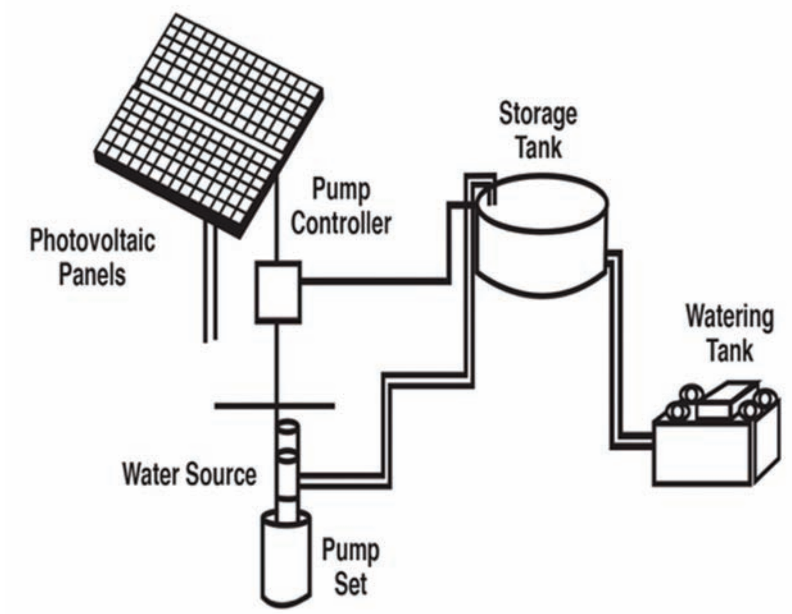
On a smaller scale, the Sun's energy can also be harnessed to cook food in specially designed solar ovens. Solar ovens typically concentrate sunlight from over a wide area to a central point, where a black-surfaced vessel converts the sunlight into heat. The ovens are typically portable and require no other fuel inputs.

BIS has formulated many standards on ways to harness solar energy, their components and testing requirements. The main standard about the solar energy vocabulary is **IS/ ISO 9488 : 2022** (Solar Energy Vocabulary (MED 4)). This document defines basic terms relating to the work of ISO/TC 180. The committee covers standardization in the field of the measurement of solar radiation and solar energy utilization in space and water heating, cooling, industrial process heating and air conditioning. Consequently, the vocabulary within this document is focussed on definitions relating to those measurement and utilisation technologies. Since the 1999 version of this document there has been considerable development in solar photovoltaic technologies and high temperature solar thermal technologies that use heat to produce electricity or to provide high temperatures for processes that require elevated temperatures. This standard has some definitions that are useful also for those technologies; however, there are other documents that cover vocabulary for these technologies in more detail.

Water pumping systems

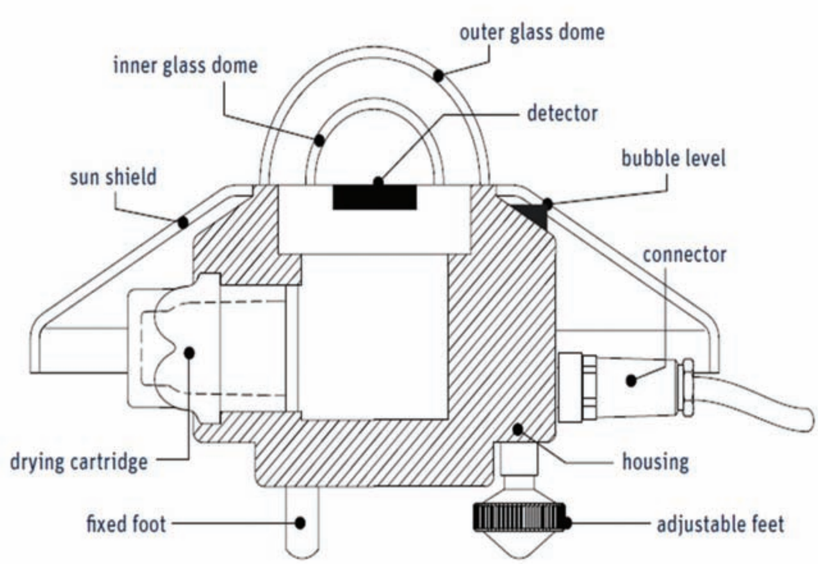
One of the many uses of solar energy is to run handpumps and pumping systems to draw water from the borewells. Solar handpumps are being used in the country and

BIS has also formulated a standard on it. **IS 17941: 2022** (Hand pump cum Solar Pumping System – Specifications (MED 4)) specifies the technical requirements for "handpump cum solar pumping system". The purpose of combining the solar pumping system and the handpump is to reduce efforts to pump water manually and to ensure uninterrupted and continuous access to safe drinking water. This system provides lifting of water to the overhead storage tank. Solar energy is stored in the form of water in an overhead tank thus avoiding the need of a battery system. This standard cover design qualifications and performance specifications. **IS 17429: 2020** (Solar Photovoltaic Water Pumping Systems - Testing Procedure – Guidelines (MED 4)) guidelines lay down basis for testing set up and testing procedures for Solar Photovoltaic (SPV) water pumping system. The SPV water pumping system covered are centrifugal pumps of all types from 0.75 kW/1 HP up to 7.5 kW/10 HP capacity.



Pyranometers

A pyranometer is a sensor that converts the global solar radiation it receives into an electrical signal that can be measured. Pyranometers measure a portion of the solar spectrum.



IS/ISO 9847: 1992 (Solar energy - Calibration of field pyranometers by comparison to a reference pyranometer (MED 4)) gives the methods for calibration of pyranometers. The methods of calibration specified are traceable to the world radiometric reference (WRR).

This Standard specifies two preferred methods for the calibration of field pyranometers using reference pyranometers.

One method, the outdoor calibration or type I, employs solar radiation as the Source, while the other method, the indoor calibration or type II, em- ploys an artificial radiation Source.

The outdoor calibration of field pyranometers may be performed with the pyranometer in a horizontal position (i.e. Zero tilt) (type Ia), in a tilted Position (type Ib), or at normal incidence (type Ic) maintaining the receiver surface perpendicular to the sun's beam component.

The indoor calibration of field pyranometers may be performed using an integrating sphere with shaded (type Ha) or unshaded (type Hb) lamp(s), or at normal incidence (type HC) frequently using an Optical bench to present the receiver surface perpendicular to the beam of the lamp.

Types lla and llb correspond to an outdoor calibration under conditions of overcast and sunny sky with large light cloud fields, respectively. Type Ilc is comparable with the normal incidence calibration of type lc. The details are given in the standard IS 9847:1992.

Box-Type Solar Cooker

The most commonly used form of solar cooker is the box-type solar cooker. In this section, we will be discussing the construction and working principle of a box-type solar cooker.

A box-type solar cooker consists of the following components:

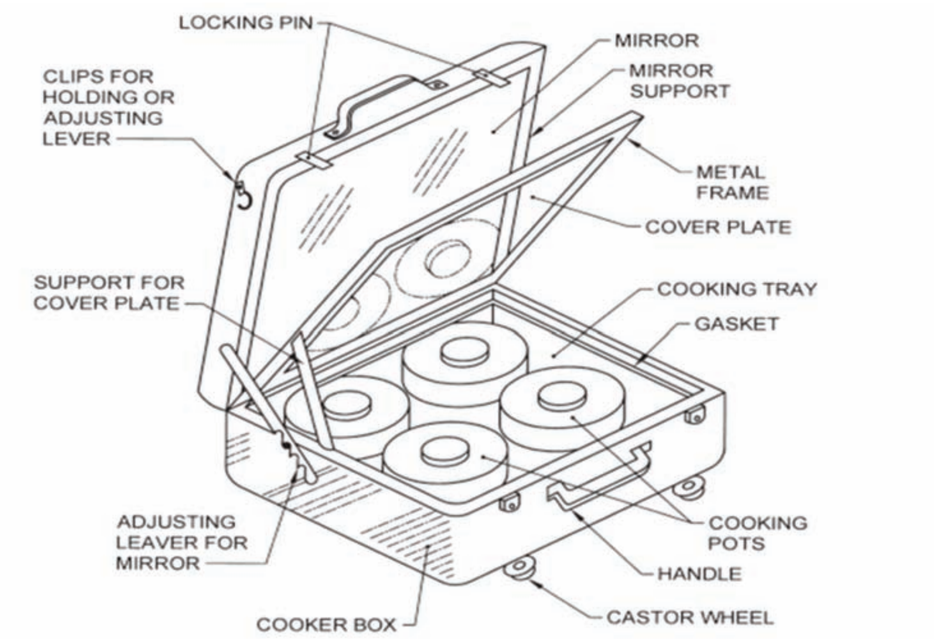
Black Box – The box is an insulated metal or wooden box which is painted black from the inside to absorb more heat.

Glass Cover – A cover made of two sheets of toughened glass held together in an aluminium frame is used as a cove for box B.

Plane Mirror reflector – The plane mirror reflector is fixed to box B with the help of hinges. The mirror reflector can be positioned at any desired angle to the box. The mirror is positioned so as to allow the reflected sunlight to fall on the glass cover of the box.

Cooking Containers – A set of aluminium containers blackened from the outside are kept in box B.

The solar cooker is placed in sunlight and a plane mirror reflector is adjusted in a way such that the strong beam of sunlight enters the box through the glass sheet. The blackened metal surfaces in the wooden box absorb infra-red radiations from the beam of sunlight and the heat produced raises the temperature of a blackened metal surface to about 100°C.



IS 13429 (Part 1): 2020 (Solar Cooker - Box Type - Specification Part 1 Requirements (MED 4)) specifies the requirements of box type solar cookers for cooking. **IS 13429 (Part 2) : 2018 (**Solar cooker - Box type - Specification: Part 2 components (Second Revision) (MED 4)) specifies the requirements of various components of box type solar cooker. **IS 13429 (Part 3) : 2018** Solar cooker - Box type - Specification: Part 3 test method (Second Revision) (MED 4)) specifies the test methods for box type solar cooker.

Flat plate collector

A Flat plate collector is a solar panel device that uses solar energy to generate thermal energy. It converts solar power into thermal energy, i.e., cheaper energy utilising water as an operating fluid.

A Flat plate solar collector takes in solar radiation and transmits heat to the functioning medium. It is suitable for several thermal applications. The average temperature range of FPC devices is 100° C. Besides, these devices have an economical cost of investment.

The FPC devices are the backbone of solar thermal devices. They have diverse applications from household to commercial sectors. Flat plate collector devices are commonly used for active space heating and water heating for further usage.

How does A Flat Plate Collector Work?

The working of a flat plate collector (FPC) involves the transfer of heat or thermal energy. The operating medium exchanges heat from the sun's rays.

The heat-absorbing plate of the collector is exposed to sunlight. As the sun rays hit the flat plate surface, a portion of their energy is transformed into heat. This leads to a rise in the temperature of the flat plate solar collector.

When a fluid is passed inside the collector, the temperature of the fluid increases as the heat from the absorbing plate heat is transmitted to the fluid.

Eventually, the fluid transmits the thermal energy from collectors to the functioning energy systems for different uses. It works on the principles of the 1st & 2nd Laws of

Thermodynamics.

Types of Flat Plate Collector Devices

We can categorise flat plate collector devices on two main grounds –

A] Based on Glaze

Glazed Panels – Glazed or Glazing Panels are insulated panels that embrace a glaze covering.

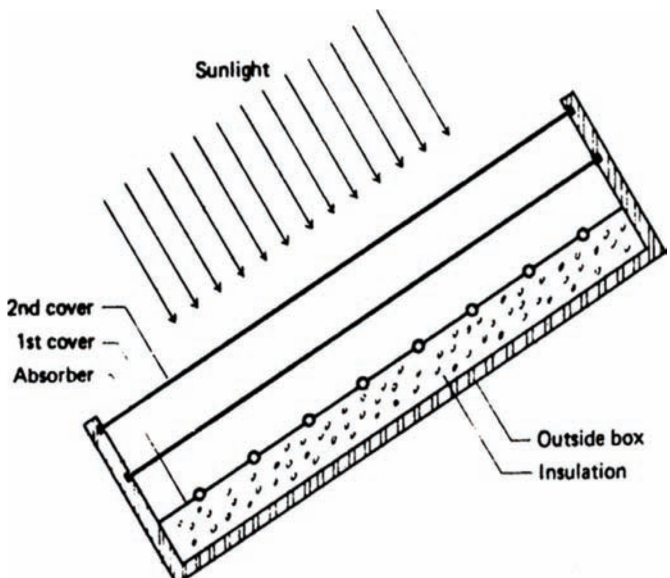
They block infrared radiation and provide insulation to the solar plate. Under the glazing, there is an absorbent in which the working fluid flows. Glazed FPCs are commonly used in household water heating installations.

Unglazed Panels: These flat plate collector devices are not glazed. Unglazed panels are usually utilised for swimming pool heating installations. They are inexpensive but less popular. Their temperature range is less than 30° C.

B] Based on Configuration

Parallel Absorbing Plate: In a Parallel flat plate collector, the heat can be dispersed with a larger volume of circulating fluid via the branches present inside. It can be installed in both horizontal and vertical orientations.

Series Absorbing Plate: Such FPCs include a sole continuous circuit. It has a high heat jump and a lesser volume of circulating fluid.



A building roof with flat-plate collectors that capture solar energy to heat air or water (more). The most widely used flat-plate collectors consist of a blackened metal plate, covered with one or two sheets of glass, that is heated by the sunlight falling on it. This heat is then transferred to air or water, called carrier fluids, that flow past the back of the plate. The heat may be used directly, or it may be transferred to another medium for storage. Flat-plate collectors are commonly used for solar water heaters and house heating. The storage of heat for use at night or on cloudy days is commonly accomplished by using insulated tanks to store the water heated during sunny periods. Such a system can supply a home with hot water drawn from the storage tank, or, with the warmed water flowing through tubes in floors and ceilings, it can provide space heating. Flat-plate collectors typically heat carrier fluids to temperatures ranging from 66 to 93 °C (150 to 200 °F). The efficiency of such collectors (i.e., the proportion of the energy received that they convert into usable energy) ranges from 20 to 80 percent, depending on the design of the collector.

Solar radiation may be converted directly into solar power (electricity) by solar cells, or photovoltaic cells. In such cells, a small electric voltage is generated when light strikes the junction between a metal and a semiconductor (such as silicon) or the junction between two different semiconductors. (*See* photovoltaic effect.) Small photovoltaic cells that operate on sunlight or artificial light have found major use in low-power applications—for example, as power sources for calculators and watches. Larger units have been used to provide power for water pumps and communications systems in remote areas and for weather and communications satellites. By connecting large numbers of individual cells together, however, as in solar-panel arrays, hundreds or even thousands of kilowatts of electric power can be generated in a solar electric plant or in a large household array.

IS 12976 : 2023 Solar water heating systems (Code of Practice) (First Revision) (MED 4) gives general characteristics of all types of solar water heating systems with flat plate or tubular collectors and their performance evaluation methods.

