LED ARGENTINA
Tecnología de Iluminación LED

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GLOSSARY: LED LIGHTING TECHNOLOGY

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AC - Alternating Current: the flow of electric charge that periodically reverses direction. Alternating current is the prevailing electrical current in use today. [L.R.C./R.P.I.]

ACCENT LIGHTING (Highlighting): a technique that emphasizes a particular object or draws attention to a particular area (or field of view). Accent lighting is best achieved with LEDs (traditionally also utilizing the tight beam control of PAR lamps or MR lamps.

AMBIENT LIGHTING: lighting that is designed to provide a substantially uniform light level throughout an area, exclusive of any provision for special local requirements. [L.R.C./R.P.I.]

AMPERAGE: the amount of electrical current through a conductive source. [L.R.C./R.P.I.]

APPROPRIATE TECHNOLOGY: technology, processes, products and services whose nature corresponds to the environment, the socio-cultural milieu and the needs of broad sectors of the population.

BALLAST: a passive component used in an electric circuit to moderate changes in current. A device used with an electric-discharge lamp to obtain the necessary circuit conditions (voltage, current, and waveform) for starting and operating; all fluorescent and HID light sources require a ballast for proper operation.

BEAM ANGLE: the angle between the two directions for which the intensity (candlepower) is 50% of the maximum intensity as measured in a plane through the nominal beam centreline (centre beam candlepower).

BEAM SPREAD: the width of a light beam, expressed in degrees. The beam of light from a reflector-type lamp (PAR, R, ER, or MR) can be thought of as a cone; the beam spread is the angular width of the cone. Common beam spreads are known as spot, narrow, narrow flood, and flood. [L.R.C./R.P.I.]

BIPV - BUILDING INTEGRATED PHOTOVOLTAICS: photovoltaic modules integrated into the building roof or façade, substituting traditional building components with glass laminates that encapsulate photovoltaic cells. BIPV panels (or modules) are incorporated into the building construction materials as an integrated unit; the photovoltaic system is designed for producing electricity and taking on the role of a building element. BIPV modules have an energy conversion rate of around 10% (a module of 10% efficiency with a 1 m^2 surface area can be expected to produce approximately 100 watts of power).

BRIGHTNESS: see *Luminance*

CANDELA (**cd**): the standard unit of luminous intensity. It is formally defined as the magnitude of an electromagnetic field (a source that emits monochromatic radiation), in a specified direction, that has a radiant intensity of 1/683 watt per steradian at a frequency of 540 terahertz ($540x10^{12}$Hz). Originally, luminous intensity was measured in terms of units called candles; one candle represented approximately the amount of visible radiation emitted by a candle flame; this was an inexact specification because burning candles vary in brilliance (for a time, a specified amount of radiation from elemental platinum at its freezing temperature was used as the standard; late in the 20th century, the current definition and terminology were adopted). Millicandela (**mcd**) and Megacandela (Mcd) are measurement units of light intensity (brightness of lamps).

CCT-CORRELATED COLOUR TEMPERATURE: see Colour Temperature.

CELL EFFICIENCY: the percentage of electrical energy that a solar cell produces (under optimal conditions) as compared to the total amount of energy from the sun falling on the cell. At the sunward surface of the cell the highest possible average incident solar radiation is about 1000 W/m^2.

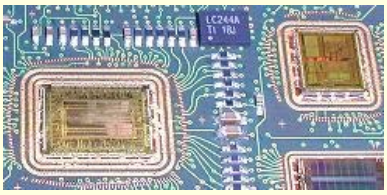
CENTRE BEAM CANDLEPOWER (CBCP): the luminous intensity at the center of a beam, expressed in candelas (cd)

CFL - COMPACT FLUORESCENT LAMP: a light bulb that is utilized in an incandescent fixture, and has the efficiency and qualities of a standard fluorescent bulb. These bulbs generally offer 75% savings in electricity while maintaining comparable light levels.

CHARGE CONTROLLER (Regulator): regulates the current from the solar panels to prevent the batteries from overcharging. Overcharging causes gassing and loss of electrolyte, resulting in damage to the batteries. It senses when the batteries are fully charged and stop, or decrease, the amount of current flowing to the battery. Most solar charge controllers include a Low Voltage Disconnect feature, which will switch off the supply to the load if the battery voltage falls below the cut-off voltage (preventing the battery from permanent damage and reduced life expectancy). A solar regulator also prevents the battery from back feeding into the solar panel at night and, hence, flattening the battery. Solar charge controllers are rated by the amount of current they can receive from the solar panels. Reflected sunlight and specific temperature conditions can increase the output current of a solar panel by as much as 25% above it's rated output current, therefore the solar charge controller must be sized to handle the increased current.

CHROMATICITY: the dominant or complementary wavelength and purity aspects of the colour taken together, or of the aspects specified by the chromaticity coordinates of the colour taken together. [L.R.C./R.P.I.]

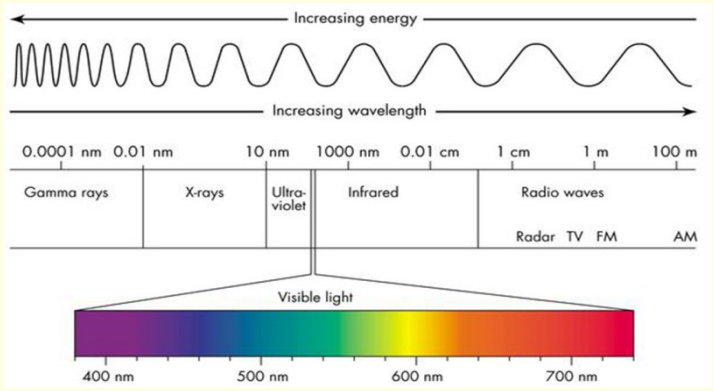
COB - Chip-on-Board: the semiconductor assembly technology wherein the microchip or die is directly mounted on and electrically interconnected to its final circuit board, instead of individually undergoing traditional assembly or packaging. Chips without housing get glued directly onto the circuit board; cold welding is used to bond the micro wires to chip and board. The elimination of conventional device packaging from COB assemblies simplifies the over-all process of designing and manufacturing the final product, as well as improves its performance as a result of the shorter interconnection paths. The COB technology allows very high chip densities and lm/mm² values. Applications can also be manufactured very space saving and flat. The general term for COB technology is actually 'Direct Chip Attachment' (DCA). Aside from circuit boards used for COB's, various substrates are available for use in DCA (ceramic, glass, organic, flex substrates); thus, DCA assemblies have received a number of other names aside from 'COB' based on these available substrates, e.g., chip-on-glass (COG), chip-on-flex (COF), etc.



COEFFICIENT OF UTILIZATION: the ratio of luminous flux (lumens) calculated as received on the work plane to the total luminous flux (lumens) emitted by the lamps alone. [L.R.C./R.P.I.]

COLOUR: the property possessed by an object of producing different sensations on the eye as a result of the way it reflects or emits light. The true colour of a light source is derived from a complicated relationship of CCT, CRI and spectral distribution.

COLOUR SPECTRUM: (visible light spectrum, optical spectrum of light) is the section of the electromagnetic radiation spectrum that is visible to the human eye. It ranges in wavelength from approximately 400 nm (4x10^{-7}m) to 700 nm (7x10^{-7}m). The wavelength (which is related to frequency and energy) of the light determines the perceived colours (specific wavelengths of light stimulate the retinas of our eyes). The range of wavelengths the human eye is capable of perceiving is referred to as 'visible



light'. The colours are ordered in the spectrum in the sequence red, orange, yellow, green, blue, indigo, violet (each of these colours has a different wavelength); we perceive the light with the longest wavelengths as red and that with the shortest wavelengths as violet. Light with wavelengths longer than the range of visible light is in the infrared range, and light with wavelengths shorter is in the ultraviolet range.

COLOUR TEMPERATURE or **CCT-Correlated Colour Temperature** (chromaticity): the appearance of a theoretical black body heated to high temperatures; as the black body gets hotter, it turns red, orange, yellow, white, and finally blue; the CCT of a light source is the temperature (on the Kelvin scale -K) at which the heated black body matches the colour of the light source in question. Colour temperature is the colour appearance of the lamp itself and the light it produces. In the lighting industry, colour temperature and correlated colour temperature are often used interchangeably. The colour temperature of lamps makes them visually 'warm', 'neutral' or 'cool' light sources; generally speaking, the lower the temperature is, the warmer the source, and vice versa. The true colour of a light source is derived from a complicated relationship of CCT, CRI and spectral distribution.

