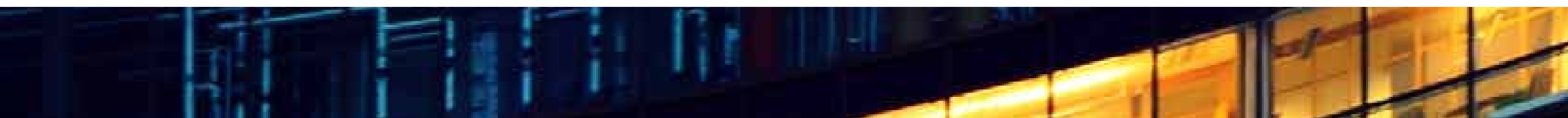
Smart lighting

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The lighting revolution

The invention of electric light changed the lives of millions of people. It lead to safer working conditions and better educational environments, improved healthcare and economic growth, throughout the 20th century.

We now stand on the threshold of a new lighting revolution. With the advent of light emitting diode (LED) technology, the prospects of what can be done with lights have expanded tremendously. The unique properties of LED make it a sustainable alternative to other light sources, as well as a smart option for use in a wide range of applications, including vertical farming and public street lighting. New technologies such as light fidelity (Li-Fi) enable lights to perform an additional range of tasks including wireless data transmission.

Since the very early days of electrical lighting, IEC International Standards have ensured that the technology involved meets the required safety and performance specifications. Just as importantly, IEC is now paving the way for the LED revolution.

IEC standardization expertise

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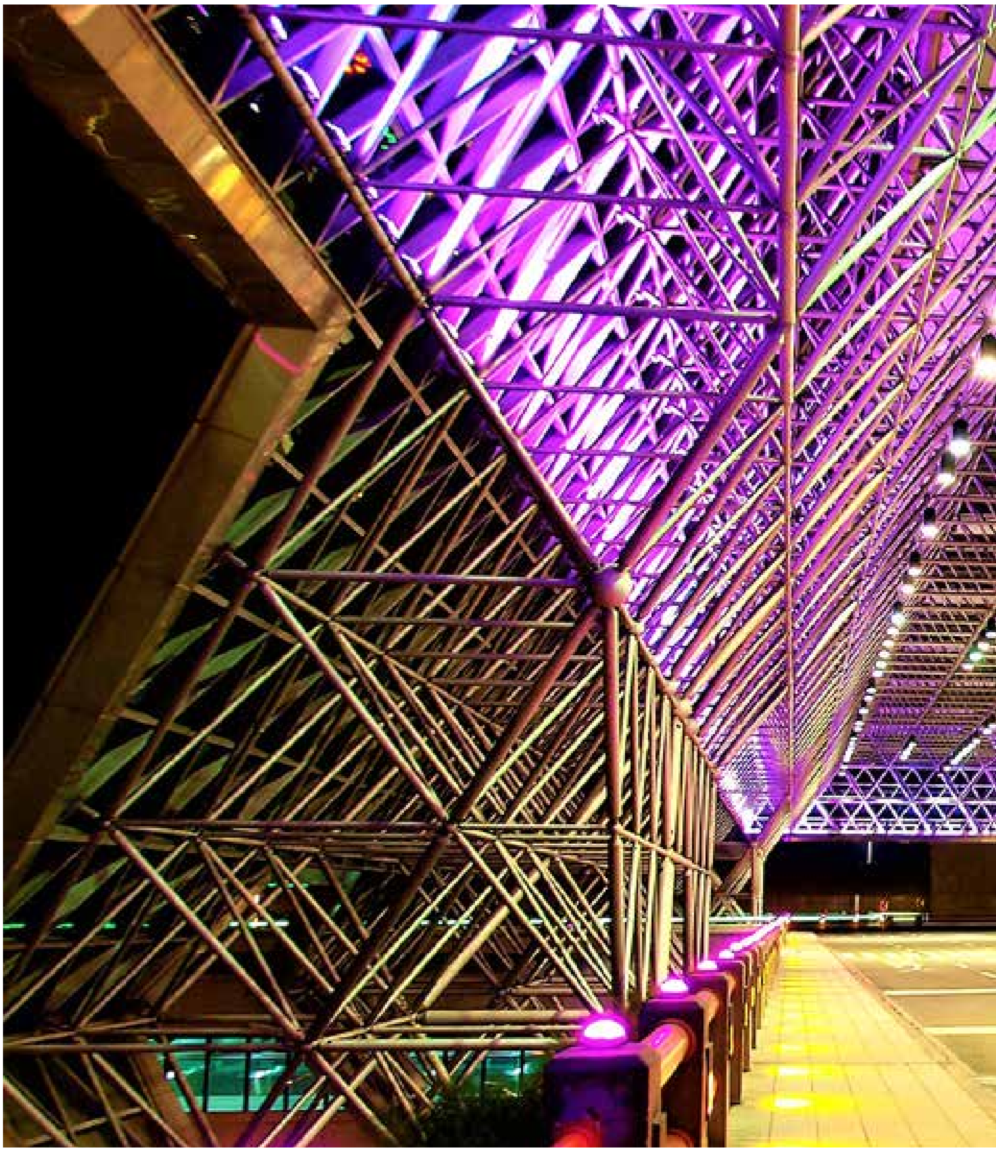
IEC Technical Committee 34: Lighting, develops standards on safety, performance and compatibility specifications for electric lamps and light sources, caps and holders, controlgear for electric lamps and luminaires and lighting systems. It is the leading IEC TC on lighting standards. TC 34 has published close to 600 documents relating to lighting technology and prepares publications that are essential for LED technology. It has established four subcommittees (SCs) to address the various areas and the wide range of applications relating to the lighting industry.