Tests on flat plate solar collector

The main standard **IS 12933 (part 1)** gives tests that are required to be done on solar flat plate collector, which are as follows:

- Outdoor no flow exposure tests
- External Thermal Shock Test
- Internal Thermal Shock Test
- Rain Penetration Test
- Impact Resistance Test
- Thermal Efficiency Test
- Determination of the Time Constant
- Incident Angle Modifier Test
- Static Pressure Leakage Test

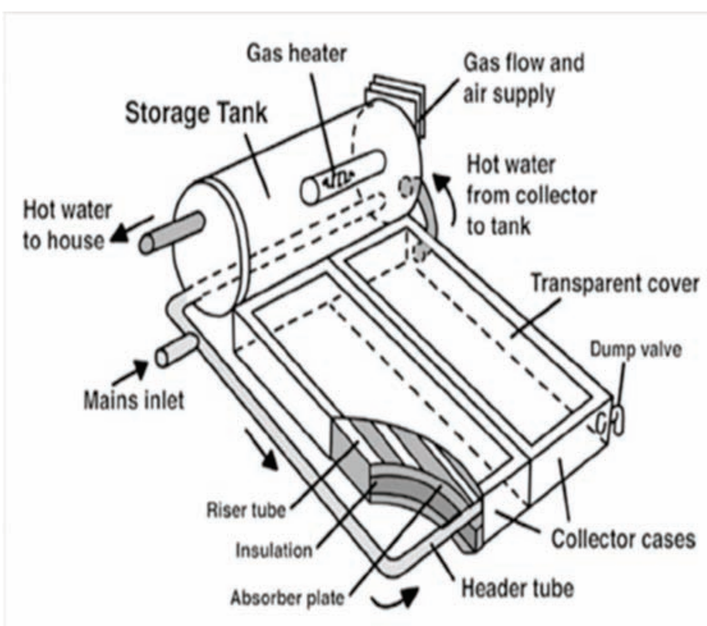
IS 12933 (Part 2) : 2003 **(**Solar flat plate collector - Specification: Part 2 components (Second Revision) (MED 4)) specifies the requirements for various components of solar flat plate collector for water heating. **IS 12933 (Part 3) : 2003** **(**Solar flat plate collector - Specification: Part 3 measuring instruments (First Revision) (MED 4)**)** specifies the measuring instruments for solar flat plate collector for water heating. **IS 12933 (Part 5): 2003(**Solar flat plate collector - Specification: Part 5 test methods (Second Revision) (MED 4)) specifies the test methods for solar flat plate collector for water heating.

IS 13129 (Part 1) : 2023 (Solar heating domestic water heating systems: part 1 – Performance rating procedure using indoor test methods (MED 4)) specifies a uniform indoor method of testing for rating solar domestic water heating systems for thermal performance, under benchmark conditions. For the determination of yearly thermal performance, refer to Part 2 and Part 3. **IS 13129 (Part 2): 2023 (**Solar heating domestic water heating systems part 2 procedure for system performance characterization and yearly performance predication (MED 4)) sets out a method of determining the performance of a solar water heating system under natural outdoor conditions and prescribes a method of transforming the test results from the particular climate conditions of the test to long-term average conditions for the test location or for other location with similar solar irradiation conditions. **IS 13129 (Part 3): 1991 (** Solar heating - Domestic water heating systems: Part 3 procedures for system component characterization and - Predication for yearly performance using component performance data (MED 4)) specifies a method for predication of the long-term yearly performance of solar water heaters based on detailed simulation of the system. The standard specifies two approaches to characterize the necessary system parameters for the simulation, either by separate component testing or by a certain computer simulation programme, but swell-established detailed national programmes are to be used for this purpose. **IS 13129 (Part 4) : 2023 (**Solar heating domestic water heating systems: part 4 Determination of durability and reliability (MED 4)) establishes uniform methods of testing solar domestic water heating systems for short term durability and reliability.

Syphon type domestic solar water heating systems

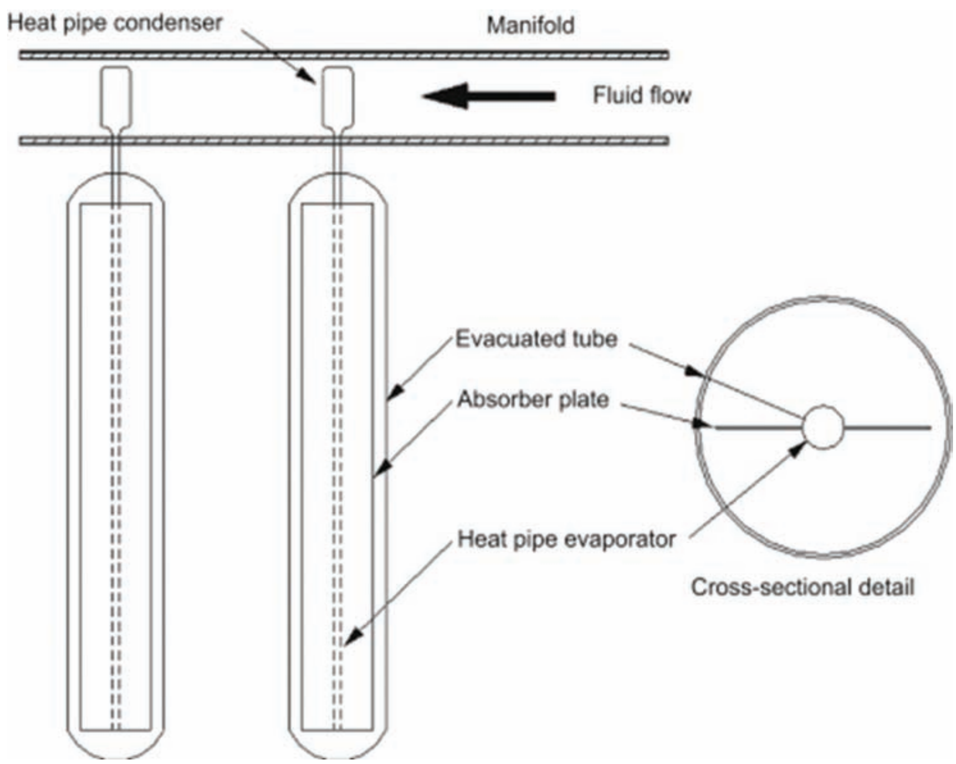
Another use of solar energy is to heat water and for that **Syphon type domestic solar water heating systems** are used. This water heating system uses flat plate collector (FPC) or evacuated tubular collector (ETC), working on thermo-syphonic flow of water under natural outdoor conditions. The test on syphon type domestic solar hot water heating systems shall be carried out in the following sequence:

Sequence	Test
1	Pre-conditioning test
2	Static pressure leakage test
3	Thermal performance test (day time and night-time tests shall be performed one after another to complete one data set)



IS 16368 : 2015 (Test procedure for thermos syphon type domestic solar hot water heating systems (MED 4)) covers test procedure to evaluate thermal performance of domestic solar hot water systems.

Solar collectors operating on evacuated tube systems operate different from the collectors presented so far as they usually consist of a heat pipe inside a vacuum-sealed tube. The area of one tube is small; therefore to increase the heat collection area many tubes are connected to the same manifold (usually 10–20 tubes are used). The evacuated tube collector (ETC) usually employs a fin with a tube.

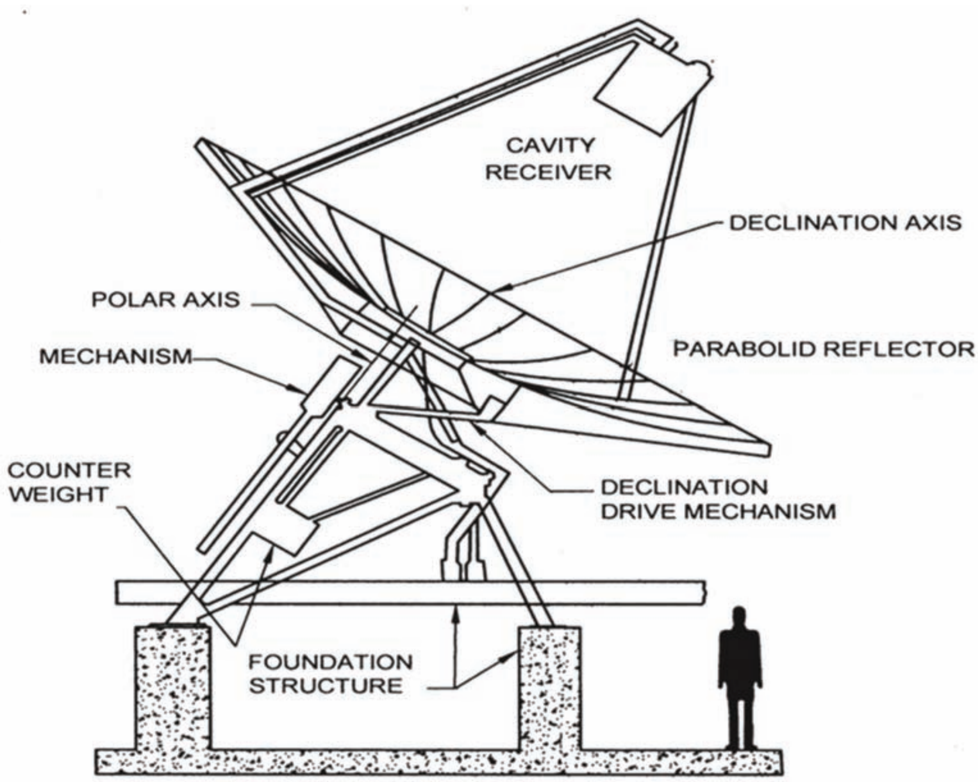


IS 16543 : 2016 (All glass evacuated solar collector tubes – Specification (MED 4)) specifies requirements of all-glass evacuated solar collector tubes of non-concentrating type solar collector hot water output up to 80 °C. **IS 16544 : 2016** (All glass evacuated tubes solar water heating system) specifies requirements of all glass evacuated tubes solar water heating system. This standard covers only non-concentrating, direct, vented solar collector system based on thermosyphon principle.

IS 16542 : 2016 (Direct insertion type storage water tank for all glass evacuated tubes solar collector – Specification (MED 4)) specifies requirements of direct insertion type storage water tank of water capacity up to 500 litre for use with all glass evacuated tubes solar collector. This standard covers only vented type storage water tank.

Solar thermal concentrator

Concentrator technologies use mirrors to reflect and concentrate sunlight onto a receiver. The energy from the concentrated sunlight heats a high temperature fluid in the receiver. This heat - also known as thermal energy - can be used to spin a turbine or power an engine to generate electricity. It can also be used in a variety of industrial applications, like water desalination, enhanced oil recovery, food processing, chemical production, and mineral processing.



IS 16648 (Part 1) : 2017 (Concentrated solar thermal - Specification: Part 1 paraboloid dish concentrator (MED 4)) specifies requirements of paraboloid dish concentrator for process heating and steam generation for temperature range of 60°C to 350°C. **IS 16648 (Part 2) : 2017 (**Concentrated solar thermal - Specification: Part 2 scheffler concentrator (MED 4)) specifies requirements of paraboloid dish concentrator for process heating and steam generation for temperature range of 60°C to 350°C. The paraboloid dish shall be useful for steam generation, high pressure hot water and thermic fluid systems in the above mentioned temperature range. **IS 16648 (Part 3) : 2017 (**Concentrated solar thermal - Specification: Part 3 parabolic trough concentrator (MED 4)) specifies requirements of solar parabolic trough collector (PTC) for process heating and steam generation for range 60°C to 250°C. The PTC also shall be useful for steam generation, high pressure hot water and thermic fluid systems in the above mentioned temperature range. **IS 16648 (Part 4) : 2018 (**Concentrated solar thermal - Specification: Part 4 non - Imaging concentrator (MED 4)) specifies requirements of non-imaging concentrator (NIC) for process heating and steam generation for range 60°C to 120°C. The NIC shall be useful for low to medium process heat application.

IS 16648 (Part 5) : 2017 (Concentrated solar thermal - Specification: Part 5 test methods (MED 4)) covers the determination of thermal performance of tracking concentrating solar collectors and non-tracking non-imaging concentrator (NIC). This test method applies to one or two-axis tracking reflecting concentrating collectors and non-imaging concentrator (NIC) in which the fluid enters the collector through a single inlet and leaves the collector through a single outlet, multiple collectors in series having single inlet and outlet may also be used. The main test on the solar concentrator is thermal performance test. Thermal performance is the rate of heat gain of a collect or relative to the incident solar power. This test method contains procedures to measure the thermal performance of a collector for certain well-defined test conditions. The procedures determine the response of the collector for various angles of incidence of solar radiation, and the thermal performance of the collector at various operating temperatures. The test method requires quasi-steady state conditions, measurement of environmental parameters and rate of useful heat gain (sensible and latent) by the fluid. The solar power incident on the collector is determined by the collector area, its angle relative to the sun, and the irradiance measured during the test.

IS/ISO/TR 10217: 1989 (Solar energy - Water heating systems - Guide to material selection with regard to internal corrosion (MED 4)) provides a discussion of the Parameters that have a bearing on the internal corrosion of solar water heating Systems. In many fields, the corrosion problem is hard to deal with, because it overlaps several matters. As far as solar Systems are concerned, corrosion prevention cannot be treated only in respect of a component, or only as a durability Problem, or only as a design Problem. lt cannot be solved only by specific tests, or only by design recommendations. This Technical Report addresses the question of which requirements are necessary, to predict with confidence long failure-free lifetimes in active solar Systems, from the Point of view of internal corrosion. lt gathers information provided in previous Papers on this subject especially bibliography references 2, 3 and 4) while staying in agreement with them.

Photovoltaic devices

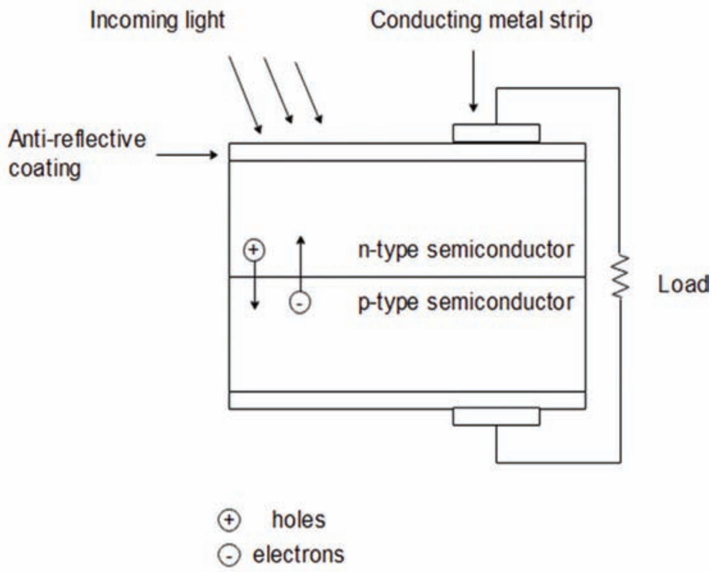
Photovoltaic (PV) devices contain semiconducting materials that convert sunlight into electrical energy. A single PV device is known as a cell, and these cells are connected together in chains to form larger units known as modules or panels.

A single PV cell is a thin semiconductor wafer made of two layers generally made of highly purified silicon (PV cells can be made of many different semiconductors but crystalline silicon is the most widely used). The layers have been doped with boron on one side and phosphorous on the other side, producing surplus of electrons on one side and a deficit of electrons on the other side.

When the wafer is bombarded by sunlight, photons in the sunlight knock off some of excess electrons, this makes a voltage difference between the two sides as the excess electrons try to move to the deficit side. In silicon this voltage is .5 volt

Metallic contacts are made to both sides of the semiconductor. With an external circuit attached to the contacts, the electrons can get back to where they came from and a current flows through the circuit. This PV cell has no storage capacity, it simply acts as an electron pump.

The amount of current is determined by the number of electrons that the solar photons knock off. Bigger cells, more efficient cells, or cells exposed to more intense sunlight will deliver more electrons.