COOL WHITE: Reference to the colour tone or appearance of light produced by a lamp for a specific colour temperature. Cool White is most widely used LED and fluorescent lamp colour in lighting today. Its name comes from the cool, airy atmosphere it creates wherever it is used. Modern, efficient and business-like, it is popular in stores, classrooms, offices, corridors and factories. [ANSI]

COST PER WATT - CPW ($/W): the cost of the electric power output that a solar installation generates under average conditions ($/W). It provides a basis for comparison among photovoltaic technologies and between installations, as well as between solar energy and other sources of electricity. It's probably the most important metric in the solar industry, although it fails to take into account the amount of usable energy that is generated by a given solar installation. That cost is better (and more accurately) measured in terms of $/kWh (not $/W). Different photovoltaic installations having the same $/W often have different average daily power output, leading to widely varying $/kWh. To improve CPW, manufacturers can either reduce cost (by improving yield, increasing throughput, and other variables in the manufacturing process) or increase the wattage available from a given panel area. In turn, increasing output power requires improved conversion efficiency: the panel must capture more incident photons, convert more of them to free carriers, and deliver more of those carriers to the panel's terminals. The average daily electric power output of a solar photovoltaic system is approximately equal to its power output multiplied by the average peak hours of sunlight (roughly around 4-5 hours/day, or 40-50% of direct sunlight hours). Watt-peak (Wp) is the amount of power that a PV module is able to supply when it receives 1000 W/m^2 of solar radiation. A barrel of oil (159 l) produces 1700 KWH, at $70/barrel (Aug.09): $0.05/kWh [1$m^3$ of gas generates 10.59 kWh, at $0.29/$m^3$: 0.03 kWh]; however, this is only the energy generation cost; capital equipment costs (power plant) are not taken into account, neither the transmission losses from the central power plant to the consumer.

CRI - COLOUR RENDERING INDEX (Ra): a quantitative measure of the ability of a light source to reproduce the colours of various objects faithfully in comparison with an ideal or natural light source. Light sources with a high CRI are desirable in colour-critical applications such as photography and cinematography. The CRI is expressed on a scale of 0-100 Ra (unit of measurement), where 100 is the best in producing true colour (the CRI by itself does not indicate what the colour temperature of the reference light source is). CRI may be compared only for light sources of equal CCT; differences in CRI values of less than five points are not significant (e.g., light sources with 80 and 84 Ra are essentially the same).The true colour of a light source is derived from a complicated relationship of CCT, CRI and spectral distribution.

CUT-OFF ANGLE: (of a luminaire) the angle from the vertical at which a reflector, louver or other shielding device cuts off direct visibility of a light source. It is the complementary angle of the shielding angle (the angle measured from the ceiling plane to the line of sight where the bare lamp in a luminaire becomes visible; higher shielding angles reduce direct glare).

DC - Direct Current: the unidirectional flow of electric charge. Direct current may flow in a conductor such as a wire, but can also be through semiconductors, insulators, or even through a vacuum as in electron or ion beams. Direct current may be obtained from an alternating current supply by use of a rectifier (a current-switching arrangement); and it may be made into alternating current with an inverter.

DIFFUSER: a device to redirect or scatter the light from a source, primarily by the process of diffuse transmission. [L.R.C./R.P.I.]

DIODE: a device with two electrodes, in particular an anode and a cathode, and a nonlinear current/voltage characteristic. [L.R.C./R.P.I.]

DIRECT LIGHTING: lighting by luminaires distributing 90 to 100% of the emitted light in the general direction of the surface to be illuminated. The term usually refers to light emitted in a downward direction.

DOWNLIGHT: a directional luminaire that directs light downward. [L.R.C./R.P.I.]

ELECTROLUMINESCENCE: an optical and electrical phenomenon in which a material emits light in response to an electric current passed through it, or to a strong electric field (distinct from light emission resulting from heat -incandescence).

ELECTROMAGNETIC SPECTRUM: a continuum of electric and magnetic radiation encompassing all wavelengths. [L.R.C./R.P.I.]

EFFICACY: efficiency of a light source expressed in lumens per watt (LPW or lm/W). [ANSI]

ENERGY: a measure of work done by an electrical system over a given period of time, often expressed in kilowatt-hours (kWh). [ANSI]

ENERGY CONVERSION EFFICIENCY (solar): the percentage of power converted by a solar cell (from absorbed light to electrical energy), collected and transmitted to an electrical circuit. It is equal to the ratio of the maximum power point (W), divided by the input light irradiance (W/m^2) and the surface area of the solar cell (m^2), n=Pm/(E x Ac). The losses of a solar cell encompass reflectance losses (increased by accumulated dust), thermodynamic efficiency, recombination losses and resistive electrical loss. A solar cell of 12% efficiency with a 1 m^2 surface area can be expected to produce approximately 120 watts of power. In general, energy conversion efficiency is the ratio between the useful energy output (electric power, mechanical work, heat) of an energy conversion machine and the energy input. [solar cell maximum 42.8%, TFPV 12%, BIPV 10%, c-Si 23%, wind turbine up to 59% (theoretical limit), hydroelectric turbine up to 90%, gas turbine up to 40%, combustion engine 10-50%, LEDs 35%, incandescent bulbs 5-10%, fluorescent lamps 28%, household refrigerators 20-50%; electric motors 30-60% (<10W), 50-90% (10-200W), 70-99.99% (>200W); muscle 14-27%]

FAB: in the microelectronics industry, a semiconductor fabrication plant that makes semiconductor devices such as integrated circuits or chips (processors, flash memory, microcontrollers, etc.). It is a complex sequence of photographic and chemical processing steps during which electronic circuits are gradually created on a wafer made of pure semiconducting material. The entire manufacturing process from start to packaged chips ready for shipment takes six to eight weeks and is performed in highly specialized facilities (fabs). Fabs require many expensive devices to function; estimates put the cost of building a new fab over one billion US$ (with values as high as 3-4 billion). The central part of a fab is the clean room, an area where the environment is controlled to eliminate all dust (a microcircuit has features much smaller than dust); the clean room must also be dampened against vibration and kept within narrow bands of temperature and humidity; controlling temperature and humidity is critical for minimizing static electricity. The clean room contains extremely precise and expensive devices (several hundred), such as the steppers for photolithography, etching, cleaning, doping and dicing machines. A business that operates a semiconductor fab for the purpose of fabricating the designs of other companies (fabless semiconductor companies) is known as a foundry; if a foundry does not also produce its own designs, it is known as a pure-play semiconductor foundry.

FLUORESCENCE: the ability of some materials, such as phosphors, to convert ultraviolet energy into visible light. [L.R.C./R.P.I.]

FLUORESCENT LAMP: an efficiency lamp utilizing an electric discharge through low pressure mercury vapour to produce ultra-violet (UV) energy; the UV excites phosphor materials applied as a thin layer on the inside of a glass tube which makes up the structure of the lamp; the phosphors transform the UV to visible light. [ANSI]

F.P.D.: Flat Panel Display.

GENERAL LIGHTING: lighting designed to provide a substantially uniform illuminance throughout an area, exclusive of any provision for special object/local requirements.

GLARE: excessive brightness that may be caused by either direct or indirect viewing of a light source; any brightness or brightness relationship that annoys, distracts or reduces visibility.

GLOBALIZATION: continuous world expansion of capital to deeper and broader levels than any previous period, which conditions the processes of production of goods and services, international capital flows, and at the same time determines the nature, dynamics and the direction of technological change. The globalization of the economy increased in the 1980's as a result of two crucial changes: the economy deregulation policies and the role of information and communications technologies. Globalization implies a logic of homogenization and standardization of the economy, production, consumption, knowledge, education and culture. Globalization emerges as the interrelationship of planetary chaotic flows (mainly financial), and works as a social, political and cultural destructuring, segmentational and marginalizational phenomenon.