TC 34 cooperates with the International Commission on Illumination (CIE) and the European Environmental Citizen Organisation for Standardisation (ECOS). It also collaborates with ISO TC 274 on light and lighting as well as with ISO TC 22 on road vehicles.

Several other IEC TCs issue publications that are relevant to lighting technology. Many of these TCs liaise with TC 34. Together, they strive to prepare for a more sustainable, safer and smarter future for lighting.



Conformity assessment for lighting

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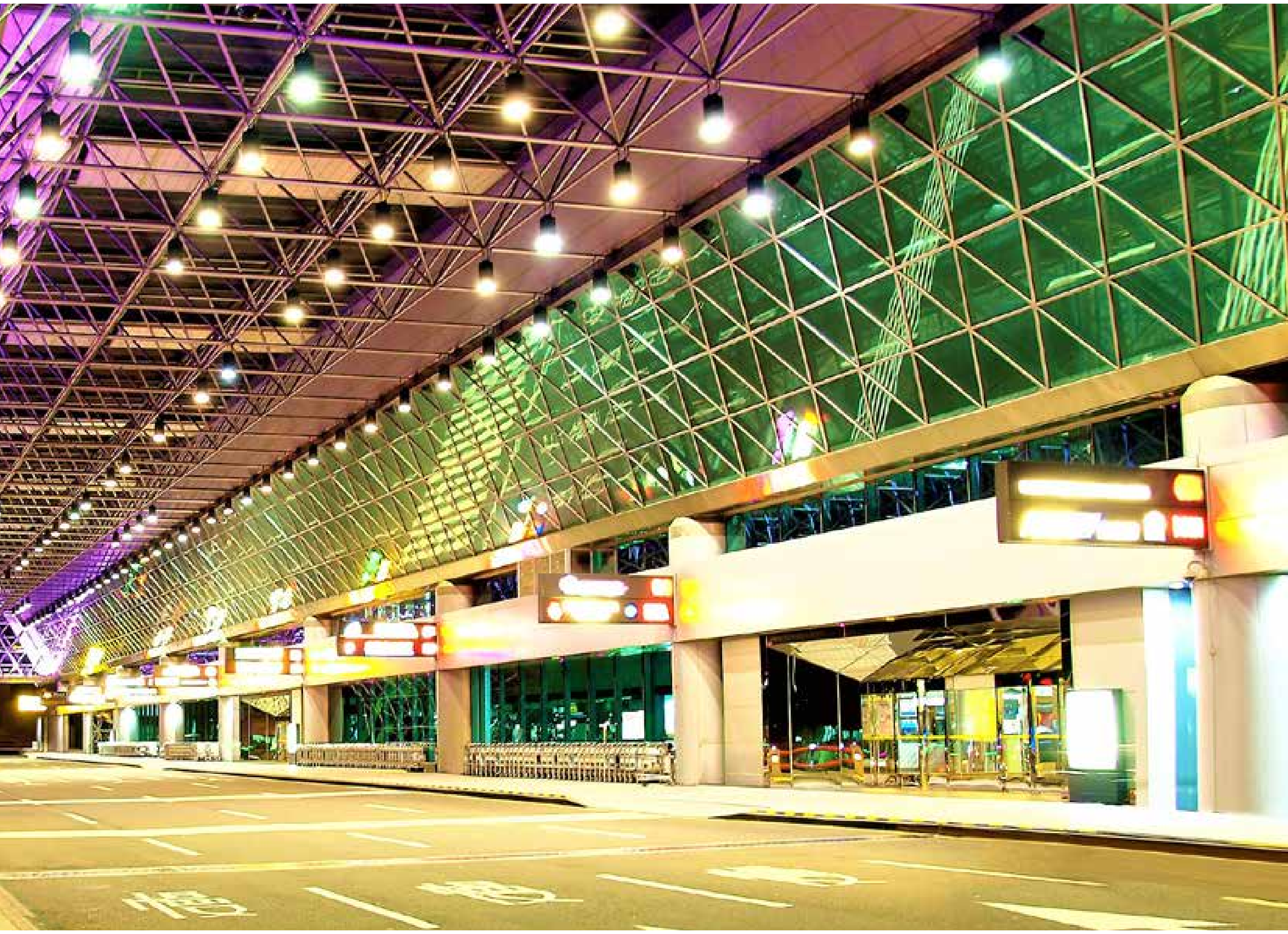
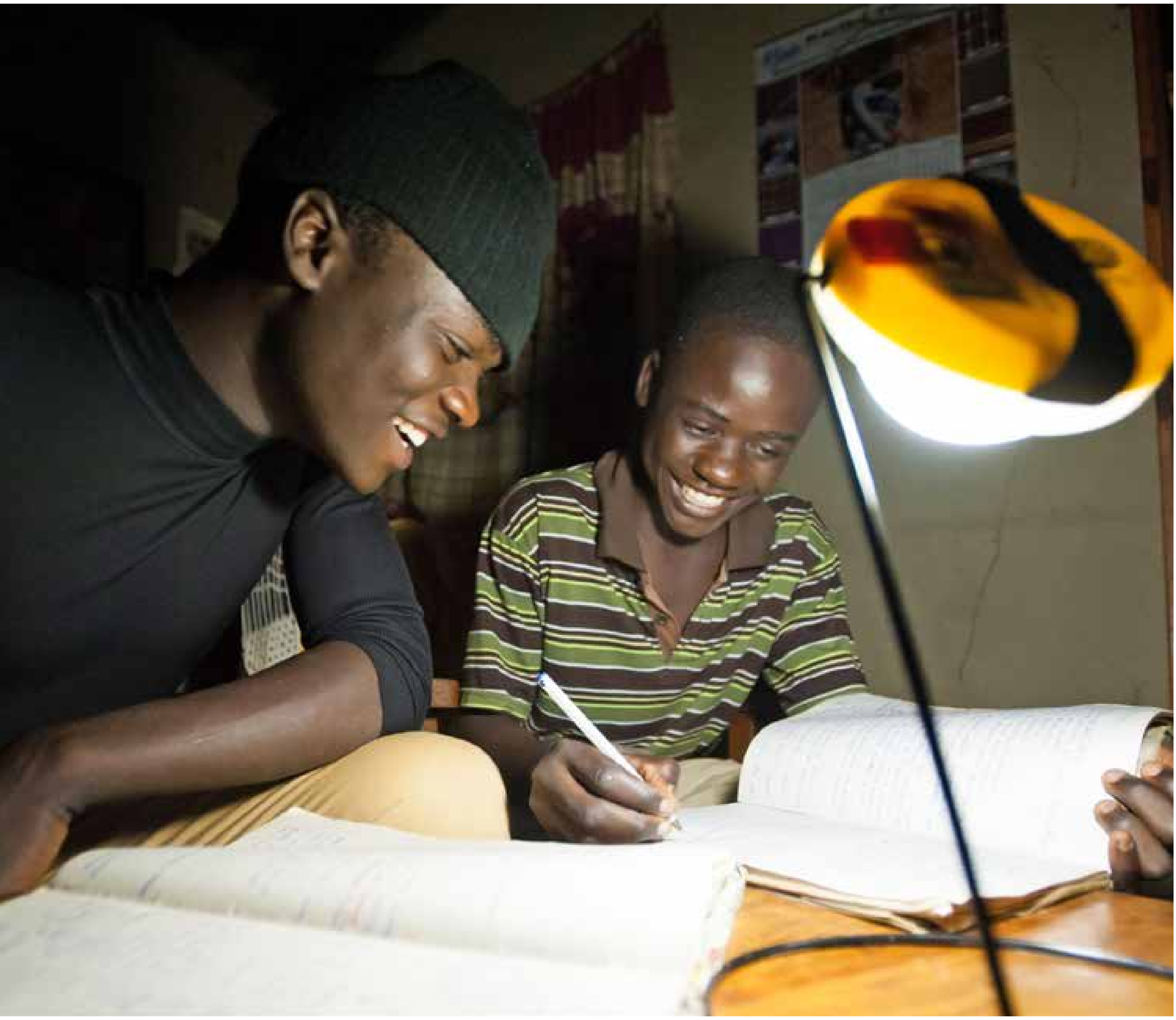
The IEC runs four conformity assessment systems, three of which have a direct relevance to lights and lighting systems.