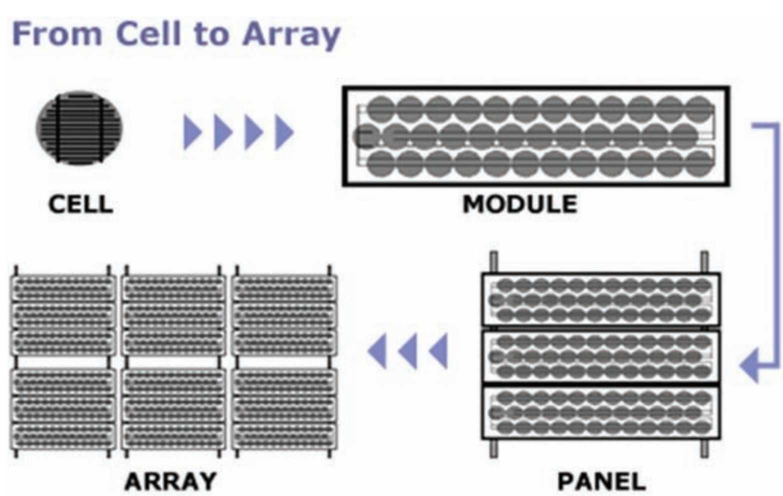
Photovoltaic Modules

A PV module consists of many PV cells wired in parallel to increase current and in series to produce a higher voltage. 36 cell modules are the industry standard for large power production.

The module is encapsulated with tempered glass (or some other transparent material) on the front surface, and with a protective and waterproof material on the back surface. The edges are sealed for weatherproofing, and there is often an aluminum frame holding everything together in a mountable unit. In the back of the module there is a junction box, or wire leads, providing electrical connections.

The photovoltaic effect is the basic principal process by which a PV cell converts sunlight into electricity. When light shines on a PV cell, it may be reflected, absorbed, or pass right through. The absorbed light generates electricity.

In the early 1950s, photovoltaic (PV) cells were developed as a spin-off of transistor technology. Very thin layers of pure silicon are impregnated with tiny amounts of other elements. When exposed to sunlight, small amounts of electricity are produced. Originally this technology was a costly source of power for satellites but it has steadily come down in price making it affordable to power homes and businesses.



Concentrated solar power plants employ concentrating, or focusing, collectors to concentrate sunlight received from a wide area onto a small blackened receiver, thereby considerably increasing the light's intensity in order to produce high temperatures. The arrays of carefully aligned mirrors or lenses can focus enough sunlight to heat a target to temperatures of 2,000 °C (3,600 °F) or more. This heat can then be used to operate a boiler, which in turn generates steam for a steam turbine electric generator power plant. For producing steam directly, the movable mirrors can be arranged so as to concentrate large amounts of solar radiation upon blackened pipes through which water is circulated and thereby heated.

IS 12762 series of standards formulated by BIS covers subjects on photovoltaics like measurement of PV characteristics, measurement of spectral responsivity and comparison with reference devices. **IS 12762 (Part 1) : 2010** (Photovoltaic devices: Part 1 measurement of photovoltaic current - Voltage characteristics (First Revision) (ETD 28)) describes procedures for the measurement of current-voltage characteristics of photovoltaic devices in natural or simulated sunlight. These procedures are applicable to a single photovoltaic solar cell, a sub-assembly of photovoltaic solar cells, or a PV module. **IS 12762 (Part 1/Sec 1) : 2020 (**Photovoltaic Devices Part 1 Measurement of Current-Voltage Characteristics Section 1 Multi-junction PV devices (ETD 28)) describes procedures for the measurement of the current-voltage characteristics of multi-junction photovoltaic devices in natural or simulated sunlight. It is applicable to single PV cells, sub-assemblies of such cells or entire PV modules. It is principally intended for non-concentrating devices, but parts may be applicable also to concentrating multi-junction PV devices. An essential prerequisite is the spectral responsivity of the multi-junction devices, whose measurement is covered by IEC 60904-8-1. **IS 12762 (Part 1/Sec 2) : 2020 (**Photovoltaic Devices Part 1 Measurement of Current-voltage Characteristics Section 2 Bifacial photovoltaic (PV) devices (ETD 28)) describes procedures for the measurement of the current-voltage (I-V) characteristics of bifacial photovoltaic devices in natural or simulated sunlight. It is applicable to single PV cells, sub-assemblies of such cells or entire PV modules.

IS 12762 (Part 2) : 2018 (Photovoltaic devices: Part 2 Requirements for photovoltaic reference devices (Second Revision)(ETD 28)) gives requirements for the classification, selection, packaging, marking, calibration and care of photovoltaic reference devices. This standard covers photovoltaic reference devices used to determine the electrical performance of photovoltaic cells, modules and arrays under natural and simulated sunlight.

IS 12762 (Part 3) : 2020 (Photovoltaic Devices Part 3 Measurement Principles for Terrestrial Photovoltaic PV Solar Devices with Reference Spectral Irradiance Data (Third Revision) (ETD 28)) applies to the following photovoltaic devices for terrestrial applications:

– solar cells with or without a protective cover;

– sub-assemblies of solar cells;

– modules; and – systems.

This document also describes basic measurement principles for determining the electrical output of PV devices. The principles given in this document are designed to relate the performance rating of PV devices to a common reference terrestrial solar spectral irradiance distribution.

IS 12762 (Part 4) : 2024 (Photovoltaic Devices Part 4 Photovoltaic Reference Devices - Procedures for Establishing Calibration Traceability (First Revision) (ETD 28)) sets the requirements for calibration procedures intended to establish the traceability of photovoltaic (PV) reference devices to SI units. This document applies to PV reference devices that are used to measure the irradiance of natural or simulated sunlight for the purpose of quantifying the performance of PV devices. The use of a PV reference device is required in many standards concerning PV.

IS 12762 (Part 5) : 2014 (Photovoltaic devices: Part 5 determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open - Circuit voltage method (First Revision) (ETD 28)) describes the preferred method for determining the equivalent cell temperature (ECT) of PV devices (cells, modules and arrays of one type of module), for the purposes of comparing their thermal characteristics, determining NOCT (nominal operating cell temperature) and translating measured I-V characteristics to other temperatures. This standard applies to linear devices with logarithmic VOC dependence on irradiance and in stable conditions. It may be used for all technologies but one has to verify that there is no preconditioning effect influencing the measurement.

IS 12762 (Part 7) : 2023 (Photovoltaic Devices Part 7: Computation of the Spectral Mismatch Correction For Measurements of Photovoltaic Devices (First Revision) (ETD 28)) describes the procedure for correcting the spectral mismatch error introduced in the testing of a photovoltaic device, caused by the mismatch between the test spectrum and the reference spectrum (e.g. AM1.5 spectrum) and by the mismatch between the spectral responsivities (SR) of the reference device and of the device under test and therewith reduce the systematic uncertainty. This procedure is valid for single-junction devices but the principle may be extended to cover multi-junction devices.

There is IS 12762 (Part 8) series of standards for spectral responsivity. **IS 12762 (part 8): 2018** (Photovoltaic devices: Part 8 measurement of spectral responsivity of a photovoltaic (PV) device (First Revision) (ETD 28)) specifies the requirements for the measurement of the spectral responsivity of both linear and non-linear photovoltaic devices. It is only applicable to single junction devices. The spectral responsivity of a photovoltaic device is used in cell development and cell analysis, as it provides a measure of recombination and other processes occurring inside the semiconductor or cell material system.

IS 12762 (Part 8/Sec 1) : 2020 (Photovoltaic Devices Part 8 Measurement of Spectral Responsivity of a Photovoltaic (PV) Device Section 1 Multi-junction (PV) devices (ETD 28)) gives guidance for the measurement of the spectral responsivity (SR) of multi-junction photovoltaic devices. It is principally intended for non-concentrating devices, but parts may be applicable also to concentrating multi-junction PV devices. The SR is required for analysis of measured current-voltage characteristics of multi-junction PV devices.

IS 12762 (Part 9) : 2023 (Photovoltaic Devices Part 9: Classification of Solar Simulator Characteristics (First Revision) (ETD 28)) provides the definitions of and means for determining simulator classifications at the required irradiance levels used for electrical stabilization and characterisation of PV devices. IEC standards for photovoltaic devices require the use of specific classes of solar simulators deemed appropriate for specific tests. Solar simulators can be either used for performance measurements of PV devices or endurance irradiation tests. This document is applicable for solar simulators used in PV test and calibration laboratories and in manufacturing lines of solar cells and PV modules. The A+ category is primarily intended for calibration laboratories and is not considered necessary for power measurements in PV manufacturing and in qualification testing. Class A+ has been introduced because it allows for reduction in the uncertainty of secondary reference device calibration, which is usually performed in a calibration laboratory. Measurement uncertainty in PV production lines will directly benefit from a lower uncertainty of calibration, because production line measurements are performed using secondary reference devices.

IS 12762 (Part 10) : 2023 (Photovoltaic Devices Part 10: Methods of Linear Dependence and Linearity Measurements (Second Revision) (ETD 28)) describes the procedures used to measure the dependence of any electrical parameter (Y) of a photovoltaic (PV) device with respect to a test parameter (X) and to determine the degree at which this dependence is close to an ideal linear (straight-line) function. It also gives guidance on how to consider deviations from the ideal linear dependence and in general on how to deal with non-linearities of PV device electrical parameters. This document lays down the requirements for linear dependence test methods, data analysis and acceptance limits of results to ensure that these linear equations will give satisfactory results. Such requirements prescribe also the range of the temperature and irradiance over which the linear equations may be used. This document gives also a procedure on how to correct for deviations of the short-circuit current ISC from the ideal linear dependence on irradiance (linearity) for PV devices, regardless of whether they are classified linear or non-linear according to the limits set in 9.7. The impact of spectral irradiance distribution and spectral mismatch is considered for measurements using solar simulators as well as under natural sunlight.

IS 12762 (Part 13) : 2020 (Photovoltaic Devices Part 13 Electroluminescence of Photovoltaic Modules (ETD 28)) specifies methods to:

a) capture electroluminescence images of photovoltaic modules,

b) process images to obtain metrics about the images taken in quantitative terms, and

c) provide guidance to qualitatively interpret the images for features in the image that are observed.

This document is applicable to PV modules measured with a power supply that places the cells in the modules in forward bias.

IS 12762 (Part 14) : 2023 (Photovoltaic devices Part 14: Guidelines for production line measurements of single-junction PV module maximum power output and reporting at standard test conditions (ETD 28)) provides guidelines for measurements of the maximum power (P_{max}) output of single-junction photovoltaic (PV) modules and for reporting at standard test conditions (STC) in industrial production line settings. Such measurements typically:

- Record current-voltage (I-V) data while illuminating the module with a solar simulator;

- Are performed on 100 % of manufactured modules, in order to determine whether they meet nameplate requirements for various bins spanning different power output levels.

This type of measurement is widespread and performed in high volume by PV module manufacturers worldwide.

IS 16270: 2023 (Secondary cells and batteries for solar photovoltaic application - General requirements and methods of test (ETD 11)) specifies the requirements and tests for secondary cells and batteries for use in photovoltaic energy systems (PVES). This standard is applicable to all types of secondary cells and batteries used in solar photovoltaic applications. **IS 16797: 2019** (Battery charge controllers for photovoltaic systems - Performance and functioning (ETD 28)) establishes minimum requirements for the functioning and performance of battery charge controllers (BCC) used with lead acid batteries in terrestrial photovoltaic (PV) systems. The main aims are to ensure BCC reliability and to maximise the life of the battery. **IS 16169: 2014 /IEC 62116: 2014** (Utility - Interconnected photovoltaic inverters - Test procedure of islanding prevention measures (ETD 28)) describes a guideline for testing the performance of automatic islanding prevention measures installed in or with single or multi-phase utility interactive PV inverters connected to the utility grid. The test procedure and criteria described are minimum requirements that will allow repeatability. Additional requirements or more stringent criteria may be specified if demonstrable risk can be shown. Inverters and other devices meeting the requirements of this standard are considered non-islanding. This standard may be applied to other types of utility-interconnected systems (e.g. inverter based micro turbine and fuel cells, induction and synchronous machines). However, technical review may be necessary for other than inverter-based PV systems.

A ***solar tracker*** is a device that orients a payload toward the Sun. Payloads are usually solar panels, parabolic troughs, Fresnel reflectors, lenses etc. The most-common applications for solar trackers are positioning photovoltaic (PV) panels (solar panels) so that they remain perpendicular to the Sun's rays and positioning space telescopes so that they can determine the Sun's direction. **IS 16663: 2018** (Photovoltaic systems - Specifications for solar trackers (ETD 28)) provides guidelines for the parameters to be specified for solar trackers for photovoltaic systems and provides recommendations for measurement techniques. This specification provides industry-wide definitions and parameters for solar trackers. Each vendor can design, build, and specify the functionality and accuracy with uniform definition. This allows consistency in specifying the requirements for purchasing, comparing the products from different vendors, and verifying the quality of the products. In addition, this specification will clarify terminology and definitions for trackers and provide examples of measurement techniques.

Safe electrical and mechanical operation of PV module is of paramount importance during its lifetime. **IS/IEC 61730-1: 2004** (Photovoltaic (PV) Module Safety Qualification Part 2 Requirements for Testing (ETD 28)) describes the fundamental construction requirements for photovoltaic (PV) modules in order to provide safe electrical and mechanical operation during their expected lifetime. Specific topics are provided to assess the prevention of electrical shock, fire hazards, and personal injury due to mechanical and environmental stresses. **IS/IEC 61730-2: 2004** (Photovoltaic (PV) Module Safety Qualification Part 1 Requirements for Construction (ETD 28)) describes the testing requirements for photovoltaic (PV) modules in order to provide safe electrical and mechanical operation during their expected lifetime. Specific topics are provided to assess the prevention of electrical shock, fire hazards, and personal injury due to mechanical and environmental stresses. This standard also attempts to define the basic requirements for various application classes of photovoltaic modules.

IS 14286: 2010/IEC 61215 :2005 (Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval (First Revision) (ETD 28)) lays down IEC requirements for the design qualification and type approval of terrestrial photovoltaic modules suitable for long-term operation in general open air climates. This standard is intended to apply to all crystalline silicon terrestrial flat plate modules. **IS 16077: 2013/IEC 61646 : 2008** (Thin - Film terrestrial photovoltaic (PV) modules - Design qualification and type approval (ETD 28)) lays down requirements for the design qualification and type approval of terrestrial, thin-film photovoltaic modules suitable for long-term operation in general open-air climates as defined in IEC 60721-2-1. **IS 16221 (Part 2) : 2015 /IEC 62109-2 : 2011** (Safety of power converters for use in photovoltaic power systems: Part 2 particular requirements for inverters (ETD 28)) covers the particular safety requirements relevant to d.c. to a.c. inverter products as well as products that have or perform inverter functions in addition to other functions, where the inverter is intended for use in photovoltaic power systems. Inverters covered by this standard may be grid-interactive, stand-alone, or multiple mode inverters, may be supplied by single or multiple photovoltaic modules grouped in various array configurations, and may be intended for use in conjunction with batteries or other forms of energy storage.

CHAPTER III

WIND ENERGY

CHAPTER III

WIND ENERGY

Wind flow is caused by a combination of three concurrent events:

Uneven heating of the atmosphere by the Sun

Irregularities of the earth's surface

The rotation of the earth.

Wind flow patterns and speeds change greatly across the country and are influenced by many factors, including but not limited to - bodies of water, vegetation, and differences in terrain.

We humans use this wind flow, or motion energy, for many purposes, which includes generating electricity, flying a kite, sailing etc.

Onshore wind is a proven, mature technology with an extensive global supply chain. Onshore wind has evolved over the last five years to maximise electricity produced per megawatt capacity installed to unlock more sites with lower wind speeds. Wind turbines have become bigger with taller hub heights, and larger rotor diameters. Offshore wind is expected to grow rapidly in the coming years as deploying turbines at sea takes advantage of stronger winds.

Wind and solar are the predominant sources of power generation in the Net Zero Emissions by 2050 Scenario, but annual wind capacity additions until 2030 need to increase significantly to be on track with the Net Zero pathway.