HALOGEN LAMP: (tungsten-halogen) high pressure incandescent lamps containing halogen gases such as iodine or bromine which allow the filaments to be operated at higher temperatures and higher efficacies. A high-temperature chemical reaction, involving tungsten and the halogen gas, recycles evaporated particles of tungsten back onto the filament surface. [ANSI]

HEAT SINK: a body which is capable of accepting and storing heat.

HID LAMP: High Intensity Discharge lamp: an electric lamp that produces light directly from an arc discharge under high pressure. Metal halide, high pressure sodium, and mercury vapour are types of HID lamps. [L.R.C./R.P.I.]

HID PRESSURE SODIUM LAMP: an HID lamp in which radiation from sodium vapour under high pressure produces visible light, characterized by a yellow/orange colour. [L.R.C./R.P.I.]

HIGH TECH FIRMS: business units producing goods and services whose competitiveness depends on the design, development and production of new products or innovative processes, through the systematic and intensive application of scientific and technological knowledge.

ILLUMINANCE (E_V): light arriving (incident) on a surface or plane; it is also called light level (lumens/m^2 = lux). It is the intensity or degree to which something is illuminated (it is not the amount of light produced by the light source). In order to calculate the lux level on a surface or the 'maintenance illuminance' (light level in lux after several years of operation) several factors should be considered: Room dimensions, Luminaire mounting height, Work plane height (desk, workbench or floor; normally 75cm), Reflectances of the ceiling, walls and floor, Photometric data on the luminaire (fitting) to be used, Initial lumen output of each lamp and the number of lamps, Lumen output of the lamps after one year and several years time, Proper maintenance of room surfaces and the luminaires.

Lux Measurements:

Place	ILLUMINANCE
Daylight - Full	20,000 lux -100,000 lux looking at the sun
Daylight - Cloudy	4,000 lux
Medical surgical room	10,000 lux
High-Precision Work plane/Laboratory (0.75m above the floor)	800 lux
Precision Work plane/Electronics/Jewellery & watch repair	600 lux
Design / Fine Mechanics Precision Work plane	450-500 lux
Factory / Machine shop, work bench	400 lux
Shop/Office (brightly lit)	400 lux
Office	300-400 lux
Conference room	300 lux
Reception / Counter	250 lux
Hall, cafeteria, waiting room	160 lux
Corridor	100 lux
Warehouse, staircase	80 lux
Home light (average)	50-300 lux

- Living room	50 lux
- Bathroom	80 lux
- Dining room	160 lux
- Kitchen	250 lux
Stadium (night)	1,500 lux
Parking lot - outdoors	20-40 lux
Parking lot - indoors	40-50 lux
Street light / Road	20-60 lux
Plaza, square, park lane	40-50 lux
Tunnel (near threshold)	3,000-8,000 lux

INCANDESCENCE: the self-emission of radiant energy in the visible spectrum due to the thermal excitation of atoms or molecules. [L.R.C./R.P.I.]

INCANDESCENT LAMP: a light bulb that contains a filament, which glows to an incandescent level when electricity flows into the bulb.

INDIRECT LIGHTING: lighting by luminaires distributing 90 to 100 percent of the emitted light upward.

INFRARED RADIATION: any radiant energy within the wavelength range of 770 to 1106 nanometers is considered infrared energy. [L.R.C./R.P.I.]

INNOVATION: the introduction of a new technique, product, production/distribution process, or service; it is a process that may often be followed by a spread process of diffusion. There are three types: product innovation, process innovation (method of production) and organizational innovation. It frequently implies moving from invention to commercial practical use; inventions which are introduced into the regular system of production or distribution of commodities and services are 'technical innovations'; although inventions are not the only source of innovation in the economy. Innovations are of two types: (i) Incremental innovations (minor, continuous, cumulative), that bring about the improvement of the availability of products and processes; or (ii) Major innovations (radical), that result in new technologies that lead to new products, processes or services.

INSOLATION (Incident Solar Radiation): measurement of solar radiation energy (all wavelengths) received on a given surface area in a given time. The basic unit of measurement is the Langley (a unit of heat energy equivalent to 1 calorie falling on $1cm^2$ of surface).

INVENTION: discovery or devising of a new product, process or system. It is an identifiable discrete contribution to technical knowledge, to technological change, although it is not the only way in which technology changes (e.g. small improvements and adaptations). It usually is a stage of technological development at which an idea has advanced sufficiently to draw up plans, construct a working model, or in some fashion establish technical feasibility; this is the stage at which inventions are normally patentable. Technological research is the most important source of inventions.

INVERTER: converts the DC-direct current (12v, 24v, 36v) in a battery to 110-240V AC-alternating current; it is made to change the direct current (DC) electricity from a photovoltaic array into alternating current (AC) for use with electrical appliances or a utility grid. The conversion of DC to AC power results in an energy loss of approximately 10% for a solar energy system. Inverters come in two basic output designs, pure sine wave and modified sine wave (square wave). Most AC devices work fine on the modified sine wave inverter, but there are some exceptions (motors and power supplies usually run warmer and less efficiently). However, modified sine wave inverters make the conversion from DC to AC very efficiently, and they are relatively inexpensive. Pure sine wave inverters provide AC power that is virtually identical to, and often cleaner than, power from the grid. Inverters are generally rated by the amount of AC power they can supply continuously. Manufacturers generally also provide 5 second and 1/2 hour surge figures. The surge figures give an idea of how much power can be supplied by the inverter for 5 seconds and 1/2 an hour before the inverter's overload protection trips and cuts the power.

IP - Ingress Protection Rating: outlines an international classification system for the sealing effectiveness of enclosures of electrical equipment against the intrusion into the equipment of solid objects (i.e. tools, dust) and water. It specifies the environmental protection (electrical enclosure) of electrical equipment, devices and

fixtures.The standard aims to provide users more detailed information than vague marketing terms such as waterproof. IP ratings normally have two numbers, from 00 to 68: (i) Protection from solid objects or materials, (ii) Protection from liquids (water), (iii) Protection against mechanical impacts.

IRRADIANCE: the direct, diffuse, and reflected solar radiation that strikes a surface; it is usually expressed in kW/m^2. Irradiance multiplied by time equals insolation.

JUNCTION TEMPERATURE: the temperature at the light emission point at the heart of an LED device (called the 'p-n junction'). More generally, it is he highest temperature of the actual semiconductor in an electronic device. This is a critically important parameter for high reliability LED applications because both LED lifetime and LED light output are directly proportional to junction temperature. By controlling LED junction temperature through a variety of thermal management techniques, optimally efficient LED lighting designs with long service lives can be achieved.

KILOWATT (kW): A unit of electrical power, one thousand watts.

KILOWATT-HOUR (kWh): a unit of energy over time. 1kW of power continuously consumed (or produced) for one hour draws (or generates) a total of 1kWh (kilowatt-hour) of energy. The cost of the usable energy that is generated by a solar installation is better (and more accurately) measured in terms of $/kWh (not $/W).

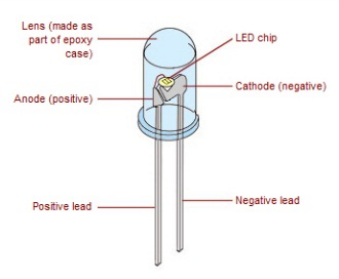
KNOW-HOW: non-divulgated, confidential, practical, unpatented, technical knowledge, professional experience and accumulated skills for the production and distribution of commodities and services.

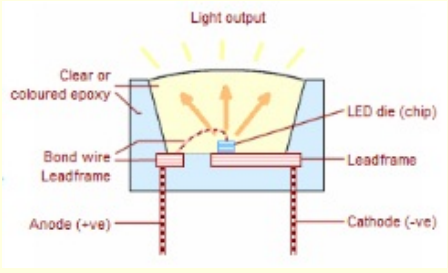
KNOWLEDGE: theoretical or practical understanding acquired on a natural or social phenomenon, or referred to thought, on the basis of information in a specific domain.

LAMP: artificial source of light; the complete light source package including the inner parts as well as the outer bulb or tube. "Lamp" is also commonly used to refer to a type of small fixture such as a table lamp.

LAMP LUMEN DEPRECIATION FACTOR: the factor to be used in illumination calculations to relate the initial rated output of light sources to the anticipated minimum rated output based on the relamping program to be used.