- In 2015, IECQ (IEC Quality Assessment System for Electronic Components) created the IECQ Scheme for LED lighting. The scheme is used as a means of certification for manufacturers and suppliers of the electronic components, modules and assemblies used in the production of LED packages, engines, lamps, luminaires and associated LED ballasts/drivers. It provides a standardized approach for evaluating suppliers and can be employed as a supply chain management tool when assessing and monitoring the various tier-level suppliers. The scheme protects consumers by ensuring that participating companies manufacture products which meet the appropriate standards in terms of reliability, safety and efficiency.
- IECEE (IEC System of Conformity Assessment Schemes for Electrotechnical Equipment and Components) has been certifying lighting products for many years. The LITE specific scheme established under the system ensures compliance with the long list of IEC International Standards developed for the lighting industry. Products and equipment tested and certified include double-capped fluorescent lamps, floodlights, LED modules for general lighting, cords, lampholders, switches, insulation, temperature control, wiring and earthing.
- IECEx (IEC System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres) can be used to test LED lights for offshore lighting or lights used in other hazardous areas. It also tests more conventional incandescent lights or compact fluorescent lamps (CFLs) to ensure that all light fixtures are explosion-proof. Manufacturers have to meet the strict requirements specified

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in the IEC 60079 series of international standards. These documents are issued by IEC TC 31: Equipment for explosive atmospheres.

Let there be light – everywhere!

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Many people around the world still have little or no access to electricity and use dangerous and toxic lighting systems such as kerosene lamps. According to the UN, 850 million people still lack access to electricity provision. One of the organization's sustainable development goals (SDGs) is to provide universal access to affordable, reliable and modern energy services for all by 2030. Basic and affordable technical solutions have been devised to bring electricity to populations that otherwise might have had to wait many years for an electrical grid connection. IEC provides the technical foundation for building safe and affordable off-grid installations that can later on be connected and expanded.