Reaching the levels of annual wind electricity generation foreseen in the Net Zero Scenario will require increased support for both onshore and offshore farms. Efforts should be focused on facilitating permitting, gaining public support, supporting the identification of suitable sites, decreasing costs and reducing project development timelines.

The wind's mechanical power is converted into electrical power or electricity. The terms "wind energy" and "wind power" both describe the process by which it is done. A generator can convert this mechanical power into electricity. This mechanical power of wind can also be used for other purposes and tasks- such as grinding grain or pumping water.

A wind turbine converts wind's mechanical energy into electricity using the aerodynamic force from the rotor blades. Wind uses the same force like an airplane's wing for this purpose. The pressure difference across the blades' sides due to wind flow causes the blade to rotate. When wind flows across the blade, the air pressure on one side of the blade decreases. The difference in air pressure across the two sides of the blade creates both lift and drag. The force of the lift is stronger than the drag and this causes the blade to rotate. The rotor connected to the blades rotates. The rotor is connected to the generator, either directly like in a direct drive turbine or through a shaft and gearbox that speeds up the rotation. This translation of aerodynamic force to rotation of a generator creates electricity.

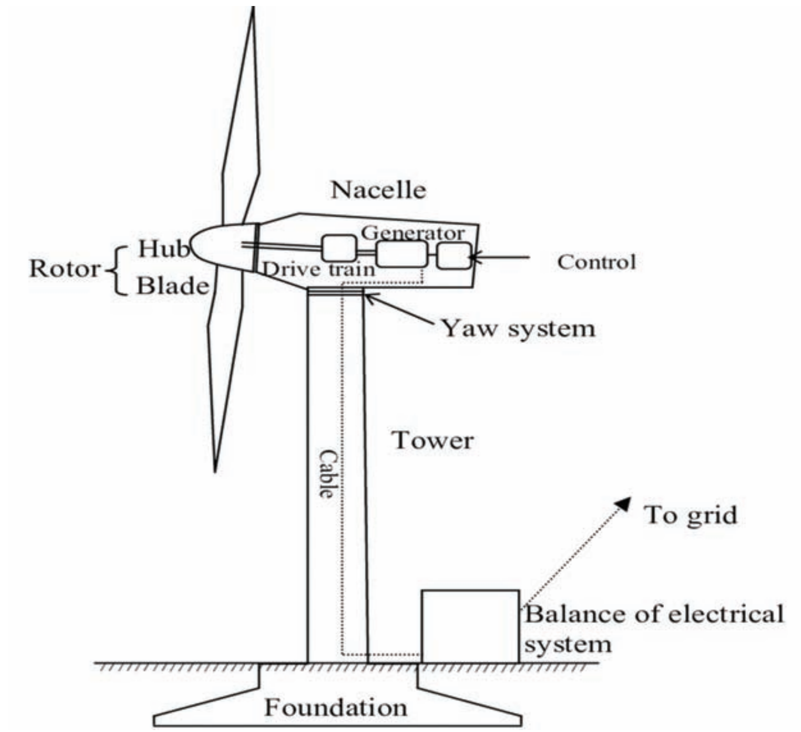
Types of wind turbines:

There are two types of wind turbines, classified according to their direction of motion of shaft. These are:

Horizontal axis wind turbines

Vertical axis wind turbines

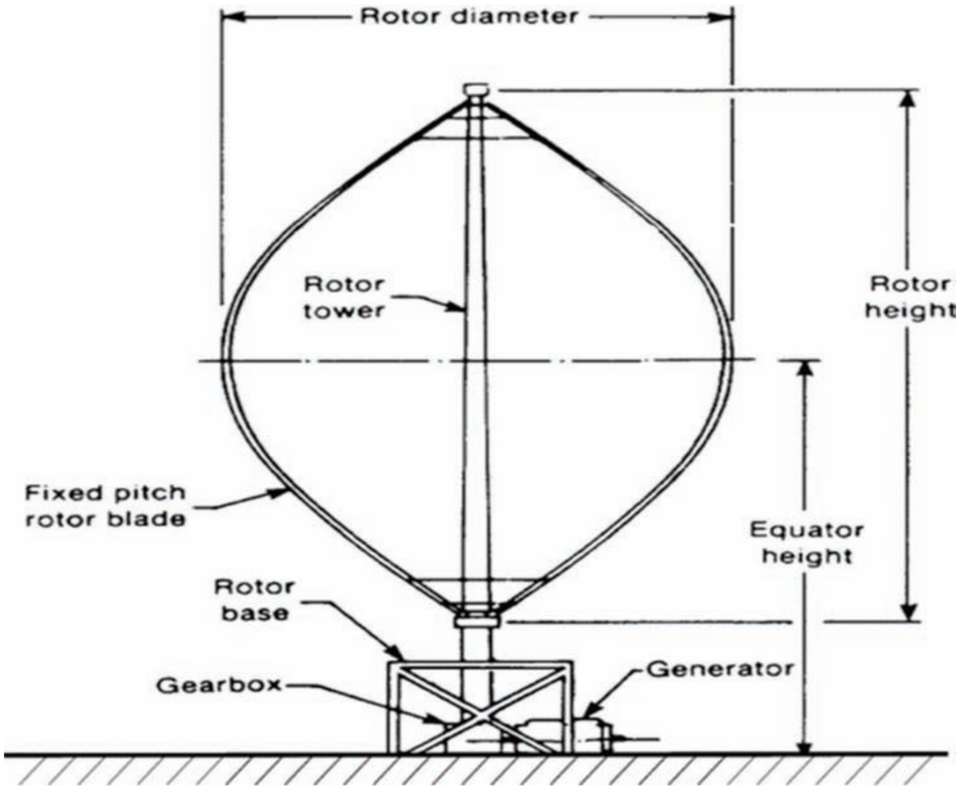
Horizontal axis wind turbines



Horizontal axis wind turbine (HAWT) is widely used for higher volume of production which often requires huge investment and occupies more space for the installation compared with vertical axis wind turbine (VAWT). The rotational axis of horizontal axis wind turbine is parallel towards the direction of wind in order to generate electricity . It requires large tower and blade to install. Highly skilled labours are required to install the horizontal axis wind turbine. The production cost is low when generating higher volume of electricity. The efficiency of horizontal axis wind turbine is high than the vertical axis wind turbine. The horizontal axis wind turbines are most suitable for sea shores, hill tops etc.,

Vertical axis type turbines

In Vertical axis wind turbine (VAWT), the rotor axis is in the vertical direction, perpendicular to the ground. Since the rotor axis is in the vertical direction, these turbines need not be pointed into the wind direction to be effective. This makes them advantageous for the usage on sites where the wind direction is highly variable. These turbines are significantly quieter than horizontal axis wind turbines. Thus, these turbines are used particularly in residential and urban areas. But tit has one drawback- it is less efficient than Horizontal axis type turbines because of the additional drag they produce when the blades rotate into the wind. Efforts are being made to reduce the drag coefficient on the VAWT in order to make it more efficient.



Vertical axis wind turbines are mainly classified into two types:

Darrieus type VAWT

Savonius type VAWT

Darrieus type wind turbines was first patented by Georges Jean Marie Darrieus, a French aeronautical engineer in 1931. These are the most efficient of all the VAWT. These types wind turbines are lift based i.e. the rotor movement and the generation of electricity is caused by the lift forces acting upon the blades. The advantage of using this type of model is its simple construction and low cost. But there are certain problems associated with these turbines such as low starting torque, build integration, blade lift forces, and low efficiency.

Savonius type wind turbine was initiated in the year 1922 by a Finnish scientist Savonius. This type is employed for the conversion of wind force into torque based on the rotational shift. The turbine has multiple aerofoils.

Standards on Wind turbines

Small wind turbines have a very small rotor diameter of around 1 m or less and generate about 300 kWh per year at sites with an average wind speed of 5,5 m/s. They are typically used for low-power uses in remote areas (e.g. fence-charging, basic lighting, electricity for sailboats). **IS/IEC 61400-2: 2013** (Wind Turbines Part 2: Small Wind Turbines (ETD 42)) deals with safety philosophy, quality assurance, and engineering integrity and specifies requirements for the safety of small wind turbines (SWTs) including design, installation, maintenance and operation under specified external conditions. Its purpose is to provide the appropriate level of protection against damage from hazards from these systems during their planned lifetime.

HAWT and VAWT typically are installed off shore or on shore, depending on the requirement. **IS 16589 (Part 4): 2017** (Wind turbines: Part 4 design requirements for wind turbine gearboxes (ETD 42)) is applicable to enclosed speed increasing gearboxes for horizontal axis wind turbine drive trains with a power rating in excess of 500 kW. This Standard provides guidance on the analysis of the wind turbine loads in relation to the design of the gear and gearbox elements. The standard is based on gearbox designs using rolling element bearings. Use of plain bearings is permissible under this standard, but the use and rating of them is not covered.

IS/IEC/TS 61400-14: 2005 (Wind Turbines Part 14: Declaration of Apparent Sound Power Level and Tonality values (ETD 42)) gives guidelines for declaring the apparent sound power level and tonality of a batch of wind turbines.

There are many standards which are for measurement of wind turbines, or the components of wind turbines. These standards address measurement requirements for wind turbines characteristics. Standardisation of measurement procedures will also facilitate comparisons between different wind turbines.

IS 16589 (Part 11): 2018 (Wind Turbines Part 11 Acoustic Noise Measurement Techniques (ETD 42)) presents measurement procedures that enable noise emissions of a wind turbine to be characterised. This involves using measurement methods appropriate to noise emission assessment at locations close to the machine, in order to avoid errors due to sound propagation, but far away enough to allow for the finite source size. The procedures described are different in some respects from those that would be adopted for noise assessment in community noise studies. They are intended to facilitate characterisation of wind turbine noise with respect to a range of wind speeds and directions. **IS/IEC 61400-12-1: 2017** (Wind Energy Generation Systems Part 12 Electricity Producing Wind Turbines Section 1 Power performance measurements (ETD 42)) describes ways to measure power measurement of wind turbines. The wind turbine power performance characteristics are determined by the measured power curve and the estimated annual energy production (AEP). The measured power curve, defined as the relationship between the wind speed and the wind turbine power output, is determined by collecting simultaneous measurements of meteorological variables (including wind speed), as well as wind turbine signals (including power output) at the test site for a period that is long enough to establish a statistically significant database over a range of wind speeds and under varying wind and atmospheric conditions. **IS/IEC 61400-12-5: 2022** (Wind energy generation systems - Part 12: Power performance - Section 5: Assessment of obstacles and terrain (ETD 42)) specifies the procedures for assessing the significance of obstacles and terrain variations on a proposed power performance measurement site and applies to the performance testing of wind turbines of all types and sizes connected to the electrical power network as described in other parts of the IEC 61400 series. The procedure applies to the performance evaluation of specific wind turbines at specific locations.

IS/IEC 61400-12-3: 2022 (Wind energy generation systems - Part 12: Power performance - Section 3: Measurement based site calibration (ETD 42)) specifies a measurement and analysis procedure for deriving the wind speed correction due to terrain effects and applies to the performance testing of wind turbines of all types and sizes connected to the electrical power network. The procedure applies to the performance evaluation of specific wind turbines at specific locations. **IS/IEC 61400-**

12-4: 2020 (Wind energy generation systems - Part 12- Power performance - Section 4 Numerical site calibration for power performance testing of wind turbines (ETD 42)) summarizes the current state of the art in numerical flow modelling, existing guidelines and past benchmarking experience in numerical model validation and verification.

IS/IEC 61400-12-6: 2022 (Wind energy generation systems - Part 12-6: Measurement based nacelle transfer function of electricity producing wind turbines (ETD 42)) specifies a procedure for measuring the nacelle transfer function of a single electricity-producing, horizontal axis wind turbine, which is not considered to be a small wind turbine. Measurement of fundamental structural loads on wind turbines for the purpose of the load simulation model validation is given in **IS/IEC/TS 61400-13: 2015** (Wind turbines part 13: Measurement of mechanical loads (ETD 42)). The standard prescribes the requirements and recommendations for site selection, signal selection, data acquisition, calibration, data verification, measurement load cases, capture matrix, post-processing, uncertainty determination and reporting. Informative annexes are also provided to improve understanding of testing methods. Electrical characteristics are measured and assessed according to **IS/IEC 61400-21-1: 2019** (Wind Energy Generation Systems Part 21 Measurement and Assessment of Electrical Characteristics Section 1 Wind Turbines (ETD 42)) and **IS/IEC/TR 61400-21-3: 2019** (Wind energy generation systems - Part 21: Measurement and assessment of electrical characteristics - Section 3: Wind turbine harmonic model and its application (ETD 42)). This standard provides guidance on principles which can be used as the basis for determining the application, structure and recommendations for the WT harmonic model.

IS/IEC 61400-23: 2014 (Wind Turbines Part 23 Full-Scale Structural Testing of Rotor Blades (ETD 42)) defines the requirements for full-scale structural testing of wind turbine blades and for the interpretation and evaluation of achieved test results. The standard focuses on aspects of testing related to an evaluation of the integrity of the blade, for use by manufacturers and third party investigators. **IS/IEC 61400-24: 2019** (Wind energy generation systems - Part 24: Lightning protection (ETD 42)) applies to lightning protection of wind turbine generators and wind power systems. This document defines the lightning environment for wind turbines and risk assessment for wind turbines in that environment. It defines requirements for protection of blades, other structural components and electrical and control systems against both direct and indirect effects of lightning. Guidance on the use of applicable lightning protection, industrial electrical and EMC standards including earthing is provided.

Certification system for wind turbines (WT) that comprises both type certification and certification of wind turbine projects installed on land or off-shore is given in **IS/IEC 61400-22: 2010** (Wind Turbines Part 22 Conformity Testing and Certification (ETD 42). This system specifies rules for procedures and management for carrying out conformity evaluation of WT and wind farms, with respect to specific standards and other technical requirements, relating to safety, reliability, performance, testing and interaction with electrical power networks.

CHAPTER IV
HYDRO ENERGY

CHAPTER IV

HYDRO ENERGY

Hydropower, or hydroelectric power, is one of the oldest and largest sources of renewable energy, which uses the natural flow of moving water to generate electricity.

Hydropower has been used since ancient times. Humans have been harnessing water to perform work for thousands of years. The Greeks used water wheels for grinding wheat into flour more than 2,000 years ago, while the Egyptians used Archimedes water screws for irrigation during the third century B.C. The evolution of the modern hydropower turbine began in the mid-1700s when a French hydraulic and military engineer, Bernard Forest de Bélidor, wrote the groundbreaking *Architecture Hydraulique*.

By the end of 19th century, the electrical generator was developed and coupled with hydraulics, was used to generate electricity. At the beginning of the 20th century, many small hydroelectric power stations were constructed. By the end of twentieth century, advanced and efficient hydropower generators were built.

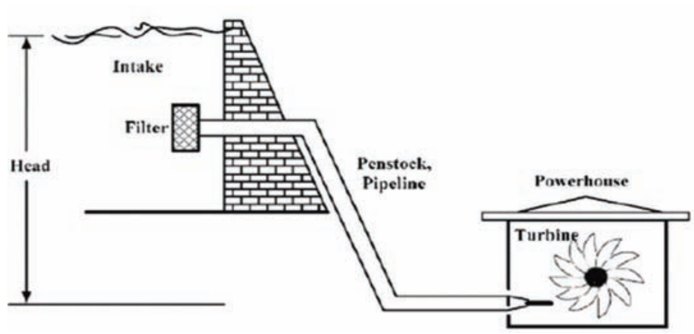
Hydropower currently generates more electricity than all other renewable technologies combined and is expected to remain the world's largest source of renewable electricity generation into the 2030s. Hydro generation is expected to be eventually overtaken by wind and solar power.