LED - Light Emitting Diode: a semiconductor diode which glows when a voltage is applied. LED is a solid state electronic component with the characteristics of a diode i.e. it only allows electrical current to flow in one direction through it. When the semiconductor diode is forward biased (switched on), electrons are able to recombine with holes and energy is released in the form of light. This effect is called electroluminescence and the colour of the light is determined by the energy gap of the semiconductor. Due to a variation on the method used to manufacture LEDs that emit white light different colour temperatures are available (2500-7000K). LEDs present many advantages over traditional light sources including lower energy consumption, longer lifetime, improved robustness, smaller size, faster switching, greater resistance to shock, vibration, and wear, and no-pollution. The LED was first invented by Oleg Vladimirovich Losev (Russia), in the 1920s. The first practical visible-spectrum (red) LED was developed in 1962 (N. Holonyak, at General Electric).





LED Die (chip)

At the heart of every LED there is a very small piece of semi-conducting material called the LED die (chip). The die can be considered in the same way as the filament in a lamp, because it is the die that produces the light. The LED is usually small in area (less than 1mm2) with integrated optical components to shape its

radiation pattern and assist in reflection. The base of the die is glued or soldered into a fine metal framework (the leadframe). A very fine wire called a bond wire is attached to the top of the LED die, which has a very fine conductive metal pattern on it. The wire is attached to the other side of the leadframe.When electricity of the correct voltage and polarity is applied to the LED via the leadframe contacts, current flows through the die.The different properties of the layers in the die cause between 50 and 90% of this electrical energy to be converted into light at the junction by a process called ‘injection electroluminescence’. This process is significantly more efficient than virtually any other light source !Injection electroluminescence does not require heat like a filament lamp (incandescence) or chemicals that glow like those used for a fluorescent tube (fluorescence). It is a phenomenon that is caused entirely by atomic differences in the material caused by doping.Unfortunately, a large proportion of the light produced at the junction does not escape from the die and is reabsorbed, the remainder being converted to heat.

Types of LEDs

Individual LEDs are called discrete LEDs. Discrete LEDs are assembled (mounted) onto printed circuit boards (PCBs), usually with additional electronic components to control the current flowing through the LED.

Through Hole or Radial LEDs

The original LEDs have legs that pass through holes on a circuit board and are fixed in place by soldering underneath the circuit board. These are called 'through hole' or 'radial' type LEDs. The package of a radial LED has a lens on the top so that it produces a higher intensity beam. However, this means that type of LED projects a spot of light onto a surface. Very narrow beam angle LED's produce a spot. Uniform illumination of an area cannot be achieved with Radial LEDs.

Surface Mount LEDs (SMD)

The more modern type of LED sits on the top of the circuit board and is soldered automatically so that the solder joint is on the top of the circuit board. These are called 'surface mount' LEDs. Surface mount LEDs range in size from tiny LEDs that measure only 0.5 x 1.5 x 0.3mm (used in space efficient equipment like mobile phones) to 'power' LEDs measuring 20 x 20 x 2.5mm or larger. Surface mount LEDs are assembled onto circuit boards very quickly and accurately by machines. So that the machine can use the LEDs they are supplied sealed into a plastic 'tape' and wound onto reels. This method of supply is called 'tape and reel' and a reel of LEDs can be between 800 pieces and 8000 depending on the size of the LED and the reel. Unlike most radial LEDs, the majority of surface mount LEDs do not have lenses and produce a much more even illumination on a surface (depending on the application LEDs with lenses or accessory lenses for LEDs are sometimes useful).

LED Modules

An assembly of one or more discrete LEDs in a unit for lighting or display is a modular LED. Although it is possible to construct a module using radial LEDs, they are usually made using Surface Mount LEDs (SMD) using automated techniques. An LED has a turn-on (threshold) voltage between 1.3 and 2 Volts, depending upon the die type. LED’s can be stacked in series like batteries, the threshold voltages will add up e.g. six LED’s in series each with a threshold voltage of 2V gives a total voltage requirement of 6x2=12V. Current ratings ranges from around 1 mA to above 20 mA. High power LEDs can be driven at currents from hundreds of mA to more than an ampere; some can produce over a thousand lumens. Since overheating is destructive, those LEDs must be mounted on a heat sink to allow for heat dissipation.

LED Colours

An LED die emits coloured light that is virtually monochromatic. Early devices emitted low-intensity red light, but modern LEDs are available across the visible, ultraviolet and infra red wavelengths, with high brightness. To produce white light a phosphor is added to the normally clear epoxy covering the LED die. Alternatively the latest technology provides a more homogeneous white light using chip level conversion (CLC), applying a thin phosphor layer on top of the die. A blue LED die stimulates the phosphor. The phosphor emits a yellowish light. The light from the phosphor and the blue LED combine to produce white light of different colour temperatures. The light emitted by an LED is of a specific colour and wavelength respectively depending on the dopant chemicals that were diffused into the die and is a virtually monochromatic saturated colour. Indium, Gallium and Nitrogen dopant chemicals produce LEDs that emit light in bands ranging from blue through to green. These are often called ‘InGaN’ LEDs after the chemical symbols for the dopants (In, Ga and N). Indium, Gallium, Alluminium and Phosphor dopants produce LEDs that emit light in bands ranging from green to red.These are often called ‘InGaAlP’ LEDs after the chemical symbols for the dopants (In, Ga, Al, P) are rearranged. At present, commercially available LEDs produce light of certain specific colour. White light is generated by using light of a blue LED and a yellow phosphor which converts a part of the blue light into yellow light. Depending on the ratio between blue and yellow light different colour temperatures can be achieved. The light from individual LEDs, particularly the primary colours red, green and blue, can be mixed together to produce a wide range of colours. By incorporating a red, green and blue LED die into the same

package the LED can be used for applications ranging from large area video screens using up to 50,000 LEDs per square metre, to colour changing luminaries for lighting whole buildings.

LED LAMP: a type of solid state lighting (SSL) that uses light-emitting diodes (LEDs) as the source of light. There are four main components in a LED luminaire: the LED light source, optics, electronic driver and thermal management. They usually comprise clusters of LEDs in a suitable housing. They come in different shapes, including the standard light bulb shape, MR16, T8 tubes, street lights, industrial lamps, etc.; this includes low voltage (typically 12v) varieties and replacements for regular AC mains (e.g. 120 or 240 VAC) lighting. LEDs also have limited temperature tolerance and falling efficiency as component temperature rises; this limits the total LED power that can practically be fitted into lamps that physically replace existing filament and compact fluorescent types; much R&D is invested in improving thermal characteristics Thermal management of (high-power) LEDs and power supply restrictions have become significant factors in the design of LED lighting equipment.

LIGHT: electromagnetic radiation that stimulates sight and makes things visible (from about 390 to 740 nm in wavelength). Most of the spectrum is ultraviolet, visible light and infra red. Photovoltaic cells can use most of this radiation and convert it to electricity.

LIFESPAN -LED LUMINAIRE: determined by the actual usable life of the many components included in the lighting system (multiple LEDs in a wide variety of use conditions) and the manufacturer's expected lumen maintenance. Each of the components must be analyzed independently in order to provide an accurate assessment, because the lamp/luminaire's life-span will be as long as the shortest life-span of any of its components (particularly power supply/driver units). It is imperative to go beyond simple lumen maintenance data (how a single LED behaves).

LIFE-CYCLE COST: (Total Cost of Ownership-TCO) the total costs associated with purchasing, operating, and maintaining a lighting system over its life.

LIGHT LOSS FACTOR: (LLF) factor that allow for a lighting system’s operation at less than initial conditions. These factors are used to calculate maintained light levels. LLFs are divided into two categories, recoverable and non-recoverable. Examples are lamp lumen depreciation and luminaire surface depreciation.

LIGHT OUTPUT: luminous flux, measured in lumens. The light output rating of a lamp is a measure of its total integrated light output. [L.R.C./R.P.I.]

LUMEN: unit of luminous flux, a measure of the perceived power of light (the light output of a luminous source). Luminous flux differs from radiant flux, the measure of the total power of light emitted, in that luminous flux is adjusted to reflect the varying sensitivity of the human eye to different wavelengths of light. The lumen is defined in relation to the candela (unit of luminous intensity, 1 lm = 1 cd•sr -steradian), describing the intensity of a light source in a specific direction; i.e., a light source that uniformly radiates one candela in all directions radiates a total of 4pi lumens (if the source were partially covered by an ideal absorbing hemisphere, that system would radiate half as much luminous flux -only 2π lumens; but the luminous intensity would still be one candela in those directions that are not obscured).The lumen rating of a lamp is a measure of the total light output of the lamp.