IEC TC 82 issues the IEC 62257 series of technical specifications (TS) that provide recommendations concerning small renewable hybrid systems for rural electrification. These documents also apply to solar pico systems which use compact solar panels to generate small amounts of electricity for powering low energy-requirement objects such as lamps or mobile phones. IEC TS 62257-9-5, for instance, applies to stand-alone renewable lighting products using batteries and solar modules, with direct current system voltage not exceeding 35 V and power ratings not surpassing 350 W.

The work of the IEC – whether in standardization or conformity assessment – is forging a path to enable lighting to meet sustainable and smart targets while continuing to improve the lives of many people around the world.

Past, present and future

The first incandescent electric light bulb was invented in the 19th century. Separate patents were filed for the invention by several different scientists, including Thomas Edison. The competition was on to produce the most durable electric light bulb.

Around the same time, various electrical engineers were also focusing on the development of alternative technologies for electric light bulbs, which used mercury vapour. Right from the start, these lights proved to be more energy efficient and longer lasting than their incandescent counterparts.

In 1919, IEC founded the first TC to establish safety and performance standards for the lighting industry, which was still nascent at the time. IEC TC 6: Lamps sockets and caps, was eventually disbanded and its work taken over by IEC TC 23: Electrical accessories, set up in 1934. IEC TC 34 subsequently took over when it was founded in 1946, just after the Second World War. However, IEC TC 23 continues to standardize electrical accessories for lighting systems inside buildings, such as control devices and certain aspects of dedicated networks. It liaises closely with IEC TC 34, which prepares complementary standards for light sources, luminaires, control gear, dedicated protocols and other aspects of dedicated networks.

Modern CFLs began to be widely used after the oil crisis of the 1970s, as they were much more energy efficient than their incandescent counterparts. They still represent an important percentage of the lights used today but their end-of-life disposal raises environmental concerns, which is especially true for older models. CFLs contain mercury that can contaminate landfills and be released into the air when burnt in incinerators. Many countries around the world have implemented recycling policies to deal with CFL waste. IEC TC 34 publishes several standards relating to the manufacture, performance, safety and waste management of CFL lamps such as the IEC 60901 series on single-capped fluorescent lamps.

IEC TC 111 publishes environmental standards for electrical and electronic products, some of which provide tools and criteria enabling organizations and companies to manage toxic substances in the supply chain. Theses standards apply to CFLs as well as many other electrical and electronic products, such as batteries.

LEDs enter the fray

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LED lights, which use semiconductors and electroluminescence to create light (this technology is also called solid-state lighting) were invented in the 1960s. However, it was not until the 1990s that engineers and scientists discovered how to produce blue and white LED light. Technology advances enabled LEDs to gradually increase their efficiency and light output. The breakthroughs are attributed to the simultaneous development of semiconductor technologies and progress in optics and material sciences. As a result, LEDs hit the mass market in the early 2000s.

LEDs use much less energy than either incandescent or fluorescent lamps. They form an electronic construct which converts electricity directly into photons of light. By comparison, in a conventional incandescent

light bulb, a filament is heated until it glows, wasting a lot of energy in the form of heat. In a fluorescent lamp, electrons in mercury vapour are charged to emit light at UV frequencies, which is then made visible through a phosphor coating on the inside of the light bulb. This also produces wasted heat although much less than incandescent bulbs. When properly built, LEDs are not only much more energy efficient but also longer lasting than these other forms of lighting.

In many countries, incandescent light bulbs are being phased out because of their low energy efficiency. The International Energy Agency (IEA) estimates that 2016 and 2017 were critical turning points for energy efficient lighting, with LEDs reaching one-third of market sales.

IEC TC 34 anticipated the LED lighting boom and issued key standards pertaining to the performance and safety of these lights. For example, IEC 62031 establishes safety specifications concerning LED modules for general lighting.

Smart lighting systems

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LED has the potential to truly transform lighting as we know it. Its properties enable it to be used in smart lighting systems: smart LED bulbs equipped with sensors can be linked to a wireless Wi-Fi network and be switched on and off from an app on a mobile device. More sophisticated smart lighting systems can work with voice-activated equipment. Motion-detecting sensors embedded in the light bulbs can discern if a person is entering a room and automatically switch the light on.

Li-Fi can transmit data by using the stream of light emitted by an LED bulb. This technology is capable of transmitting data at high speeds over the visible light spectrum as well as in the ultraviolet and infrared waveband. It has many advantages over Wi-Fi, which is produced by radio waves, including a total absence of electromagnetic interference.

The power of AI

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Self-learning networks of lighting components can communicate and set themselves up without human intervention in a similar fashion to auto-commissioning systems used in the IT industry. Artificial intelligence (AI) is used to better tailor lighting systems to people's needs. By observing and measuring the indoor environment, an AI-based lighting system can optimize and fine tune the light source, thereby enhancing users' well-being.

An automated network of lighting components continuously generates data, which is collected, analyzed and stored. AI algorithms can be designed to run at the source component level, such as that of a sensor, for decentralized, real-time decisions, or at the server level for centralized decision-making. The collected data can be shared with other building management systems, such as heating, ventilation and air conditioning (HVAC) or access management.