Without major policy changes, global hydropower expansion is expected to slow down this decade. The contraction results from slowdowns in the development of projects in China, Latin America and Europe. However, increasing growth in Asia Pacific, Africa and the Middle East partly offsets these declines. Increasingly erratic rainfall due to climate change is also disrupting hydro production in many parts of the world.

India is 5th globally for installed hydroelectric power capacity. As of 31 March 2020, India's installed utility-scale hydroelectric capacity was 46,000 MW, or 12.3% of its total utility power generation capacity. Additional smaller hydroelectric power units with a total capacity of 4,683 MW (1.3% of its total utility power generation capacity) have been installed. India's hydroelectric power potential is estimated at 148,700 MW at 60% load factor. In the fiscal year 2019–20, the total hydroelectric power generated in India was 156 TWh (excluding small hydro) with an average capacity factor of 38.71%.

How does hydropower works?

Hydropower technologies generates power by using the elevation difference, created by a dam or diversion structure, of water flowing in on one side and out, far below, on the other.



River valley projects

River valley projects are water resources projects planned for various purposes like irrigation, hydropower generation, water supply for drinking and industrial purposes, flood control, and navigation. These are projects serving more than one purpose, playing a major role in the economy and development of a country. It is commonly observed that the majority of the multipurpose river projects in India are a combination of irrigation and hydropower.

Standards on Glossary

A number of Indian Standards (around 29) have been published covering various aspects of River Valley Projects. These standards include technical terms and definitions of terms which are required to avoid ambiguity in their interpretation. The Committee on relating to River Valley Projects has brought out 'Glossary of terms relating to River Valley Projects' which has been published in 23 parts. Using these standards, one can avoid any confusion in the terms:

IS 4410 series of standards give glossary of the terms used in and related to river valley projects. **IS 4410 (Part 1) : 1991** (Glossary of terms relating to river valley projects: Part 1 irrigation practice (First Revision)(WRD 06)) covers definition of terms commonly occurring in the limited field of irrigation practice, for example, types of crops, areas and water requirements. **IS 4410 (Part 2) : 1967** (Glossary of terms relating to river valley projects: Part 2 project planning (WRD 06)) contains definitions of terms relating to types of projects, preliminary investigations and surveys, types of reports, economic aspect of project planning, estimates and contracts etc. **IS 4410 (Part 3) : 1988** (Glossary of terms relating to river valley projects: Part 3 river and river training (First Revision) (WRD 22)) contains definitions of terms relating to types of river, river flow behaviour, channel erosion, sediment load and river training. **IS 4410 (Part 4) : 1982 (**Glossary of terms relating to river valley projects: Part 4 drawings (First Revision) (WRD 06) contains definitions of terms relating to lines, scales, types of drawings, sections, projections, perspectives, charts, diagrams and maps, commonly used in river valley projects.

IS 4410 (Part 5) : 2023 (Glossary of terms relating to river valley projects: Part 5 Canals (Second Revision) (WRD 13)) contains definitions of terms relating to canal system, types of canals, design of canals, cross section of canals, longitudinal section of canals and canal lining.

IS 4410 (Part 6) : 2022 (Glossary of terms relating to river valley projects: Part 6 Reservoirs (WRD 10)) contains definitions of terms relating to the various types of reservoirs, storage and sedimentation in reservoirs, and evaporation losses from reservoirs, but does not contain definitions of terms relating to sub-surface or ground water reservoirs.

IS 4410 (Part 7) : 1982 (Glossary of terms relating to river valley projects: Part 7 engineering geology (First Revision) (WRD 05)) covers definitions of terms commonly used by engineering geologists and civil engineers. However, a few common rocks, including typically Indian types, have been included for the purpose of convenience. **IS 4410 (Part 8) : 1992** (Glossary of terms relating to river valley projects: Part 8 dams and dam: Section (First Revision) (WRD 09)) and **IS 4410 (Part 9) : 1982** (Glossary of terms relating to river valley projects: Part 9 spillways and siphons (First Revision)

(WRD 09)) contains definitions of terms relating to types of dams, dam sections, galleries, shafts and tunnels, joints and grouting in dam and definition of terms relating to types, design and parts of spillways and siphons resp.

Terms relating to hydro-electric power station including water conductor system are discussed in **IS 4410 (Part 10) : 1988** (Glossary of terms relating to river valley projects: Part 10 hydro - Electric power station including water conductor system (First Revision) (WRD 15)). Method of measurement of diaphragm walls in river valley project works (dams and appurtenant structures) are given in **IS 9401 (Part 11) : 1998** (Methods of measurement of work in river valley projects (Dams and Appurtenant structures): Part 11 diaphragm walls (First Revision) (WRD 23)).

Terms relating to temporary diversion works and those relating to operation, maintenance and repair of river valley projects are given in **IS 4410 (Part 12) : 1993** (Glossary of terms relating to river valley projects: Part 12 diversion works (First Revision) (WRD 22)) and **IS 4410 (Part 13) : 1985** (Glossary of terms relating to river valley projects: Part 13 Operation, Maintenance and Repair of River Valley Projects (WRD 23)) resp..

Soil conservation in riven valley projects and terms related to reclamation are given in **IS 4410 (Part 14/Sec 1) : 1977** (Glossary of terms relating to river valley projects: Part 14 soil conservation and reclamation: Sec 1 soil conservation (WRD 06)) and **IS 4410 (Part 14/Sec 2) : 1977** (Glossary of terms relating to river valley projects: Part 14 soil conservation and reclamation: Sec 2 reclamation (WRD 06)).

IS 4410 (Part 15/Sec 1) : 2023 (Glossary of terms relating to river valley projects: Part 15 Canal Structures Section 1 General Terms (WRD 13)) covers the definitions of general terms relating to canal structures. **IS 4410 (Part 15/Sec 2) : 2023** (Glossary of terms relating to river valley projects: Part 15 Canal Structures Section 2 Transitions (WRD 13)) covers the definitions of terms relating to transitions in canal structures. Canal structures flume, canal structures regulating works and canal structures cross-drainage works are given in **IS 4410 (Part 15/Sec 3) : 1977** (Glossary of terms relating to river valley projects: Part 15. (WRD 13)), **IS 4410 (Part 15/Sec 4) : 1977** (Glossary of terms relating to river valley projects: Part 15 (WRD 13)) and **IS 4410 (Part 15/Sec 5) : 2023** (Glossary of terms relating to river valley projects: Part 15 (WRD 13)) resp..

IS 4410 (Part 16/Sec 1) : 1999 (Glossary of terms relating to river valley projects: Part 16 gates and valves: Sec 1 gate and Terms related with gates (First Revision) (WRD 3)) and **IS 4410 (Part 16/Sec 2) : 1981** (Glossary of terms relating to river valley projects: Part xvi gates and valves: Sec 2 valves (WRD 3)) covers the terminology relating to gates, types of gates and other related terms used m-river valley and hydropower projects and definitions of the terms relating to valves resp..

IS 4410 (Part 17) : 2024 (River Valley Projects Glossary of Terms Part 17 Water Requirements of Crops (First Revision) (WRD 06)) covers terms relating to reclamation. **IS 4410 (Part 18) : 1983 (Glossary of terms relating to river valley projects: Part 18 energy dissipation devices (Stilling Basins) (WRD 09))** covers the definitions of the terms relating to energy dissipation devices adopted in river valley projects. **IS 4410 (Part 19) : 1996** (Glossary of terms relating to river valley projects: Part 19 grouting (WRD 08)) covers the definitions of terms relating to grouting for river valley projects. **IS 4410 (Part 20) : 1983** (Glossary of terms relating to river valley projects: Part 20 tunnels (WRD 14)) covers the definitions of terms relating to tunnels. However, this standard does not cover terms relating to tunnel equipment's and geology.

IS 4410 (Part 21) : 1987 (Glossary of terms relating to river valley projects: Part 21 flood control (WRD 06)), **IS 4410 (Part 22) : 1994 (**Glossary of terms relating to river valley projects: Part 22 barrages and weirs (WRD 22)) and **IS 4410 (Part 23) : 1999** (Glossary of terms relating to river valley projects: part 23 hoists, cranes and other related items (WRD 3))

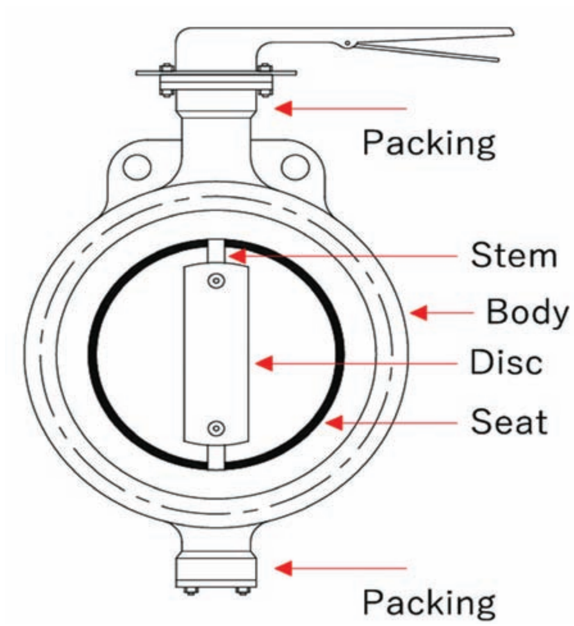
covers the definitions of terms relating to flood control. Barrages and Weirs and hoists, cranes and other related terms used in river valley and hydropower projects resp..

Standards on Gates, Hoists and Valves

The gates are used not only to pass large floods but also to regulate the reservoir level during minor variations in flow. The gate, in general is a structural steel frame consisting of end vertical girders with properly spaced horizontal girder between them. The spacing depends on the design water pressure and on dimensions of the gate. The frame is held apiece by secure welding or riveting.

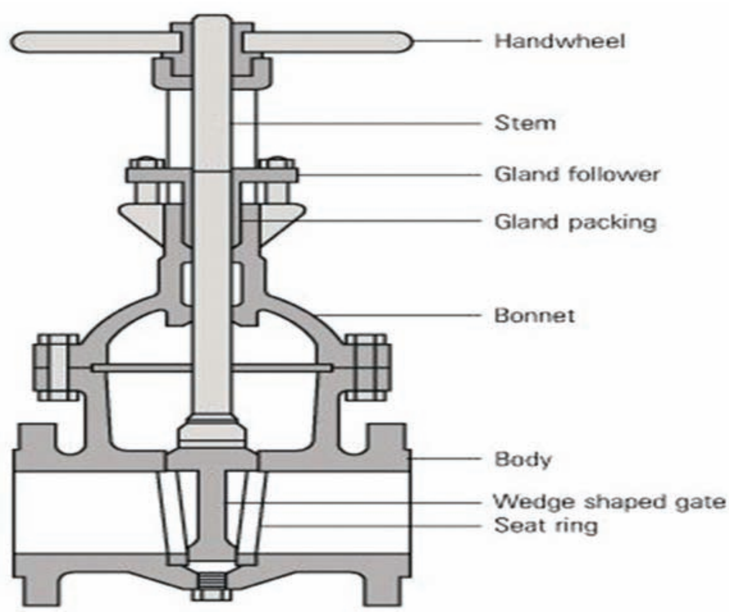
The valves, like butterfly valve, are one of the types of shut-off devices most commonly employed in hydropower station and systems. Its use is favoured because of their relatively low cost, compactness, light weight, reasonable water tightness and simplicity of operation. It serves the following purposes: a) Stops the water flow to the turbine when the latter is stopped and when no water is to be allowed to flow through the guide vanes. b) Stops the water entry in case of emergency, that is, non-closure of guide apparatus or in the event of low oil pressure in the system. c) Unit isolation in multi-unit plants where one penstock feeds more than one unit. d) To facilitate inspection of water path passage. e) To close the valve in the event of penstock rupture. In case of turbine inlet valve, valve should close in the event of over velocity due to the turbine trip or rejection of load.

Following standards have been made by BIS for gates, hoists and valves for the river valley projects/ dams / reservoirs:



Butterfly valve

IS 4622: 2020 (Recommendations for Structural Design of Fixed-Wheel Gates (Fourth Revision) (WRD 12)) provides recommendations for the structural design of fixed-wheel gates for low, medium and high heads commonly used for spillways, sluices and penstocks in dams and for barrage and canal regulators. This standard also applies to such gates installed at inclined positions subject to corresponding changes. **IS 4623: 2000** (Recommendations for structural design of radial gates (Third Revision) (WRD 12)) provides guidance for the structural design criteria of radial gates. **IS 5620 : 2020** (Recommendations for Structural Design Criteria for Low Head Slide Gates (Third Revision) (WRD 12)) lays down the criteria for the design of slide gates for low head installations, that is for water heads up to and including 15 meters over sill. This also covers design guidelines for sliding type stoplogs.



Wedge shaped gate valve

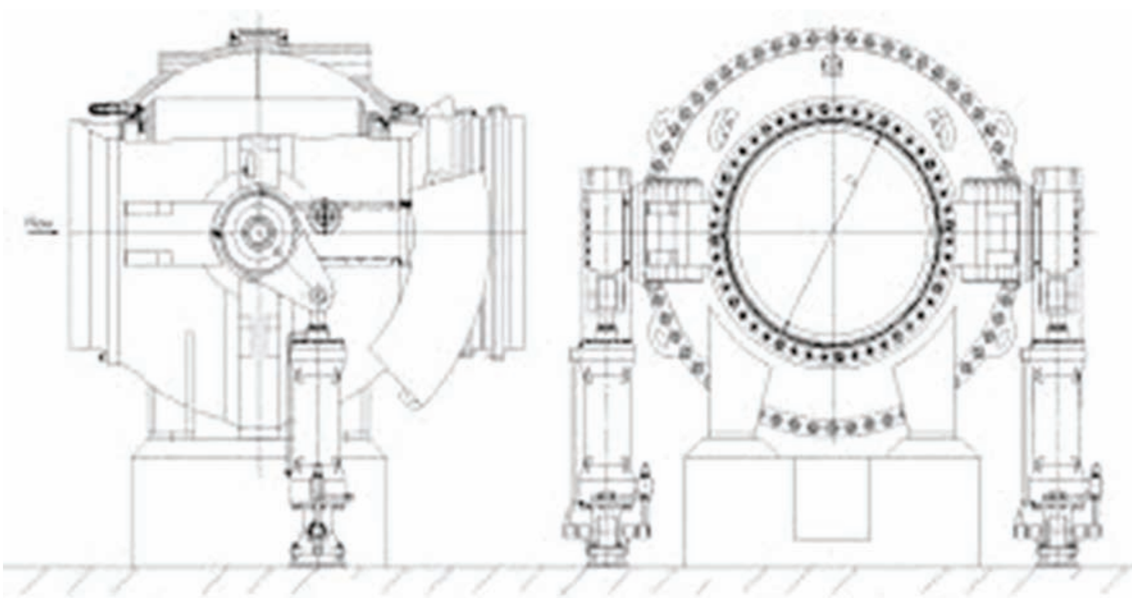
IS 6938 : 2005 (Design of rope drum and chain hoists for hydraulic gates - Code of practice (Second Revision) (WRD 12)) lays down guiding principles for design of rope drum and chain hoists used for the operation of hydraulic gates**.**

IS 7326 (Part 1) : 1992 (Penstock and turbine inlet butterfly valves for hydropower stations and systems: Part 1 criteria for structural and hydraulic design (First Revision) (WRD 12)) applies to reinforced solid rubber resilient sealing, rust resisting steel seated, doable-flanged butterfly valves and lays down the criteria for the structural and hydraulic design of butterfly valves for penstock and turbine inlet valve applications**. IS 7326 (Part 2) : 1992** (Penstock and turbine inlet butterfly valves for hydro - Power stations and systems: Part 2 guidelines for design and selection of control (WRD 12)) covers the guidelines for design and selection of control equipment for penstock and turbine inlet applications**. IS 7326 (Part 3) : 1976** (Penstock and turbine inlet butterfly valves for hydropower stations and systems: Part 3 recommendations for operations and maintenance (WRD 12)) covers the instructions for operation and maintenance of the butterfly valves.