LUMEN DEPRECIATION: the decrease in lumen output that occurs as a lamp is operated, until failure. [L.R.C./R.P.I.]

LUMEN EFFICACY: the light output of a source divided by the total power input to that source. It is expressed in lumens per watt. [ANSI]

LUMEN MAINTENANCE: the lumen output provided by a LED lamp, the percentage of initial lumens remaining, after a given period or percentage of its life. [ANSI] Lamp Lumen Maintenance Factor (LLMF) is the proportion of the initial light output of a lamp produced after a given time to that produced when new. Conventional lighting sources and LEDs both experience lumen depreciation (loss of light) over time even when operated within specified conditions. Therefore, considering the very long useful life of LED products, lumen depreciation must also be taken into account. Lumen maintenance of LED light sources is dependent on many factors including effective thermal management, ambient temperature and humidity, the method of

electrical control, driver's current, etc. High LED junction temperatures accelerate degradation in lumen maintenance, resulting in a reduction in luminous flux.

LUMINAIRE (light fixtures): a complete electric light unit, consisting of a lamp together with the parts designed to distribute the light, position and protect lamps and connect them to the power supply.

LUMINANCE (L_V): the measured brightness of a light source or of an illuminated surface that reflects light (Lv = cd/m²). Light intensity (brightness) of lamps is normally specified in terms of millicandela (**mcd**).

LUMINOUS EFFICACY: the ratio of luminous flux (photometric) to radiant flux (radiometric). In photometric quantities every wavelength is weighted according to how sensitive the human eye is to it, while radiometric quantities use unweighted absolute power.

LUMINOUS FLUX (F): the rate of flow of light, measured in lumens. The overall light output of a lamp [L.R.C./R.P.I.], the total perceived power emitted in all directions.

LUMINOUS (LIGHT) **INTENSITY** (brightness) (I_V): a measure of the wavelength-weighted power emitted by a light source in a particular direction within a solid angle of one steradian, based on the luminosity function, a standardized model of the sensitivity of the human eye [a steradian (sdr) is the standard unit solid angle in three dimensions; a sphere encloses 4 pi (approximately 12.57) steradians]. The unit of luminous intensity is the candela (cd - 'candle power'). LED light output varies with the type of chip, encapsulation, efficiency of individual wafer lots and other variables. Several LED manufacturers use terms such as "super-bright," and "ultra-bright" to describe LED intensity; such terminology is entirely subjective, as there is no industry standard for LED brightness. The amount of light emitted from an LED is quantified by a single point, on-axis luminous intensity value (Iv). LED intensity (brightness) is specified in terms of millicandela (**mcd**). Luminous intensity is roughly proportional to the amount of current supplied to the LED; the greater the current, the higher the intensity. Generally, LEDs are designed to operate at 20 milliamps (mA); however, operating current must be reduced relative to the amount of heat in the application.

LUX: the metric unit of measure for illuminance of a surface (lx = 1 lm/ m²). It is the measurement of the actual light available at a given distance (see Illuminance).

Photometry Units

Quantity	Symbol	SI unit	Abbr.
Luminous energy	Q_v	lumen second	lm·s
Luminous flux	F	lumen (= cd·sr)	lm
Luminous intensity	I_v	candela (= lm/sr)	cd
Luminance	L_v	candela per square metre	cd/m^2
Illuminance	E_v	lux (= lm/m^2)	lx
Luminous efficacy		lumen per watt	lm/W

MAINTAINED ILUMINANCE: initial illumination level from luminaires adjusted for depreciation of lamp lumens by aging, effects of dirt accumulation on luminaire surfaces, and other factors. [L.R.C./R.P.I.]

MERCURY VAPOUR LAMP: a high-intensity discharge light source operating at a relatively high pressure and temperature in which most of the light is produced by radiation from excited mercury vapour; they are energy-inefficient. [ANSI]

METAL HALIDE (MH) LAMP: (Parabolic Aluminized Reflector)an HID light source in which radiation from a mixture of metallic vapours produces visible light, characterized by a white colour. [L.R.C./R.P.I.]

MODELING: the effect of using highly directional light to create form through shadows and highlights.

MR16: a low-voltage quartz reflector lamp (Φ=5cm). Typically the lamp and reflector are one unit, which directs a sharp, precise beam of light.

OLED - Organic LED: diodes based on organic (carbon) materials. OLEDs are made in sheets which provide a diffuse area light source. The emitting material can be a small organic molecule in a crystalline phase, or a polymer. Polymer materials can be flexible; such LEDs are known as PLEDs or FLEDs. Compared with regular LEDs, OLEDs are lighter, and polymer LEDs can have the added benefit of being flexible. Some possible future applications of OLEDs could be inexpensive, flexible displays; light sources; wall decorations, luminous cloth. OLEDs have been used to produce visual displays for portable electronic devices such as cellphones, digital cameras, and MP3 players. Today, OLEDs operate at substantially lower efficiency than inorganic (crystalline) LEDs. OLEDs are still some years away from becoming a practical general illumination source; additional advancements are needed in light output, colour, efficiency, cost, and lifetime.

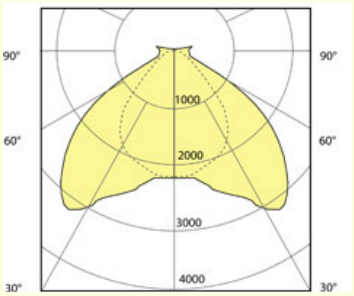
OPTOELECTRONICS: technology concerned with the combined use of electronics and light; the study and application of electronic devices that source, detect and control light. It is usually considered a sub-field of photonics. Light often includes invisible forms of radiation such as gamma rays, X-rays, ultraviolet and infrared, in addition to visible light. Optoelectronics is based on the quantum mechanical effects of light on semiconducting materials, sometimes in the presence of electric fields.

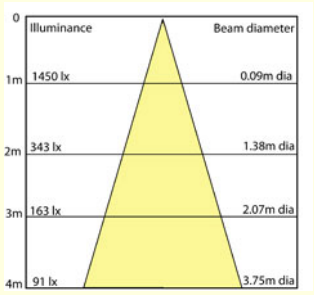
PAR LAMP: an incandescent or tungsten-halogen (or MH) incandescent lamp with a hard glass bulb and an interior reflecting surface, a precisely placed filament, and a lens to control beam spread. The lens is hermetically sealed to the reflector. [L.R.C./R.P.I.]

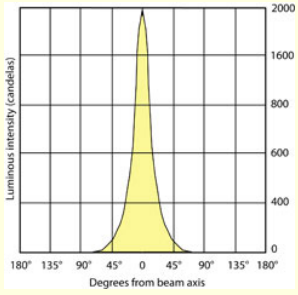
PFC - POWER FACTOR CONTROLLER (P. F. Corrector): a high-efficiency energy saving device that saves power consumption, specially regarding inductive equipment. A PFC reduces the amount of reactive power generated by an electrical device, particularly fluorescent and high bay lighting, refrigerators, air conditioners, irrigation pumps, arc furnaces, induction welders, and all kind of electrical motors. It extends the life span of home appliances, reduces electrical overheating and stabilizes electrical current (preventing sudden changes in voltage). The Power Factor (PF) of an AC electric power system is defined as the ratio of the Real Power flowing to the load to the Apparent Power, and is a dimensionless number between 0 and 1 (frequently expressed as a percentage, e.g. 0.5 PF = 50% PF): PF (λ) = P/S. In an electric power system, a load with low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. Linear loads with low power factor (such as induction motors) can be corrected with a passive network of capacitors or inductors. If a capacitor and an inductor are placed in parallel, then the currents flowing through the inductor and the capacitor tend to cancel out rather than adding. This is the fundamental mechanism for controlling the power factor in electric power transmission; capacitors (or inductors) are inserted in a circuit to partially cancel reactive power of the load. Power Factor is a practical measure of the efficiency of a power distribution system. For two systems transmitting the same amount of real power, the system with the lower power factor will have higher circulating currents due to energy that returns to the source from energy storage in the load. These higher currents produce higher losses and reduce overall transmission efficiency.