The joint technical committee of IEC and ISO, JTC 1, prepares standards relating to IT applications. Several of its SCs work in areas relevant to smart lighting systems. SC 41 prepares standards pertaining to the Internet of Things (IoT), including ISO/IEC 21823-1, which defines the framework for the interoperability of IoT systems. SC 35: User interfaces, publishes ISO/IEC 30122-1, which establishes the framework and general guidance for voice-command user interfaces. SC 42 prepares standards in the area of artificial intelligence.

One of the working groups of IEC TC 34, WG 14, is currently developing standards relating to intelligent lighting products for lighting systems. IEC TC 47: Semiconductor devices, publishes several standards relevant to sensors, including their design, manufacture, use and reuse. For instance, IEC 60747-14-1 specifies the requirements for sensors made of semiconductor material.

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Flexible display screens

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Organic light emitting diode (OLED) lights are made with organic compounds that light up when electricity is applied. OLED lighting is composed of thin carbon-based organic layers sandwiched between a cathode (which injects electrons) and an anode (which removes electrons). When direct current is applied, electroluminescence occurs and visible light is emitted.

Like LED, OLED is a solid-state lighting technology that is readily compatible with control, dimming and sensor systems. It is also much more energy efficient than incandescent lighting. SC 34A has established WG 3 to prepare and maintain standards for OLED light sources. An example of such publications is IEC 62868, which specifies the safety requirements for OLED panels for general lighting.

OLED material can be flexible due to the organic layers used to create it. It is employed for lighting various types of display screens, from mobile phones to TV sets. One manufacturer recently demonstrated a foldable mobile phone featuring a roll-up screen made from OLED. IEC TC 110: Electronic displays, publishes several standards relating to OLED screens. A project team, PT 62341, is working to establish generic specifications, terminology, letter symbols, measuring methods, environmental and mechanical endurance test methods for OLED displays.

Laser diodes represent another solid-state lighting system and are even more energy efficient than LEDs. For the same level of power input, they produce significantly higher light output. Some scientists see blue laser diodes as the next evolution in lighting technology. However, commercial applications have been retarded by price considerations as laser lights are significantly more expensive than LEDs. They are also potentially hazardous for human vision, which constitutes an important issue for regulators. Strict safety measures have to be respected when using this type of light. IEC TC 76: Optical radiation and laser equipment, publishes the IEC 60825 series, which establishes the main safety specifications for all types of lasers.

Past, present and future: IEC International Standards were, are and will continue to be an indispensable requirement for ensuring that lights remain safe, while also helping them to become increasingly smart and sustainable.

Industrial lighting and smart factories

LED lights are being widely deployed in factories and warehouses around the world due to the unique properties they offer for control and automation systems, in addition to their energy efficiency.

LEDs can be used as motion sensors to determine occupancy. Detecting infrared waves, which are radiated by moving objects, they automatically turn the light off in the absence of movement. During daylight hours, a photocell deactivates the motion sensor.

Micro energy harvesting

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LEDs can also harvest energy and power connected devices. Micro energy harvesting (EH) collects ambient energy that would otherwise be lost and converts it into electricity, which is used to power small devices. The Zürich University of Applied Sciences has built wireless sensors that are powered by the energy harvested from LEDs and photodiodes. Chinese and Swedish researchers from Beijing and Linköping Universities have developed organic solar cells optimized to convert ambient indoor light to electricity, which can be used for powering sensors employed for the IoT. IEC TC 47 has set up a working group that publishes standards, such as the IEC 62830 series on semiconductor devices for energy conversion and transfer, which includes EH.

Enhanced surveillance tools

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LED lights on security cameras enable night vision and provide better visibility and clarity than other light sources for close-circuit monitoring systems. Moreover, minute HD and Wi-Fi security cameras can be added directly to light fixtures to expand monitoring coverage. Known as light bulb cameras, these are hidden from view and offer a convenient video surveillance tool.

IEC TC 79: Electronic alarm systems, publishes IEC 62676-1-1 on the general requirements of video surveillance systems. IEC TC 100 issues standards for audio, video and multimedia systems.

Emergency lighting

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LED lights can also be used to automatically light up evacuation routes in the case of fires or other accidents.

SC 34D publishes key standards relevant to emergency escape lighting. IEC 62034 provides automatic test systems (ATS) for battery-powered emergency escape lighting. This standard is essential to ensure that the performance of these safety-related lights is systematically tested and maintained The ATS specified in the standard enable tests to be scheduled regularly and provide timely notification of performance degradation or all-out failures.

Other standards published by SC 34D include IEC 60598-2-22, which specifies the particular requirements of luminaires for emergency lighting and IEC 61347-2-7, which establishes the specifications for battery-supplied electronic controlgear for emergency lighting.

Connected lights and cyber security

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Automated lighting control systems are increasingly at risk of cyber attacks. These

breaches can either affect the lights themselves or use lighting as a vector to reach other information technology (IT) systems, for instance on industrial sites.

With the expansion of the IoT and the use of network-connected lights, the requirements for encryption and authentication are increasing. New AI-controlled lighting systems enable lights to collect data and transmit it to the cloud. According to a report from the US Department of Energy, in this type of cloud-based lighting configuration, cyber security risks are estimated to be “moderate to high”. The report lists several cyber security risks related to connected lighting, including vectoring, which occurs when an intruder enters a system to gain access to other systems in the network.