IS 7332 (Part 1) : 1991 (Spherical valves for hydropower stations and systems: Part 1 criteria for structural and hydraulic design (WRD 12)) lays down the. guidelines (criteria) for the structural and hydraulic design of spherical valves for hydropower stations**. IS**

7332 (Part 2) : 1993 (Spherical valves for hydropower stations and systems: Part 2 selection of control equipment (First Revision) (WRD 12)) gives guidelines for the design and selection of the control equipment used in spherical valves and **IS 7332 (Part 3) : 1994** (Spherical valves for hydropower stations and systems: Part 3 recommendations for operation and maintenance of spherical valves (First Revision) (WRD 12)) covers instructions for operation and maintenance of spherical valves.

IS 7718 : 2018 (Recommendations for inspection, testing and maintenance of fixed wheel and slide gate (Second Revision) (WRD 12)) lays down the recommendations for inspection, testing and maintenance of fixed wheel and slide gates. It does not cover hoists, controls, stem rods, wire ropes, etc. **IS 9349: 2006 (**Recommendations for structural design of medium and high head slide gates (Second revision)(WRD 12)) provides recommendation for structural design of medium and high head slide gates. This standard does not cover bulkhead stop log gates and hoisting mechanism.



Spherical Valve

IS 10096 (Part 1/Sec 1) : 2014 (Recommendation for inspection; testing and maintenance of radial gates and their hoists: Part 1 inspection, testing and assembly at the manufacturing stage: Sec 1 gates (WRD 12)) lays down the recommendations for inspection, testing and assembly of radial gates at the manufacturing stage. It does not cover hoisting equipment**. IS 10096 (Part 1/Sec 2) : 2014** (Recommendations for inspection, testing and maintenance of radial gates and rope drum hoists: Part 1 inspection, testing and assembly at the manufacturing stage: Sec 2 rope drum hoists (First Revision) (WRD 12)) lays down the recommendations for inspection, testing and assembly of rope drum hoists for radial gates at the manufacturing stage. This standard may be applicable for rope drum hoists for other types of gates as well. **IS 10096 (Part 2) : 1983** (Recommendations for inspection, testing and maintenance of radial gates and their hoists: Part 2 inspection, testing and assembly at the time of erection (WRD 12)) lays down the recommendations for inspection, testing and assembly of radial gates and their hoists at the time of erection. **IS 10096 (Part 3) : 2002** (Recommendations for inspection, testing and maintenance of radial gates and rope drum hoists: Part 3 after erection (Second Revision) (WRD 12)) lays down the recommendations for inspection, testing and maintenance of radial gates and their rope drum hoists after erection.

IS 13623: 1993 (Criteria for choice of gates and hoists (WRD 12)) lays down the criteria for choice of common gates and hoists. Hydraulic hoists and manual hoists used for operation of hydraulic gates are given in **IS 10210 : 1993** (Criteria for design of hydraulic hoists for gates (First Revision) (WRD 12)) and in **IS 11228 : 2023** (Recommendations for design of screw hoists for hydraulic gates First revision (WRD 12)) resp..

IS 11793 : 1986 (Guidelines for design of float driven hoisting mechanism for automatic gated control (WRD 12)) lays down guidelines for design of a float-driven hoisting mechanism for automatic gated-control. This standard includes only typical arrangements commonly used, since possible arrangements are numerous due to a variety of types of gates, hoisting-mechanisms, float-drives and automatic flow-control devices (sensors). This may be used to admit water to or drain water from the, float-well in response to deviation of the controlled-variable from its predetermined-limits.

IS 11855: 2017 (Design and use of rubber seals for hydraulic gates - Recommendations (Second Revision) (WRD 12)) lays down specification for rubber seals used for common types of hydraulic gates. Guidelines for design and use of different types of rubber seals for common types of hydraulic gates

IS 13041: 2013 (Recommendations for inspection, testing and maintenance of hydraulic hoist (After Erection) (First Revision) (WRD 12)) lays down the recommendations for inspections, testing and maintenance of hydraulic hoist **IS 14177: 2023** (Painting systems for hydraulic gates and hoists- guidelines (WRD 12)) lays down the methods of preparation of steel surfaces, painting operation and paint system applicable to hydraulic gates, hoists and their supporting structures**.**

Standards on safety of River valley projects

With large scale increase in construction activity of river valley projects, the number of major accidents have also increased. The degree of safety achieved in project constructions has a direct bearing on the amount of effort expanded to avoid accidents by those who control the conditions and practices on the project.

Following standards lay down the requirements regarding safety programme, its enforcement, employees' training for safety and contractor's/employer's overall responsibility regarding safety:

IS 10386 (Part 1) : 2013 (Safety code for construction, operation and maintenance of river valley projects: Part 1 general aspects (First Revision) (WRD 21)) lays down the requirements regarding safety programme, its enforcement, general qualifications of employees and training for safety and contractor's/employer's overall responsibility regarding safety**. IS 10386 (Part 2) : 2013** (Safety code for construction, operation and maintenance of river valley projects: Part 2 amenities, protective clothing and equipment (First Revision) (WRD 21))lays down the requirements covering first aid and medical facilities, occupational health, environmental controls, ventilation, lighting, water supply, drainage, sanitation and personal protective clothing and equipment. **IS 10386 (Part 3) : 2014** (Safety code for construction, operation and maintenance of river valley projects: Part 3 plant and machinery (First Revision) (WRD 21)) lays down the safety requirements for plant and machinery used in river valley projects. **IS 10386 (Part 4)**

: 2013 (Safety code for construction, operation and maintenance of river valley projects: Part 4 handling, transportation and storage of explosives (First Revision) (WRD 21)) lays down requirements regarding storage of different classes of explosives, selection of site for magazine, maintenance and operation of magazine, transportation of explosives, their handling, loading, unloading and inspection as well as precautions to be taken therein.

Electrical and Fire safety aspects are given in **IS 10386 (Part 5) : 2014** (Safety code for construction, operation and maintenance of river valley projects: Part 5 electrical aspects (First Revision) (WRD 21)) and **IS 10386 (Part 7) : 2020** (Construction, Operation and Maintenance of River Valley Projects Safety Code Part 7 Fire Safety Aspects (First Revision) (WRD 21)).

Part 5 lays down the safety requirements covering indoor/outdoor electrical installations of generating stations, tunnels, electrical stores, pumping stations, including generators, breakers, isolators, transformers, current transformers, potential transformers, instrument transformers, gas insulated switch gear, cables, metal clad switch gear, lightning arrestors, motors, storage batteries, illumination systems, pumps, cranes and hoists, etc. Part 7 lays down the fire safety requirements in river valley projects covering the following components and aspects: a) Main components, such as dams, canals, tunnels, penstocks, control structures, valve houses, distribution stations, transformer and switch yards. b) Buildings both permanent and temporary. c) Forest - Where most of the river valley projects are located either in hills or foot hills. d) Hydropower stations and their allied equipment. This standard is intended to be of use during the construction, operation as well as maintenance periods, for the fire safety of river valley projects. Utmost care should be taken in fire precautions during the construction time of the project as it is the busiest period for various activities and on account of large deployment of men and material.

IS 10386 (Part 6) : 2020 (Safety code for construction operation and maintenance of river valley projects: Part 6 construction (WRD 21)) lays down the safety requirements regarding scaffolds, platforms, gangways and runs, ladders, ramps, openings, dangerous corners, forms for concrete, grouting and guniting, structural steel erection, welding, riveting and cutting, painting storage of materials like cement, pipes, poles, steel, sand, gravel, crushed stone, paints, etc. **IS 10386 (Part 8) : 2024** (construction operation and maintenance of river valley projects Safety code : Part 8 open excavation (first revision) (WRD 21)) lays down requirements for the safety aspects to be taken during excavation for structure like dams, barrages, power houses, canals, channels and such other structures associated with river valley projects.

IS 10386 (Part 9) : 1998 (Safety code for operation and maintenance of river valley projects: Part 9 canals and cross drainage works (WRD 21)) lays down guidelines for safety measures to be adopted during operation of a canal/ cross drainage work. **IS 11399 (Part 1) : 1985** (Guidelines for estimating output norms of items of work in construction of river valley projects: Part 1 earthwork excavation (WRD 23)) lays down the norms for various factors involved in estimating the output of machinery used in earthwork excavation.

IS 10386 (Part 10) : 1983 (Safety code for construction, operation and maintenance of river valley projects: Part 10 Storage, handling, detection and safety measures for gases, chemicals and flammable liquids (WRD 21)) lays down the requirements regarding storage, handling, detection and safety measures for gases, chemicals and flammable liquids used in river valley projects

BIS has also formulated standards for estimating unit rates of various works in river valley projects. **IS 11590 : 1995** (Guidelines for working out unit rate cost of the construction equipment used for river valley projects (First Revision) (WRD 23)) lays down guidelines for working out hourly owning and operating cost of different types of construction equipment used on river valley projects. **IS 11638 : 2000** (Proforma for estimation of unit rate of construction of embankment by mechanical means (First Revision) (WRD 23)) lays down proforma for estimation of unit rate of construction of embankment by mechanical means. **IS 13418 : 1992** (Proforma for analysis of unit rate of grouting used in river valley projects (WRD 23)) lays down proforma intended for analysis of unit rate of grouting per kg of grout when cement based grout with additives wherever required, is used. (**IS 13419 : 1992** (Proforma for analysis of unit rate of shotcreting/guniting used in river valley projects(WRD 23)) lays down proforma for analysis of unit rate of guniting/shotcreting used in River Valley Projects. **IS 14835 : 2000** (Guidelines for estimating unit rate of items of works in construction of rubble masonry for river valley projects (WRD 23)) stipulates general requirements for the estimation of unit rate of various items of work in construction of rubble masonry used in river valley projects. **IS 4851 : 202** (Estimating Unit Rate of Concrete Used in Mechanized Construction of River Valley Projects Proforma (Third Revision) (WRD 23)) lays down the proforma for estimating unit rate of concrete used in mechanized construction of river valley projects. **IS 4877 : 1968** (Guide for preparation of estimate for river valley projects (WRD 23) enumerates the different items for estimating the cost of various components of the project and the Project as a whole with reasonable accuracy.

Method of measurement of various works have been enumerated in **IS 9401 (Part 12): 1992** (Method of measurement of works in river valley projects (Dams And Appurtenant Structures) (WRD 23)) covers the methods of measurement in respect of topographical surveys to be carried out for river valley projects. **IS 9401 (Part 13) : 1992** (Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 13 earth and fill dams (WRD 23)) covers the method for measurement of earth and fill dams. **IS 9401 (Part 14) : 1992** (Method of measurement of works in river valley projects (Dams and Appurtenant structures): Part 14 canal works (WRD 23)) covers the methods of measurement of canal works in river valley projects.

Drilling of bore holes and tunnelling work in the three main work areas involved, namely excavation, support system and concrete lining and its measurement is given in **IS 9401 (Part 15) : 2010** (Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 15 investigation works - Drilling of bore holes and exploratory drifting and logging (WRD 23)) **IS 9401 (Part 16) : 1999** (Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 16 tunnelling (WRD 23)).

Hydromechanical and sheet piling work measurement is given in **IS 9401 (Part 17) : 1999** (Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 17 hydromechanical and related metal works (WRD 23)) and **IS 9401 (Part 18) : 2000** (Method of measurement of work in river valley projects (Dams And Appurtenant Structures): Part 18 sheet piling (WRD 23))

IS 9401 (Part 19) : 2022 (Method of measurement of works in river valley projects Dams and appurtenant structures Part 19 Electro Mechanical Works (WRD 23)) covers the method of measurement of electromechanical works in terms of units of measurement for the works carried out in river valley projects. **IS 9401 (Part 20) : 2013** (Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 20 protection works(WRD 23)) covers the methods for the measurement of protection works in terms of units of measurement for the works carried out in river valley projects.

Standards on environmental assessment of hydro projects

IS 15442 : 2004 (Parameters for environmental impact assessment of water resources projects (WRD 24)) gives the various parameters which needs to be standardized with respect to environmental impact assessment of water resources projects. **IS 15845 : 2009** (Environment management plan for hydropower/irrigation/flood control/ multipurpose river valley projects (WRD 24)) provides guidance on environmental management plan of a project includi ng restoration, mitigation, amelioration and compensation for the projects on hydropower, irrigation, drainage, flood control and multipurpose projects. **IS 17422 : 2021** (Guidelines for assessment of the environmental health impacts of river valley projects (WRD 24)) provides guidance on the methodology and criteria for Environmental Health Impact Assessment for the projects on hydropower, irrigation, drainage, flood control and multipurpose river valley projects.

CHAPTER V

BIO-ENERGY

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BIO-ENERGY

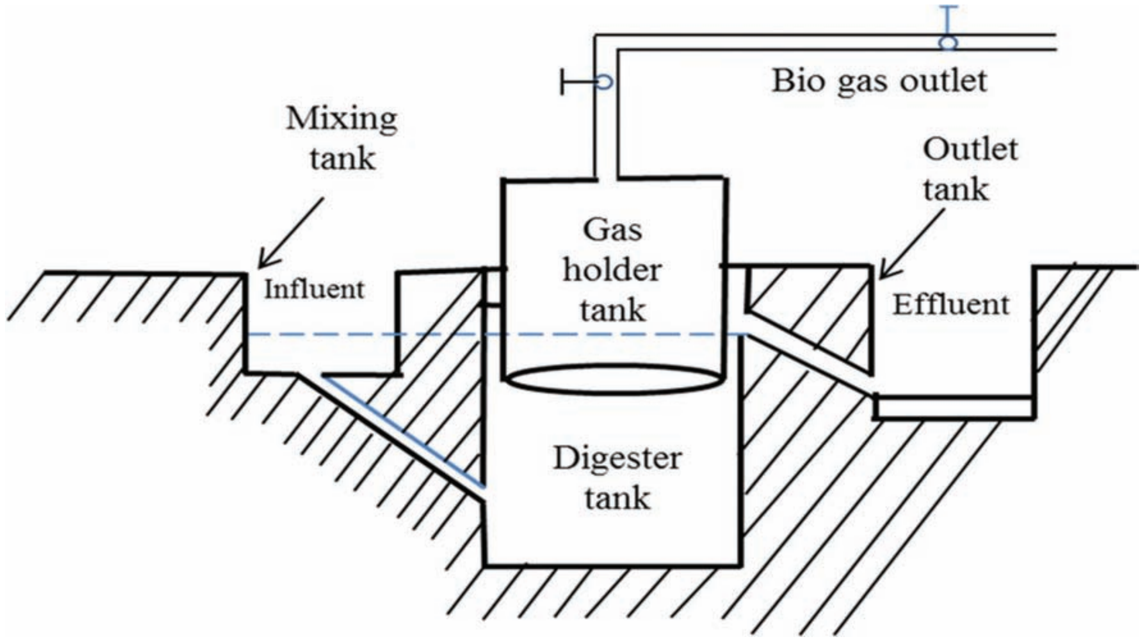
Biogas is a gaseous renewable energy source produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste, wastewater, and food waste. Bioenergy is produced from organic material, known as biomass, which contains carbon absorbed by plants through photosynthesis. When this biomass is used to produce energy, the carbon is released during combustion and returns to the atmosphere. As more biomass is produced an equivalent amount of carbon is absorbed, making modern bioenergy a near zero-emission fuel. It is the largest source of renewable energy globally, accounting for 55% of renewable energy and over 6% of global energy supply.