PHOTOCELL: a device that converts light to electrical current. A light sensing device used to control luminaires and dimmers in response to detected light levels. Based on the amount of incident light, a photocell can switch a lamp on or off or regulate a lamp's light output to maintain a preset level of light. [L.R.C./R.P.I.]

PHOTOMETRIC DIAGRAM (**CURVE**): a representation of the luminous (light) intensity distribution of a light source (luminaire). The diagrams provide a visual guide to the type of distribution expected from the luminaire e.g. wide, narrow, direct, indirect, etc., in addition to intensity.
Polar Luminous Intensity Graph: illustrates the distribution of luminous intensity, in candelas (cd/klm), for the transverse and axial planes of the luminaire.
Illuminance Cone Diagram: indicates the maximum illuminance at different distances away from the lamp; used for spotlights or lamps with reflectors.
Cartesian Luminous Intensity Graph: used when light intensity changes rapidly within a small angular area.







It is usually the main component of a photometric file (IES, EULUMDAT, CIBSE, LTLI). The lighting performance of a luminaire may be measured either by the manufacturer or by an independent testing laboratory; the results of these measurements are produced in a photometric report, which often becomes part of the manufacturer's catalogue description of that luminaire. [L.R.C./R.P.I.]

PHOTOMETRIC FILE (Report): a collection of data assembled in a given format (IES, CIBSE, EULUMDAT, LTLI) that describes the output of luminous flux at specific angles from the tested lamp/fixture combination (lamp+fixture=luminaire). Manufacture's photometric files are normally used for reporting luminaire performance. Lighting fixture manufacturers publish photometric data gathered through testing process for their products. The most popular file formats for the electronic transfer of photometric data are: (i) IES: IESNA-Illuminating Engineering Society of North America; (ii) EULUMDAT: European Luminaire Data; (iii) CIBSE: Chartered Institution of Building Services Engineers (UK); (iv) LTLI: created by the Danish Illuminating Laboratory, and used primarily in Scandinavian countries. The data in a photometric report fall into three broad categories: the general information consists of a title block that includes information such as a description of the light fixture and its components; the photometric data provides data related to the performance of the light fixture such as candela distribution summary table, luminous intensity distribution curve, and light fixture efficiency; and the application data such as coefficient of utilization table and spacing criteria; the application data is designed to aid lighting professionals in choosing light fixtures for spaces of different sizes and surface characteristics.

PHOTOMETRIC PERFORMANCE (of luminaire): the efficiency and effectiveness with which the light fixture delivers the light produced by the lamp to the intended target (see Luminous Efficacy).

PHOTOMETRY: the science of the measurement of light, in terms of its perceived brightness to the human eye. It is distinct from radiometry, which is the science of measurement of radiant energy (including light) in terms of absolute power; rather, in photometry, the radiant power at each wavelength is weighted by a luminosity function (visual sensitivity function) that models human brightness sensitivity. Typically, this weighting function is the photopic sensitivity function, although the scotopic function (and others) may also be applied in the same way. The human eye is not equally sensitive to all wavelengths of visible light. Photometry attempts to account for this by weighing the measured power at each wavelength with a factor that represents how sensitive the eye is at that wavelength. The standardized model of the eye's response to light as a function of wavelength is given by the luminosity function, but the eye has different responses as a function of wavelength when it is adapted to light conditions (photopic vision) and dark conditions (scotopic vision). Photometry is typically based on the eye's photopic response, and so photometric measurements may not accurately indicate the perceived brightness of sources in dim lighting conditions where colours are not discernible, such as under just moonlight or starlight. Photometric measurement is based on photo detectors, devices (of several types) that produce an electric signal when exposed to light. Light meters are used to measure the total amount of light incident on a point. More complex forms of photometric measurement are used frequently within the lighting industry: Spherical photometers can be used to measure the directional luminous flux produced by lamps, and consist of a large-diameter globe with a lamp mounted at its centre (a photocell rotates about the lamp in three axes, measuring the output of the lamp from all sides); luminaires are tested using Goniophotometers and rotating mirror photometers, which keep the photocell stationary at a sufficient distance that the luminaire can be considered a point source.

There are two parallel systems of quantities known as photometric and radiometric quantities. Every quantity in one system has an analogous quantity in the other system:

- Luminance (photometric) and radiance (radiometric)
- Luminous flux (photometric) and radiant flux (radiometric)
- Luminous intensity (photometric) and radiant intensity (radiometric)

In photometric quantities every wavelength is weighted according to how sensitive the human eye is to it, while radiometric quantities use unweighted absolute power (for example, the eye responds much more strongly to green light than to red, so a green source will have greater luminous flux than a red source with the same radiant flux would). Radiant energy outside the visible spectrum does not contribute to photometric quantities at all (i.e. electric heaters).

Photometry Units

Quantity	Symbol	SI unit	Abbr.
Luminous energy	Q_v	lumen second	lm·s
Luminous flux	F	lumen (= cd·sr)	lm
Luminous intensity	I_v	candela (= lm/sr)	cd
Luminance	L_v	candela per square metre	cd/m^2
Illuminance	E_v	lux (= lm/m^2)	lx
Luminous efficacy		lumen per watt	lm/W

PHOTOPIC AND SCOTOPIC VISION: Photopic vision is the vision of the eye under well-lit conditions (daylight) (luminance level 1 to 10^6 cd/m²). Photopic vision allows for good visual acuity and colour perception, mediated by cone cells (one of the retina's photoreceptors), and colour sensitivity peak is in the (green/) yellow region of the spectrum (550 nanometres light wavelength). Scotopic vision is the vision of the eye under low light conditions (night light, interiors). As cone cells are non-functional in low light, thus scotopic vision is produced exclusively through rod cells (the other photoreceptors of the retina) which are most sensitive to the blue (/green) region of the spectrum (500 nanometres light wavelength), and insensitive to the red region (>640 nanometres light wavelength). Scotopic vision occurs at luminance levels of about 0.01 cd/m² (10^{-2} to 10^{-6} cd/m²). This luminance is about equivalent to a full moon. It relies mostly upon rod receptors and colour sensitivity peak is blue. Mesopic vision occurs in intermediate lighting conditions, at illuminance levels of 1 cd/m² to 0.01 cd/m², and is effectively a combination of photopic and scotopic vision; this however gives weak visual acuity and colour discrimination (sensitivity peak moves between yellow/green and blue). Cone and rod reception is somewhat overlapping.

PHOTOSYNTHETICALLY AVAILABLE RADIATION - PAR: the light in the 400nm to 700nm spectral region that is available for photosynthesis to take place. The unit for measuring PAR, micro-mols per second (µmol/s), indicates how many photons in this spectral range fall on the plant each second. Spectroradiometers are used to properly measure the amount of energy present for photosynthesis; it measures the energy, in watts, at each specific wavelength over a range of wavelengths; a spectroradiometer can provide a direct comparison of each lamp's ability to produce light that plants can use for photosynthesis. The non-absorbed or reflected part of the light spectrum is what gives photosynthetic organisms their color (e.g., green plants, red algae, purple bacteria) and is the least effective for photosynthesis in the respective organisms. (Hydroponics is the process of growing plants in sand, gravel, or liquid, with added nutrients but without soil). The most accurate unit that can be used to measure plant lighting is the Photosynthetic Photon Flux Density (PPFD) in micro mole per m^2 per second, which measures how many photons of light strike an area per second. The PPFDis crucial to photosynthesis since the light requirement for the production of a given quantity of oxygen is a fixed number of photosynthetically active photons (about nine moles of photosynthetically active photons form a mole of oxygen).

PHOTOVOLTAIC (PV) PANEL: (photovoltaic module) a packaged interconnected assembly of photovoltaic cells (solar cells -usually made from a monocrystalline silicon wafer). An installation of photovoltaic panels is known as a photovoltaic array. A collection of PV panels are mechanically fastened together, wired, and designed to be a field-installable unit, sometimes with a glass covering and a frame and backing made of metal, plastic or fibreglass. A photovoltaic installation typically includes an array of PV panels, an inverter, batteries and interconnection wiring.