IEC TC 65 develops the IEC 62443 series of standards, which recommends that security should be an integral part of the development process, through the incorporation of security functions in the equipment and systems from the outset. These transversal standards establish efficient security processes and procedures that cover the whole value chain, from the manufacturers of automation technology to installers as well as operators. They address and mitigate current security vulnerabilities as well as pre-empt future ones.

One of the advisory groups of TC 34, AG 4, is developing the requirements for specific lighting cyber security standards.

Vertical farming and other agricultural requirements

According to the UN Food and Agriculture Organization, 820 million people in the world today do not have enough to eat. Farmers and policy makers are looking at new production methods to meet world food demand. While indoor farming has existed since antiquity, new concepts such as vertical farming are becoming increasingly mainstream. Instead of growing produce horizontally in a field or under a greenhouse, vegetables and fruit are cultivated indoors in vertically-stacked layers, without natural daylight or soil. This form of farming does not require pesticides or long-distance transport, making it more sustainable.

The momentum for vertical farming has risen as the prices of LED lamps have tumbled. LED lights emit significantly less heat than other forms of lighting, allowing them to be tightly packed in vertical installations without harming crops. Specific LED grow lights have been developed, which can produce the exact spectrum of light required for photosynthesis to occur in optimal conditions. These lights can replicate and even improve on the properties of sunlight. LEDs can be finely tuned to match the different development stages of plants, from blooming to fruit development, improving their taste and their levels of vitamins and antioxidants.

Animal welfare

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LEDs are also used for conventional indoor farming. Optimized lux levels can be beneficial to animal well-being and reproduction. Optional intelligent controls can be cost efficient in large facilities, thanks to increased energy savings. Despite these advantages, most indoor farms still use fluorescent grow lights as well as high pressure sodium (HPS) and metal halide lights, which produce different colour hues.

SC 34A publishes safety standards for discharge lamps in IEC 62035. It also publishes safety and performance specifications for fluorescent lights, including the IEC 60081 series, which establishes the performance requirements for double-capped fluorescent lamps.

Except for LEDs, all grow lights need ballast to regulate the level of current in the lamp. At the start, a discharge lamp requires a high level of current to light the bulb which then needs to be lowered to avoid overheating. Too much heat could result in the explosion of the bulb. SC 34C, which was established to publish standards for lamp auxiliaries, issues safety and performance standards relating to ballasts, including the IEC 61347-2 series, which specifies requirements for electronic ballasts for discharge lamps.

IEC TC 34 has set up an advisory group on horticultural lighting, AG 15, which provides a coordinated approach to standardization in this area.

Safety for workers

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Considerable coverage has been devoted to blue light hazard in vertical farming. As the lamps are stacked vertically and close to each other, they also shine into workers' eyes. At a sufficiently high intensity, any type of light, regardless of the source, has the potential to harm the eyes or skin through prolonged thermal exposure or the photochemical effects of ultraviolet, blue light and/or infrared emissions. Shorter wavelength, higher-energy blue light can cause retina damage through a combination of photochemical action and high intensity.

Like other lighting technologies, LED grow lights must therefore be checked for photobiological safety. IEC TC 76 publishes IEC 62471, which gives guidance for evaluating the photobiological safety of lamps and lamp systems. The standard concerns all electrically powered broadband sources of optical radiation, including LEDs but excluding lasers. To complete this standard, IEC TC 34 issues the technical report, IEC TR 62778, which gives guidance on the assessment of blue light hazard for all lighting products which emit in the visible spectrum.

Smart and bright cities

According to the UN, 68% of the world's population is expected to live in urban areas by 2050. The challenge will be to supply these populations with basic resources such as safe food, clean water and sufficient energy, while also ensuring overall economic, social and environmental sustainability.

Cities will have to become smarter and use technology in different ways to meet these challenges. Several IEC Standards, including those relevant to lighting, will contribute to this global effort.

The IEC Systems Committee Smart cities coordinates the development of standards to support the integration, interoperability and effectiveness of smart city systems. ISO/IEC JTC 1 created WG 11, which is developing foundational standards for the use of information and communication technology (ICT) in smart cities.

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Revisiting the lamppost

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Several cities are upgrading their streetlights to LEDs, because they are longer lasting, much more energy efficient and cheaper to use than conventional lights (usually HPS).

Some urban centres have opted to only retrofit LED light bulbs to save energy, but others have invested in smart LEDs equipped with sensors and connected through a wireless network. Networking offers the benefits of remote monitoring and management, automatic outage detection and proactive maintenance of lampposts. Other applications for smart LED streetlights are smart parking, pollution monitoring and traffic management.

Cities upgrading to smart LEDs include Copenhagen, Chicago and Glasgow. The European Union (EU) launched the *Humble Lamppost project*, which aims to make streetlights an integral part of the development of smart cities. Under the slogan "*a dozen things you can do with a humble lamppost that has nothing to do with light*", the EU wants to upgrade 10 million lampposts, making them solar-powered smart devices able to deliver a range of smart city services. In India, the country's *Street Light National Programme* has installed more than ten million smart LED streetlights and the effort is ongoing.

Making sure lights are EM compatible

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Electromagnetic compatibility (EMC) signifies the ability of equipment to function satisfactorily in the surrounding EM environment without introducing intolerable EM disturbances to other equipment. All lights emit EM energy – visible light is a part of the EM spectrum. IEC TC 34 publishes IEC 61547, which specifies EM immunity requirements for general lighting purposes.