Modern bioenergy is an important source of renewable energy - its contribution to final energy demand across all sectors is currently five times higher than wind and solar PV combined, even when the traditional use of biomass is excluded. Heating remains the largest use of bioenergy, and while space heating will be increasingly electrified, bioenergy could potentially play a major role in hard-to-electrify sectors such as aviation and shipping.

Modern bioenergy does not include the traditional use of biomass in developing countries and emerging economies for cooking and heating with open fires or simple stoves, which badly impairs human health and the environment. Use of these traditional biomass falls to zero by 2030 in the Net Zero Scenario to achieve the UN Sustainable Development Goal/ 7 on Affordable and Clean Energy.

Biogas is produced by anaerobic digestion with anaerobic organisms or methanogens inside an anaerobic digester, biodigester or a bioreactor. The gas composition is primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulfide (H_2S), moisture and siloxanes. The methane can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel; it can be used in fuel cells and for heating purpose, such as in cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat.

After removal of carbon dioxide and hydrogen sulfide it can be compressed in the same way as natural gas and used to power motor vehicles. In the United Kingdom, for example, biogas is estimated to have the potential to replace around 17% of vehicle fuel. It qualifies for renewable energy subsidies in some parts of the world. Biogas can be cleaned and upgraded to natural gas standards, when it becomes bio-methane. Biogas is considered to be a renewable resource because its production-and-use cycle is continuous, and it generates no net carbon dioxide. From a carbon perspective, as much carbon dioxide is absorbed from the atmosphere in the growth of the primary bio-resource as is released, when the material is ultimately converted to energy.



A **biogas plant** is a facility that provides oxygen-free conditions where anaerobic digestion can occur. Simply put, it's an artificial system where you can turn waste into sustainable energy and fertilizers, with positive effects on the environment.

A biogas plant has three major components that make the biogas production process possible:

- a reception area
- a digester (or fermentation tank)
- a gas holder

The reception area is where the raw materials arrive and are prepared for anaerobic digestion. Each type of biomass has a different fermentation process, so the overall length of the biogas production process varies depending on the raw materials used, and it isn't uncommon to use pre-treatments in industrial biogas plants to accelerate fermentation and increase the production of biogas.

Some of the most popular biomass choices are crop residues, municipal and industrial sewage, agricultural material, livestock manures, seaweed, food-processing, and paper wastes, but the list of raw materials used is significantly longer.

The digester is an air-tight, waterproof container with a mean of entry for the biomass. Here, you introduce the raw materials to be transformed into energy. Then, agitators shift the biomass periodically to free the gases and prevent the formation of layers. The digester also includes a pipe that enables the digestate to be removed after the fermentation is over.

The gas holder is an airproof container, preferably made in steel, that collects the gas generated during fermentation. It's provided with a gas outlet that permits the biogas to come out of the system and produce energy and heat.

Depending on the quantity of waste you want to eliminate from the environment or the volume of biogas you need to produce, a plant might have more than one digester and gas holders.

IS 9478 : 2023 (Design, Construction, Installation and Operation of Biogas (Biomethane) Plant Code of Practice (MED 4)) specifies the requirements for design, construction, installation and operation of small, medium and large sized biogas (biomethane) plants. It includes the classification of biogas plants on the basis of daily biogas production, included and excluded feedstocks for plant, plant performance parameters, different designs and materials for digesters and gas holders, and their construction.

IS 12986 (Part 1) : 1990 (Biogas plants - Glass fibre reinforced polyester resin gas holders - Specification: Part 1 with steel frame (MED 4)) specifies the requirements for contact moulded glass fibre reinforced polyester resin biogas holders with steel frame suitable for floating drum type biogas plants.

IS 13152 (Part 1) : 2013 (Portable solid bio - Mass cookstove (Chulha) - Specification (First Revision) (MED 4)) covers requirements of different designs and types of solid bio-mass portable cookstove (chulha) for domestic and community/commercial applications.

CHAPTER VI

MARINE ENERGY

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MARINE ENERGY

Marine energy or marine power (also sometimes referred to as ocean energy, ocean power, or marine and hydrokinetic energy) refers to the energy carried by ocean waves, tides, salinity, and ocean temperature differences. The movement of water in the world's oceans creates a vast store of kinetic energy, or energy in motion. Some of this energy can be harnessed to generate electricity to power homes, transport and industries.

The term marine energy encompasses both wave power i.e. power from surface waves, and tidal power i.e. obtained from the kinetic energy of large bodies of moving water.

The oceans have a tremendous amount of energy and are close to many if not most concentrated populations. Oceans are a source of abundant renewable energy potential, capable of driving a blue economy. Energy harnessed from oceans, through offshore renewables, can contribute to the decarbonisation of the power sector and other end user applications relevant for a blue economy (e.g. shipping, cooling, water desalination). Offshore renewables can also provide significant socio-economic opportunities to countries with coastal areas and island territories, such as jobs creation, improved livelihoods, local value chains and enhanced synergies between blue economy actors.

Among the broad range of renewable energy options available within the global energy transition, ocean energy offers significant potential to support decarbonisation efforts. With a global market potential of 350 GW by 2050, ocean energy can provide clean, local, predictable electricity to coastal nations and islands around the world. Ocean energy technologies can also interact in a symbiotic way with the blue economy; contribute to climate change mitigation; create new employment opportunities; and support overall grid resilience.

Marine energy presents a wide variety of benefits to the communities and stakeholders who may one day use the power source. Marine energy can leverage waves, tides, currents, and differences in water temperature to provide essential power to even the hardest to reach communities.

Marine and Hydrokinetic (MHK) or marine energy development includes projects using the following devices:

- Wave power converters in open coastal areas with significant waves;- Waves are generated primarily by wind passing over the sea's surface and also by tidal forces, temperature variations, and other factors. As long as the waves propagate slower than the wind speed just above, energy is transferred from the wind to the waves.
- Tidal turbines placed in coastal and estuarine areas- Tidal power or tidal energy is harnessed by converting energy from tides into useful forms of power, mainly electricity using various methods.;
- Ocean current turbines in areas of strong marine currents;- The kinetic energy of marine currents can be converted in much the same way that a

wind turbine ¯extracts energy from the wind, using various types of open-flow rotors.

· Ocean thermal energy converters in deep tropical waters- harnesses the temperature difference between the warm surface waters of the ocean and the cold depths to run a heat engine to produce electricity.

Despite their potential, ocean energy technologies face recurring challenges to their deployment, including a lack of funding opportunities and market visibility.

Work on 'marine energy wave-tidal and other water current converters' has also been done and standards have been formulated on this topic. These standards are under print. The standards are on the following topics:

- Marine energy- Wave tidal and other water current converters Part 1 Vocabulary
- Marine energy -Wave tidal and other water current converters Part 2 Marine energy systems Design requirements
- Marine Energy -wave tidal and other water current converters Part 10 Assessment of mooring system for marine energy converters MECS
- Marine Energy -wave tidal and other water current converters Part 20 Design and Analysis of an Ocean Thermal Energy Conversion OTEC plant General Guidance
- Marine Energy -Wave Tidal and Other Water Current Converters Part 100 Electricity producing wave energy converters - Power performance assessment

IS 15122: 2014 (Measurement of liquid flow in open channels under tidal conditions (WRD 1)) provides a summary of a selection of recommended methods available for the measurement of liquid flow in tidal channels. special consideration being given to those techniques that are either unique to or particularly appropriate for measurement under tidal conditions, including treatment of errors.

CHAPTER VII

BIS COMMITTEES IN LIAISON WITH INTERNATIONAL TECHNICAL COMMITTEES FOR RENEWABLES

CHAPTER VII

BIS COMMITTEES IN LIAISON WITH INTERNATIONAL TECHNICAL COMMITTEES FOR RENEWABLES

Standard development is not a standalone task. Many experts at national and international level, many organizations working in the similar field, and other stakeholders like government and consumers are involved in the task of developing a standard. National; committees are a part of the international committees and regularly participate in the work of international standard formulation work. Thus, national interests of each country is taken care of during this international standard formulation.

In India, the committees of Bureau of Indian Standards (BIS), the National Standards Body of India, are constantly in liaison with the committees of International Standards Organization (ISO) and International Electrotechnical Commission (IEC) and help in formation of international standards. Following is the list of committees of ISO/IEC in liaison with BIS committees:

- BIS Committee: MED 4 (Renewable Energy Sources) is in liaison with

ISO/TC 180	-	Solar energy
ISO/TC 180/SC 1	-	Climate - Measurement and data
ISO/TC 180/SC 4	-	Systems - Thermal performance, reliability and durability
ISO/TC 285	-	Clean cook stoves and clean cooking solutions
ISO/TC 285/TG1	-	Communications Task Group
ISO/TC 285/TG2	-	Review of existing Standards on Fuels
ISO/TC 285/WG1	-	Conceptual framework
ISO/TC 285/TG4	-	Social impacts

- BIS Committee: ETD 28 (Solar Photovoltaics Energy Systems) is in liaison with

IEC TC 82	-	Solar photovoltaic energy systems

- BIS Committee: ETD 42 (Wind Turbines) is in liaison with

IEC TC 88	-	Wind energy generation systems

- BIS Committee: ETD 46 (Grid Renewables of Renewables) is in liaison with

IEC TC 8 / SC 8A	-	Grid Integration of Renewable Energy Generation
IEC TC 8 / SC 8B	-	Decentralized electrical energy systems
IEC TC 8/SC 8A/WG 2	-	Renewable energy power prediction

IEC TC 8/SC 8A/WG 6 - Connection of Renewable Energy with HVDC System -

IEC TC 8/SC 8A/WG 8 - Modeling of renewable energy generation for power system dynamic analysis

- BIS Committee: ETD 54 (Marine Energy Conversion Systems) is in liaison with

  IEC TC 114 - Marine energy - Wave, tidal and other water current converters

- BIS Committee: WRD 1 (Hydrometry) is in liaison with

  ISO TC 113/SC 6 - Sediment transport

- BIS Committee: WRD 29 (Small Hydropower plants) is in liaison with

  ISO TC 339 - Small hydropower plants (SHP plants)

The details about these ISO/IEC committees are available at their respective websites www.iso.org and www.iec.ch respectively.

CHAPTER VIII

REGULATIONS ON RENEWABLES IN INDIA AND MAPPING WITH GOVERNMENT SCHEMES

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REGULATIONS ON RENEWABLES IN INDIA AND MAPPING WITH GOVERNMENT SCHEMES

Technical Standard/ Regulation

India's governance has federal structure where administration is divided in Centre, States and Provinces. Thus, the policies and regulations related to renewables are issued by both Centre and the states.

However, about the implementation of Indian Standards on renewables, only centre, through its various ministries and departments, has issued some regulations. These are technical regulations, thereby making the Indian Standard related to renewables a mandatory standard for implementation. The extent and way of implementation is usually given in the regulation itself.

Following technical regulations have been issued by the centre. These regulations are about standards on renewables:

· List of Solar Photovoltaics, Systems, Devices and Components under Compulsory Registration Scheme- Notified by Ministry of New and Renewable Energy

S No.	Indian Standard	Product	Technical Regulation
1	IS 14286IS/ IEC 61730 -1 IS/IEC 61730 -2	Crystalline Silicon Terrestrial c Photovoltai (PV) modules (Si wafer based)	Solar Photovoltaics, Systems, Devices and Components Goods (Requirements for Compulsory Registration) Order, 2017
2	IS 16077IS/ IEC 61730 -1 IS/IEC 61730 -2	Thin-Film Terrestrial Photovoltaic (PV) Modules (a-Si, CiGs and CdTe)	
3	IS 16221 (Part 2	Power converters for use in photovoltaic power system	
4	IS 16169	Utility –Interconnected Photovoltaic inverters	
5	IS 16270	Storage battery	

The information on technical regulations (issued in the form of Quality Control Orders-QCOs) issued by the Central Government can be obtained from BIS website under the following link:

Conformity Assessment > Product Certification > Products under Compulsory Certification

(https://www.bis.gov.in/wp-content/uploads/2021/07/Guidance-document-on-QCOs-Revised-1.pdf)

Mapping with government Schemes

Apart from this, many government departments have issued many notifications and orders related to renewables. Government has also brought out various schemes involving renewables. These schemes are for masses. BIS has identified standards which are associated with these schemes. Some of the renewables standards mapped by BIS with these government schemes are given in the table below:

Sl. No.	Government Scheme	Indian Standard	Title
1.	National Programme on High Efficiency Solar PV Modules	IS 12762 (Part 3): 2020	Photovoltaic Devices Part 3 Measurement Principles for Terrestrial Photovoltaic PV Solar Devices with Reference Spectral Irradiance Data
		IS 12762 (Part 9): 2023	Photovoltaic Devices Part 9: Classification of Solar Simulator Characteristics
		IS 12933 (Part 1): 2003	Solar flat plate collector - Specification: Part 1 requirements
		IS 13129 (Part 2): 2023	Solar heating domestic water heating systems part 2 procedure for system performance characterization and yearly performance predication
		IS 13129 (Part 3): 1991	Solar heating - Domestic water heating systems: Part 3 procedures for system component characterization and - Predication for yearly performance using component performance data
		IS 13429 (Part 1): 2020	Solar Cooker - Box Type - Specification Part 1 Requirements
		IS 16270 : 2014	Secondary cells and batteries for solar photovoltaic application - General requirements and methods of test
		IS 16270 : 2023	Secondary cells and batteries for solar photovoltaic application - General requirements and methods of test
		IS 16663 : 2018	Photovoltaic systems - Specifications for solar trackers
		IS 17429 : 2020	Solar Photovoltaic Water Pumping Systems - Testing Procedure - Guidelines
		IS 17941 : 2022	Hand pump cum Solar Pumping System - Specifications

2.	Facilitating Offshore Wind Energy in India	IS 16589 (Part 4): 2017	Wind turbines: Part 4 design requirements for wind turbine gearboxes
		IS 16589 (Part 11): 2018	Wind Turbines Part 11 Acoustic Noise Measurement Techniques
		IS/IEC 61400-2 : 2013	Wind Turbines Part 2: Small Wind Turbines
		IS/IEC 61400-12-1) : 2017	Wind Energy Generation Systems Part 12 Electricity Producing Wind Turbines Section 1 Power performance measurements
		IS/IEC 61400-12-3) : 2022	Wind energy generation systems - Part 12: Power performance - Section 3: Measurement based site calibration
		IS/IEC 61400-12-4) : 2020	Wind energy generation systems - Part 12- Power performance - Section 4 Numerical site calibration for power performance testing of wind turbines
		IS/IEC 61400-12-5) : 2022	Wind energy generation systems - Part 12: Power performance - Section 5: Assessment of obstacles and terrain
		IS/IEC 61400-12-6) : 2022	Wind energy generation systems - Part 12-6: Measurement based nacelle transfer function of electricity producing wind turbines
		IS/IEC/TS 61400-13 : 2015	WIND TURBINES PART 13: MEASUREMENT OF MECHANICAL LOADS
		IS/IEC/TS 61400-14 : 2005	Wind Turbines Part 14: Declaration of Apparent Sound Power Level and Tonality values
		IS/IEC 61400-21-1) : 2019	Wind Energy Generation Systems Part 21 Measurement and Assessment of Electrical Characteristics Section 1 Wind Turbines
		IS/IEC/TR 61400-21-3) : 2019	Wind energy generation systems - Part 21: Measurement and assessment of electrical characteristics - Section 3: Wind turbine harmonic model and its application
		IS/IEC 61400-22 : 2010	Wind Turbines Part 22 Conformity Testing and Certification
		IS/IEC 61400-23 : 2014	Wind Turbines Part 23 Full-Scale Structural Testing of Rotor Blades
		IS/IEC 61400-24 : 2019	Wind energy generation systems - Part 24: Lightning protection