PLANT GROWTH & HYDROPONICS LED LIGHTS: a grow light is an electric lamp designed to promote plant growth by emitting an electromagnetic spectrum appropriate for photosynthesis. The lamps provide a light spectrum similar to that from the sun, mimicking outdoor conditions; natural daylight has a high colour temperature (6000 K) and appears bluish. Grow lights are used for indoor gardening, plant propagation and food production, including indoor hydroponics and aquatic plants, both on an industrial level and in households. Plants also require both dark and light ('photo') periods; so, lights may to be timed to turn them on and off at set times; the optimum photo/dark period depends on the species and variety of plant, as some prefer long days and short nights and others prefer the opposite. LED lights LEDs emit only the wavelengths

of light corresponding to chlorophyll's absorption peaks (without ultra-violet -UV- or infra-red -IR- rays), and, besides big energy savings, they produce a fraction of the heat of HID/HPS lamps (plants transpire less under LED grow lights, as a result of the reduction in heat, and thus the time between watering cycles is longer). There are four chlorophyll absorption peaks and LED grow lights use four different types of LEDs to hit all four peaks (two red and two blue), which outperform fluorescent (CFL), high-pressure sodium (HPS), and metal halide (HID) lamps (all have high power consumption, excessive heat generation and contain mercury and other toxic substances -not recyclable). Different vegetation requires different light sources to flourish: Seedlings–blue light (450~460 nm), Flowering plants–red light (650~670 nm), Fruit bearing plants–green light (545 nm), Vegetables–blue light (450~460 nm), Large leafy plants–blue light (450~460 nm). Red, blue and green lights may be combined using a specific luminous ratio to create the optimum situation for a specific plant growth. (Hydroponics is the process of growing plants in sand, gravel, or liquid, with added nutrients but without soil).

PRODUCTIVITY: a measure of the rate at which output flows from the use of given amounts of inputs. Productivity is usually measured by expressing output as a ratio to a selected input (labour productivity, capital productivity).

PROJECT: an integrated set of activities geared to attain specific objectives and goals, having defined resources (human, physical, equipment, material and information), a specific budget, responsible persons/institutions and a given time frame.

QUALITY OF LIGHTING: pertains to the distribution of luminance in a visual environment. The term is used in a positive sense and implies that all luminances contribute favourably to visual performance, visual comfort, ease of seeing, safety and aesthetics for the specific visual tasks involved.

RADIOMETRY: the science of the measurement of radiant energy (including light) in terms of absolute power.

Radiometry Units

Quantity	Symbol	SI unit	Abbr.
Radiant energy	*Q*	joule	J
Radiant flux	*Φ*	watt	W
Radiant intensity	*I*	watt per steradian	$W \cdot sr^{-1}$
Radiance	*L*	watt per steradian per square metre	$W \cdot sr^{-1} \cdot m^{-2}$
Irradiance	*E, I*	watt per square metre	$W \cdot m^{-2}$

RATED POWER (power rating): the amount of power a resistive circuit element or electrical device can withstand flowing through it. It is also the power that a device may generate if it's a power source.

REFRACTOR: a device that transmits and redirects the luminous flux from a source. Refractors for outdoor luminaires are typically made from acrylic, polycarbonate, or glass, and when designed well, help control direct glare. [L.R.C./R.P.I.]

RENEWABLE ENERGY: energy generated from natural resources, such as solar radiation, wind, rain, wave power, hydroelectricity, geothermal heat and biomass, which are renewable (naturally replenished).

RETROFIT: upgrading a fixture, room, or building by installing new parts or equipment. A replacement lamp (LED) that converts a light source to either reduce energy consumption or change its characteristics.

RGB LEDs: contain red, green and blue colour controllable emitters, generally using a four-wire connection with one common lead (anode or cathode).

ROOFING MEMBRANE WITH THIN-FILM PHOTOVOLTAIC LAMINATE (TFPV): SBS bitumen membranes composed of many layers adhered to flexible thin-film photovoltaic cells, usually multiple junction technology composed of (2-3) superimposed layers of photovoltaic cells to produce maximum electrical output across the entire solar spectrum. Placing the thin-film photovoltaic laminates directly on the roofing material helps generate energy in low-light and cloudy days. The laminates are sturdy enough to walk on without being damaged. A photovoltaic roofing membrane is an alternative 'green' roofing option for integrating solar photovoltaic strategies into the design of buildings. It has an advantage over conventional silicon solar panels

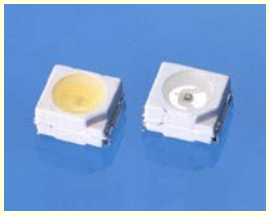
(c-Si) because of its better performance in high temperatures, low lighting, or the presence of shadows or dirty modules.

SCIENCE: (from the Sanskrit -'special wisdom', and its Latin derivation -'knowledge'): organized system of knowledge related to nature, society and thought. Science is knowledge-driven. Science may eventually be applied to the production or distribution of commodities and services, but only in an indirect and mediate manner. Science is, to some extent, universally valid. However, in its broader sense, science (and technology) is neither neutral, value -free nor non-normative, but, just like other ways of classifying reality and arranging data, it is generated in historical and social contexts which implant their values and social interests in its structure.

SCIENTIFIC RESEARCH (traditionally called basic or fundamental research): activity oriented towards creating new systematic (scientific) knowledge, innovations in the field of science and with no immediate practical application to production or distribution of commodities and services; it has no perceptible relevance to techniques. However, it can have an explicit function as a generator of ideas and methodologies of immediate application. Eventually, it may result in a 'scientific discovery'.

SMALL WIND TURBINE (SWT): supplementary renewable energy generator for homes and buildings. Small wind turbines generate 1 kW to 30 kW and Mini wind turbines 300 W to 1 kW. SWTs mean energy independence, energy price stability and a personal or corporate contribution to a cleaner environment. It can produce power at less than 50% the cost of some traditional electricity sources (diesel electric generators). Small wind turbines are very different than large wind turbines and involve different materials and technologies, including the mechanisms for transferring energy. SWT often have direct drive generators (magnets at the edges of the fan to generate a current, instead of a gear box in the shaft), direct current output, aeroelastic blades, lifetime bearings and use a vane to point into the wind (larger, more costly turbines generally have geared power trains, alternating current output, flaps and are actively pointed into the wind). Because of the variability of the wind, the amount of energy a wind turbine actually produces is a function of the capacity factor (e.g., a wind turbine produces 20% to 35% of its rated capacity over a year, and 50% of the energy generated usually arrives in just 15% of the operating time; as wind turbines do not have a consistent output, wind energy is used primarily as a supplementary power source).

SMD (Surface-Mount Device) LEDs: LEDs are soldered to the surface of the printed circuit board (PCB) by soldering their external interconnection features (such as leads, bumps, or balls) to their corresponding mounting sites on the PCB; the LED die is integrated into the package design. SMD components can be assembled faster and with better quality than through-hole components. SMD LEDs also have a wide viewing angle, thanks to the fact that it does not have the standard LED's epoxy enclosure that focuses the beam.



SOLAR ENERGY: the radiant light and heat from the Sun. Solar applications includes space heating and cooling through solar architecture, potable water via distillation and disinfection, day lighting, hot water, thermal energy for cooking, and high temperature process heat for industrial purposes. Solar technologies are broadly characterized as either passive solar or active solar depending on the way they capture, convert and distribute sunlight. Active solar techniques include the use of photovoltaic panels, solar thermal collectors, with electrical or mechanical equipment, to convert sunlight into useful outputs. Passive solar techniques include orienting a building to the Sun, selecting materials with favourable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. Solar power is the generation of electricity using solar energy, the result of converting sunlight into electricity; solar power provides electrical generation by means of photovoltaics or heat engines.