In addition, IEC TC 77 issues basic and generic EMC standards, such as the IEC 61000 series, which includes terminology, descriptions of EM phenomena and the EM environment. It also specifies measurement and testing techniques and guidelines on installation and mitigation.

The International Special Committee on Radio Interference (CISPR) is made up of the participating IEC National Committees and several international organizations, including the International Telecommunication Union (ITU) and the European Broadcasting Union (EBU). CISPR pursues a very broad scope of standardization in the field of EMC, aspects of which are addressed by its various SCs. For instance, it has released CISPR 15 concerning the limits and measurement methods for radio disturbance characteristics of electrical lighting and similar equipment.

New technology for car lights

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LEDs, OLEDs and laser diodes can be used in the manufacturing of automotive lights. LEDs have already been employed for some time to enable cars to save energy as these lights last longer and are more energy efficient than conventional ones.

OLED taillights are also produced by several car manufacturers. Due to their extremely thin and flat shape, they make new form factors and design options possible. Moreover, automotive companies are looking into the production of prototypes for flexible, three-dimensional OLED taillights. OLED lights are printed electronics which are thin, lightweight, flexible, and robust. Electrical components can be integrated directly into low-cost production processes. IEC TC 119: Printed electronics, publishes the IEC 62899 series of international standards, which measures the sheet resistance of printed conductive film.

Laser technology is the new kid on the block: it enables cars to use a much narrower and precise beam of light. The brightness is almost four times that of an LED. This means that headlights can be made much smaller in the future – without compromising on light intensity. The improved visibility makes road traffic safer.


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Airports and AGL

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LEDs are increasingly used inside airports for general lighting and outside for airfield or aeronautical ground lighting (AGL) systems. These lighting systems guide pilots during take-off and landing, on runways as well as associated taxiways and aprons, which is the area where the aircraft is parked, loaded and unloaded.

LEDs are replacing incandescent lights not only because they last much longer and are more energy efficient but also because they provide better visibility in foggy conditions, have a wider colour spectrum and are more robust.

IEC TC 97: Electrical installations for lighting and beaconing of aerodromes, prepares standards for power distribution systems adapted to the operational and safety needs of AGL. The TC is a pioneer in the preparation of international standards for constant circuit systems which are particularly adapted to LEDs.

Smart buildings and the DC microgrid

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LED lighting systems, photovoltaic (PV) systems with batteries and charging systems for electro-mobility are used in modern intelligent buildings. All require direct current (DC) in order to function.

Some cities have equipped smart buildings with DC microgrids. This is a way to forego the energy losses which unavoidably occur when converting from alternating current (AC) to DC systems. In most cases, electricity is transmitted from the power station to the home over a long-distance AC network, which then must be converted to DC before use in the home. A microgrid is a decentralized distributed energy resource which can supply electricity to a building or group of buildings independently from the main grid. It can also supply DC current if powered by renewable energy sources such as solar PV or wind. LED lighting systems do not require high voltage levels to function and several trials have been carried out using low voltage direct current (LVDC). Extremely compact 48 V DC-DC converters can supply increasingly small LED luminaires.

IEC is forging the path for LVDC. It has set up a systems committee to identify gaps where international standards are needed. It is also helping to coordinate the work of the different TCs involved in this area.

Sport and entertainment

Different types of lights are used for sporting and entertainment events. Flood lights on football pitches, underwater lighting in swimming pools, laser light shows during concerts, projectors in cinemas, lights on movie sets, all require different lighting technologies.

IP ratings

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Water and electricity are not a good mix. IEC Standards are required to ensure that electrical installations in swimming pools perform adequately and remain safe. IEC TC 64: Electrical installations and protection against electric shock, publishes IEC 60364-7-702, which applies to swimming pools and specifies how to select and install electrical equipment near or under water.

SC 34D: Luminaires, issues IEC 60598-2-18 on the requirements for swimming pool lights. Among other things, this standard for low-voltage installations describes tests for mechanical strength and corrosion that underwater lighting fixtures must pass.

IEC TC 70: Degrees of protection against enclosures, publishes a key standard, IEC 60529, which rates water resistance using the ingress protection (IP) rating code. While the first IP digit refers to dust, the second is specific to water ingress.

Manufacturers the world over use this IP classification to specify the water resistance of the electronic devices they produce – including lights. The ingress levels start with resistance to water drops, which is the lowest level of protection, and extend to continuous immersion in water and resistance to high pressure jets.

Conventional flood lights used in stadiums and on football pitches are most often halogen or metal halide. SC 34D publishes 60598-2-5, which specifies requirements for floodlights on supply sources not exceeding 1000 V.

LED lights are increasingly being used both for underwater and flood lighting. SC 34D has updated IEC 60598-1, a generic standard which establishes general requirements and tests for luminaires and includes LEDs.

Under the spotlight

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Laser lights are commonly used for light shows during music concerts and similar events. While they are enjoyed for their colourful display, they can also be dangerous for the human eye.

IEC TC 76 publishes a safety standard for lasers, which is widely used by industry. IEC 60825-1 offers a global classification scheme for laser products according to the safety requirements and emission limits involved. It is viewed as THE reference for laser equipment by manufacturers, installers and regulators in most countries around the world. For instance, the standard specifies determination of the nominal ocular hazard distance as measured from the laser source. IEC 60825-1 is a horizontal publication, meaning that it provides a global framework for most other IEC TCs developing standards for specific laser-based products, such as printers, hair removal devices and barcode scanners. It ensures that all the standardization documents produced by each TC are mutually coherent.