3.	Energy Storage Systems(ESS) Projects	IS 16797 : 2019	Battery charge controllers for photovoltaic systems - Performance and functioning
4.	Development of Solar Parks and Ultra Mega Solar Power Projects	IS/ISO/TR 10217 : 1989	Solar energy - Water heating systems - Guide to material selection with regard to internal corrosion
		IS 14286 : 2010/IEC 61215 :2005	Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval (First Revision)
		IS/IEC 61730-2 : 2004	Photovoltaic (PV) Module Safety Qualification Part 1 Requirements for Construction
		IS/IEC 61730-1 : 2004	Photovoltaic (PV) Module Safety Qualification Part 2 Requirements for Testing
		IS 16077 : 2013/IEC 61646 : 2008	Thin - Film terrestrial photovoltaic (PV) modules - Design qualification and type approval
		IS/IEC 61730-1 : 2016	Photovoltaic (PV) Module Safety Qualification Part 1 Requirements for Construction
		IS/IEC 61730-2 : 2019	Photovoltaic (PV) module safety qualification: Part 2 requirements for testing
		IS 16221 (Part 2) : 2015 IEC 62109-2 : 2011	Safety of power converters for use in photovoltaic power systems: Part 2 particular requirements for inverters
		IS 16169 : 2014 IEC 62116 : 2014	Utility - Interconnected photovoltaic inverters - Test procedure of islanding prevention measures
		IS 16270 : 2014	Secondary cells and batteries for solar photovoltaic application - General requirements and methods of test
5	Bio gas Programme	IS 12986 (Part 1): 1990	Biogas plants - Glass fibre reinforced polyester resin gas holders - Specification: Part 1 with steel frame
		IS 9478 : 2023	Design, Construction, Installation and Operation of Biogas (Biomethane) Plant Code of Practice
6	Policy on Hydro Power Development	IS 14476 (Part 19) : 1998	Test pumping of water wells - Code of practice

		IS 15755 : 2007	Hydrometry - Geophysical logging of boreholes for hydrogeological purposes - Considerations and guidelines for making measurements
		IS 15897 : 2011	Surface geophysical surveys for hydro geological studies
		IS 16094 : 2018	Hydrometry - Measuring the water level in a well using automated pressure transducer methods - Guidelines
		IS 4410 (Part 11/Sec 1) : 1972	Glossary of terms relating to river valley projects: Part 11 hydrology: Sec 1 general terms
		IS 4410 (Part 11/Sec 2) : 1972	Glossary of terms relating to river valley projects: Part 11 hydrology: Sec 2 precipitation and run off
		IS 4410 (Part 11/Sec 3) : 1973	Glossary of terms relating to river valley projects: Part 11 hydrology: Sec 3
		IS 4410 (Part 11/Sec 4) : 1973	Glossary of terms relating to river valley projects: Part 11: Sec hydrology hydrograph
		IS 4410 (Part 11/Sec 6) : 2018	Glossary of terms relating to river valley projects: Part 11 hydrology: Sec 6 groundwater (Second Revision)
		IS 4410 (Part 11/Sec 7) : 1984	Glossary of terms relating to river valley projects: Part 11 hydrology: Sec 7 quality of water
		IS 10096 (Part 1/Sec 1): 2014	Recommendation for inspection; testing and maintenance of radial gates and their hoists: Part 1 inspection, testing and assembly at the manufacturing stage: Sec 1 gates
		IS 10096 (Part 1/Sec 2): 2014	Recommendations for inspection, testing and maintenance of radial gates and rope drum hoists: Part 1 inspection, testing and assembly at the manufacturing stage: Sec 2 rope drum hoists (First Revision)
		IS 10096 (Part 2) : 1983	Recommendations for inspection, testing and maintenance of radial gates and their hoists: Part 2 inspection, testing and assembly at the time of erection
		IS 10096 (Part 3) : 2002	Recommendations for inspection, testing and maintenance of radial gates and rope drum hoists: Part 3 after erection (Second Revision)

		IS 10210 : 1993	Criteria for design of hydraulic hoists for gates (First Revision)
		IS 11228: 2023	Recommendations for design of screw hoists for hydraulic gates First revision
		IS 11793: 1986	Guidelines for design of float driven hoisting mechanism for automatic gated control
		IS 11855: 2017	Design and use of rubber seals for hydraulic gates - Recommendations (Second Revision)
		IS 13041: 2013	Recommendations for inspection, testing and maintenance of hydraulic hoist (After Erection) (First Revision)
		IS 13623: 1993	Criteria for choice of gates and hoists
		IS 14177: 2023	Painting systems for hydraulic gates and hoists First Revision of IS 14177
		IS 4410 (Part 16/Sec 1) : 1999	Glossary of terms relating to river valley projects: Part 16 gates and valves: Sec 1 gate and Terms related with gates (First Revision)
		IS 4410 (Part 16/Sec 2): 1981	Glossary of terms relating to river valley projects: Part xvi gates and valves: Sec 2 valves
		IS 4410 (Part 23) : 1999	Glossary of terms relating to river valley projects
		IS 4622 : 2020	Recommendations for Structural Design of Fixed-Wheel Gates (Fourth Revision)
		IS 4623 : 2000	Recommendations for structural design of radial gates (Third Revision)
		IS 5620 : 2020	Recommendations for Structural Design Criteria for Low Head Slide Gates (Third Revision)
		IS 6938 : 2005	Design of rope drum and chain hoists for hydraulic gates-Code of practice (Second Revision)
		IS 7326 (Part 1) : 1992	Penstock and turbine inlet butterfly valves for hydropower stations and systems: Part 1 criteria for structural and hydraulic design (First Revision)
		IS 7326 (Part 2) : 1992	Penstock and turbine inlet butterfly valves for hydro - Power stations and systems: Part 2 guidelines for design and selection of control
		IS 7326 (Part 3) : 1976	Penstock and turbine inlet butterfly valves for hydropower stations and systems: Part 3 recommendations for operations and maintenance

		IS 7332 (Part 1) : 1991	Spherical valves for hydropower stations and systems: Part 1 criteria for structural and hydraulic design
		IS 7332 (Part 2) : 1993	Spherical valves for hydropower stations and systems: Part 2 selection of control equipment (First Revision)
		IS 7332 (Part 3) : 1994	Spherical valves for hydropower stations and systems: Part 3 recommendations for operation and maintenance of spherical valves (First Revision)
		IS 7718 : 2018	Recommendations for inspection, testing and maintenance of fixed wheel and slide gate (Second Revision)
		IS 9349 : 2006	Recommendations for structural design of medium and high head slide gates (Second revision)
		IS 10386 (Part 1) : 2013	Safety code for construction, operation and maintenance of river valley projects: Part 1 general aspects (First Revision)
		IS 10386 (Part 2) : 2013	Safety code for construction, operation and maintenance of river valley projects: Part 2 amenities, protective clothing and equipment (First Revision)
		IS 10386 (Part 3) : 2014	Safety code for construction, operation and maintenance of river valley projects: Part 3 plant and machinery (First Revision)
		IS 10386 (Part 4) : 2013	Safety code for construction, operation and maintenance of river valley projects: Part 4 handling, transportation and storage of explosives (First Revision)
		IS 10386 (Part 5) : 2014	Safety code for construction, operation and maintenance of river valley projects: Part 5 electrical aspects (First Revision)
		IS 10386 (Part 6) : 2020	Safety code for construction operation and maintenance of river valley projects: Part 6 construction
		IS 10386 (Part 7) : 2020	Construction, Operation and Maintenance of River Valley Projects â•” Safety Code Part 7 Fire Safety Aspects (First Revision)
		IS 10386 (Part 8) : 2024	construction operation and maintenance of river valley projects Safety code : Part 8 open excavation (first revision)

		IS 10386 (Part 9) : 1998	Safety code for operation and maintenance of river valley projects: Part 9 canals and cross drainage works
		IS 10386 (Part 10) : 1983	Safety code for construction, operation and maintenance of river valley projects: Part 10 Storage, handling, detection and safety measures for gases, chemicals and flammable liquids
		IS 10386 (Part 11) : 2012	Safety Code for Construction, Operation and Maintenance of River Valley Projects: Part 11 Underground Excavation
		IS 4410 (Part 13) : 1985	Glossary of terms relating to river valley projects: Part 13 Operation, Maintenance and Repair of River Valley Projects
		IS 11399 (Part 1) : 1985	Guidelines for estimating output norms of items of work in construction of river valley projects: Part 1 earthwork excavation
		IS 11590: 1995	Guidelines for working out unit rate cost of the construction equipment used for river valley projects (First Revision)
		IS 11638: 2000	Proforma for estimation of unit rate of construction of embankment by mechanical means (First Revision)
		IS 13418: 1992	Proforma for analysis of unit rate of grouting used in river valley projects
		IS 13419: 1992	Proforma for analysis of unit rate of shotcreting/guniting used in river valley projects
		IS 14835: 2000	Guidelines for estimating unit rate of items of works in construction of rubble masonry for river valley projects
		IS 4851 : 2024	Estimating Unit Rate of Concrete Used in Mechanized Construction of River Valley Projects Proforma (Third Revision)
		IS 4877 : 1968	Guide for preparation of estimate for river valley projects
		IS 9401 (Part 1) : 1999	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 1 excavation for foundation (First Revision)
		IS 9401 (Part 2) : 2003	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 2 dewatering (First Revision)

		IS 9401 (Part 3) : 2003	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 3 grouting (Second Revision)
		IS 9401 (Part 4) : 2018	Method of measurement of works in river valley projects (dams and appurtenant structures): Part 4 Concrete work
		IS 9401 (Part 5) : 2014	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 5 masonry (First Revision)
		IS 9401 (Part 6) : 2013	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 6 ventilation pipes and other embedded Materials (First Revision)
		IS 9401 (Part 7) : 2013	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 7 joints (First Revision)
		IS 9401 (Part 8) : 1985	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 8 instrumentation
		IS 9401 (Part 9) : 1987	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 9 lining
		IS 9401 (Part 10) : 1990	Method of measurement of works in river valley projects (Dams - And Appurtenant Structures): Part 10 formwork
		IS 9401 (Part 11) : 1998	Methods of measurement of work in river valley projects (Dams and Appurtenant structures): Part 11 diaphragm walls (First Revision)
		IS 9401 (Part 12) : 1992	Method of measurement of works in river valley projects (Dams And Appurtenant Structures)
		IS 9401 (Part 13) : 1992	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 13 earth and fill dams
		IS 9401 (Part 14) : 1992	Method of measurement of works in river valley projects (Dams and Appurtenant structures): Part 14 canal works
		IS 9401 (Part 15) : 2010	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 15 investigation works - Drilling of bore holes and exploratory drifting and logging
		IS 9401 (Part 16) : 1999	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 16 tunneling

		IS 9401 (Part 17) : 1999	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 17 hydromechanical and related metal works
		IS 9401 (Part 18) : 2000	Method of measurement of work in river valley projects (Dams And Appurtenant Structures): Part 18 sheet piling
		IS 9401 (Part 19) : 2022	Method of measurement of works in river valley projects Dams and appurtenant structures Part 19 Electro Mechnical Works
		IS 9401 (Part 20) : 2013	Method of measurement of works in river valley projects (Dams And Appurtenant Structures): Part 20 protection works
		IS 15442: 2004	Parameters for environmental impact assessment of water resources projects
		IS 15845: 2009	Environment management plan for hydropower/irrigation/flood control/ multipurpose river valley projects
		IS 17422: 2021	Guidelines for assessment of the environmental heath impacts of river valley projects
		IS 4410 (Part 1) : 1991	Glossary of terms relating to river valley projects: Part 1 irrigation practice (First Revision)
		IS 4410 (Part 2) : 1967	Glossary of terms relating to river valley projects: Part 2 project planning
		IS 4410 (Part 4) : 1982	Glossary of terms relating to river valley projects: Part 4 drawings (First Revision)
		IS 4410 (Part 14/Sec 1) : 1977	Glossary of terms relating to river valley projects: Part 14 soil conservation and reclamation: Sec 1 soil conservation
		IS 4410 (Part 14/Sec 2) : 1977	Glossary of terms relating to river valley projects: Part 14 soil conservation and reclamation: Sec 2 reclamation
		IS 4410 (Part 17) : 2024	River Valley Projects â•” Glossary of Terms Part 17 Water Requirements of Crops (First Revision)
		IS 4410 (Part 21) : 1987	Glossary of terms relating to river valley projects: Part 21 flood control
		IS 10824: 1984	Code of practice for amenities in hydroelectric power houses

		IS 12800 (Part 1) : 1993	Guideltnbs for selectjon of turbines, preliminary dimensioning and layout of surface hydro - Electric powerhouses: Part 1 medium and large power houses
		IS 12800 (Part 2) : 1989	Guidelines For Selection Of Turbines, Preliminary Dimensioning And Layout Of Surface Hydro-electric Power House Part 2 Pumped Storage Power Houses
		IS 12800 (Part 3) : 1991	Guidelines for selection of hydraulic turbine,preliminary dimensioning and layout of surface hydroelectric power houses: Part 3 small, mini
		IS 12837: 1989	Hydraulic turbines for medium and large power houses - Guidelines for selection
		IS 4247 (Part 1) : 1993	Structural design of surface hydroelectric power stations: Part 1 data for design - Code of practice (Third Revision)
		IS 4247 (Part 2) : 1992	Code of practice for structural design of surface hydroelectric power station: Part 2 superstructure (Second Revision)
		IS 4247 (Part 3) : 1998	Code of practice for structural design of surface hydel power stations: Part 3 sub - Structure (Second Revision)
		IS 4410 (Part 10) : 1988	Glossary of terms relating to river valley projects: Part 10 hydro - Electric power station including water conductor system (First Revision)
		IS 4461 : 1998	Code of practice for joints in surface hydroelectric power stations (Second Revision)
		IS 4720 : 2020	Ventilation of Surface Hydel Power Stations â•” Code of Practice (Second Revision)
		IS 4721 : 2014	Code of practice for drainage and dewatering of surface/ underground hydroelectric power stations (Second Revision)
		IS 5496 : 1993	Guide for preliminary dimensioning and layout of elbow type draft tubes for surface hydroelectric power stations (First Re Vision)
		IS 7207 : 1992	Criteria for design of generator foundation for hydroelectric power stations (First Revision)
		IS 7418 : 1991	Criteria for design of spiral casing (Concrete And Steel) (First Rewsion)

		IS 9120 : 1979	Guidelines for planning, layout and design of cavities in underground hydroelectric power stations

CHAPTER IX

HOW TO ACCESS INDIAN STANDARDS

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HOW TO ACCESS INDIAN STANDARDS

Indian Standards, which are formulated by BIS, can be categorized into following groups:

- Indigenously developed Indian Standards
- Standards adopted from ISO/ IEC without any change
- Standards adopted from ISO/ IEC with changes according to Indian requirements

The standards in the first category, i.e., indigenous standards are freely available on BIS website. The route to get these standards is as follows:

BIS website (www.bis.gov.in) > conformity assessment > Products under compulsory certification > Indigenous Indian Standards- Free Download

Indigenous standards are available free of cost and can be downloaded from the above link/ route.

The other groups of standards, i.e., Standards adopted from ISO/ IEC without any change and standards adopted from ISO/ IEC with changes according to Indian requirements are not available free of cost and can be purchased from the website of M/s Book Supply Bureau, who are authorised agents of BIS for selling these standards online. Website of M/s Book Supply Bureau is as follows:

www.bsbedge.com