SOLAR PANEL (module): a device that collect energy from the sun. There are two types: (i) Solar photovoltaic modules: use solar cells to convert light from the sun into DC electricity; they are usually made of multiple solar cells bonded between glass and a backing material; typical solar modules would be around 100 Watts of power output (module powers can range from 1 Watt to 300 Watts); and (ii) Solar thermal collectors: use the sun's energy to heat water or another fluid such as oil or antifreeze. At the sunward surface of the cell the highest possible average incident solar radiation is about 1000 W/m^2. A solar module of 12% efficiency with a 1 m^2 surface area can be expected to produce approximately 120 watts of power. Most commercially available panels are configured to produce an open circuit voltage of around 20 Volts and a nominal voltage

of around 14 Volts to make them suitable for charging a 12 Volt battery; they are generally made up of 36 cells in series and referred to as 12 Volt panels. A Tilt Angle for solar panels, according to the local latitude, greatly enhances their performance. It is commonly accepted that the tilt angle (from the horizontal axis) should be equal to the local latitude, plus 15 degrees in Winter, or minus 15 degrees in Summer. In the Winter season it is sometimes recommended to adjust the tilt angle by taking the local latitude, multiply it by 0.9, and add 29 degrees.

SOLAR RADIATION: radiant energy emitted by the sun from a nuclear fusion reaction that creates electromagnetic energy. It is the dominant energy input to the Earth and is intercepted by the atmosphere and absorbed at the surface (watts/m^2). The spectrum of solar radiation is close to that of a black body with a temperature of about 5800 K. About half of the radiation is in the visible short-wave part of the electromagnetic spectrum; the other half is mostly in the near-infrared part, with some in the ultraviolet part of the spectrum. *Direct normal solar radiation* refers to the sunlight that can cast a shadow. A certain percentage of solar radiation is made up of diffuse or scattered light, caused by clouds, humidity or particulates. Solar resource measurements are reported as either direct normal radiation (no diffuse light) or *total radiation* (direct+diffuse). At the sunward surface of a photovoltaic cell the average incident irradiance radiation is about 1000 W/m^2.

SOLID-STATE LIGHTING (SSL): a technology that uses semi-conducting materials to convert electricity into light. A type of lighting that utilizes light-emitting diodes (LEDs), organic light-emitting diodes (OLED), or polymer light-emitting diodes (PLED) as sources of illumination rather than electrical filaments, plasma (used in arc lamps such as fluorescent lamps), or gas. The term "solid-state" refers to the fact that light in an LED is emitted from a solid object (a block of semiconductor) rather than from a vacuum or gas tube, as is the case in traditional incandescent light bulbs and fluorescent lamps.

SUSTAINABLE DEVELOPMENT: development that meets the needs of the present without compromising the ability of future generations to meet their own needs. [Brundtland Commission] Sustainable development is maintaining a balance between the human need to improve lifestyles and feeling of well-being on one hand, and preserving natural resources and ecosystems, on which we and future generations depend.

TECHNOLOGICAL RESEARCH (R&D): (traditionally known as applied research and experimental development) activity oriented towards the generation of new (technical) knowledge that can be directly applied to the production and distribution of commodities and services; it may lead to an invention, an innovation and an improvement (a minor application).

TECHNOLOGY: often scientific knowledge, but also differently organized knowledge, systematically applied to the production and distribution of commodities and services. Technology is the sum of knowledge and methods for producing and distributing commodities and services, including those embodied in the means of labour, labour-force, processes, products and organization. Technology is need-driven, by the satisfaction of the needs of society, economy and business. It is a system of technical knowledge, a systematic knowledge of the practical or industrial arts; it consists of a series of techniques (it is implemented through them). Technology comprises empirical techniques, traditional knowledge, craftsmanship, skills, procedures and experience not grounded on science. Technology reflects and is determined by both technical and social relations of production (it is not 'neutral') within a given social formation; it is a concrete response to specific social economic conditions.

TFPV - THIN-FILM PHOTOVOLTAICS: photovoltaic modules constructed with sequential layers of thin film semiconductor materials only micrometers thick deposited onto glass substrate. A layer of semiconductor material, such as amorphous silicon (a-Si) or polycrystalline materials (cadmium telluride (CdTe) and copper indium (gallium) diselenide -CIS, CIGS), a few microns or less in thickness, used to make photovoltaic cells. TFPV panels (or modules) are incorporated into the building envelope substituting cladding materials (ceramics, tiles, or marble, granite, glass or aluminium panels) with glass laminates that encapsulate photovoltaic cells. The modules are placed on top of raw building materials (brick, concrete), on the building façade or on the roof. The main advantage of a-Si in large scale production is not efficiency, but cost; a-Si cells use approximately 1% of the silicon needed for typical c-Si cells (the cost of the silicon is by far the largest factor in cell cost). Coloured thin-film modules are manufactured by depositing a dichroic reflective interference filtering film. Flexible thin film cells on polymer substrate, or multi-layered high efficiency cells, are getting closer to commercialization. TFPV modules have an energy conversion rate of around 12% (a

module of 12% efficiency with a 1 m^2 surface area can be expected to produce approximately 120 watts of power).

THERMAL MANAGEMENT: LED lights produce heat that must be managed in order to ensure optimum performance; it is important to maintain a low junction temperature to keep good performance of an LED. LED devices will operate normally as long as the temperature does not exceed an upper limit (specified as the ambient temperature and the temperature of the junction inside the LED light source). When this upper limit is exceeded, LEDs stop operating normally and become damaged. Therefore, it is necessary to successfully dissipate the generated heat so as to keep the temperature within specified level. Conduction, convection, and radiation are the three means of heat transfer. Typically, LEDs are encapsulated in a transparent resin, which is a poor thermal conductor; nearly all heat produced is conducted through the back side of the chip. Heat is generated from the PN junction by electrical energy that is not converted to useful light, and conducted to outside ambience (from junction to solder point, solder point to board, and board to the heat sink and then to the atmosphere). Thermal management is a relatively new obstacle for the lighting industry as it was historically not a factor for either incandescent or fluorescent lights (heat was simply radiated out of the luminaire). Generally, LEDs are designed to operate at 20 milliamps (mA); however, operating current must be reduced relative to the amount of heat in the application. For example, 6-chip LEDs produce more heat than single-chip LEDs; 6-chip LEDs incorporate multiple wire bonds and junction points that are affected more by thermal stress than single-chip LEDs; similarly, LEDs designed to operate at higher design voltages are subject to greater heat. LEDs are designed to provide long-life operation because of optimal design currents considering heat dissipation and other degradation factors.

THROUGH-HOLE LEDs: the mounting scheme used for LEDs (and other electronic components) that involves the use of leads on the components that are inserted into holes (PTH-Plated Through-Hole) drilled in printed circuit boards (PCB) and soldered to pads on the opposite side (automated insertion mount machines or manual assembly).

TRANSFORMER: electrical device with no moving parts, which change distribution voltages to higher or lower levels. It typically steps 120-240V distribution downward to 12V, although 5.5V and 24V models are also offered. [L.R.C./R.P.I.]

UPS - Uninterruptible Power Supply ('source', battery/flywheel backup): an electrical device that provides emergency power to a load when the input power source fails (the utility mains). A UPS differs from an auxiliary or emergency power system or standby generator in that it will provide instantaneous or near-instantaneous protection from input power interruptions by means of one or more attached batteries and associated electronic circuitry for low power users, and or by means of diesel generators and flywheels for high power users. UPS are commonly used to protect computers, data centers, telecommunication equipment, offices, shops where an unexpected power disruption could cause serious business disruption, data loss, injuries, etc. UPS units range in size from units designed to protect a single computer without a video monitor (around 200 VA rating) to large units powering entire data centers, buildings, or even cities.

WATT: a unit of electrical power. Lamps are rated in watts to indicate their power consumption. Power consumed over time equals the electrical energy used. It defines the rate of energy consumption by an electrical device when it is in operation. The energy cost of operating an electrical device is calculated as its wattage times the hours of use. (P=VI, Watts=Volts x Amps).

WORK PLANE: the plane at which work usually is done, and on which the illuminance is specified and measured (it is assumed to be a horizontal plane 0.75 meters above the floor).

ZERO ENERGY BUILDING - ZEB: (Net-Zero) a building with zero net energy consumption and zero carbon emissions annually. Zero energy buildings are autonomous from the energy grid supply, as energy is produced on-site by solar photovoltaic panels or small wind turbines. 'Green buildings' aim at using resources more efficiently and reducing their negative impact on the environment, whereas Zero energy buildings achieve one key green-building goal of completely or very significantly reducing energy use and greenhouse gas emissions for the life of the building. Zero energy buildings may or may not be considered 'green' in all areas, such as reducing waste, using a water treatment system or recycled building materials, etc.