Laser lights can also be used for image projectors in cinemas. IEC TC 76 issues IEC 62471-5, which establishes measuring conditions for image projectors based on the end user's exposure to laser light.

It's a wrap!

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Lights used on film sets are based on different lighting technologies, each of which has advantages and drawbacks.

→ Tungsten halogen lamps are similar to the incandescent lamps which were the norm in offices, factories and homes before the advent of more energy efficient forms of lighting. The key difference is that they use bulbs that take advantage of what is known as the halogen cycle. The pressurized halogen gas inside the bulb helps to redeposit evaporated tungsten metal back onto the filament. The glass bulb is also made from a much stronger quartz or aluminosilicate glass. The lamps operate at a higher temperature than do normal incandescent tungsten bulbs. They produce a continuous spectrum of light from near ultraviolet to infrared, producing virtually perfect colour rendition, and are usually employed for inside shootings. Disadvantages are the heat they generate and the level of power they use. IEC TC 34 publishes the relevant safety standard, IEC 60432-3, while establishing the performance criteria for halogen lamps in IEC 60357.

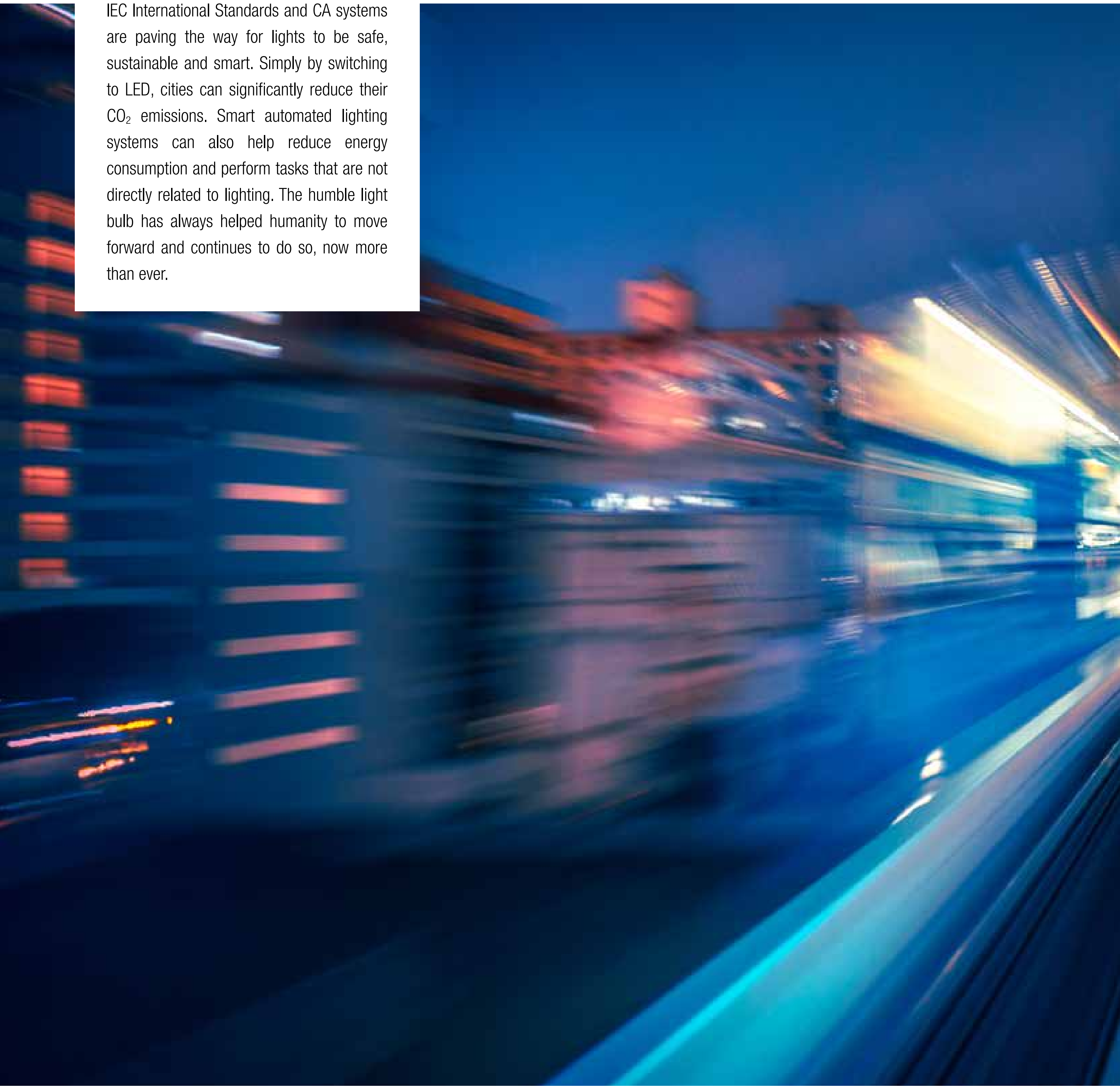
→ Another form of lighting used on film sets is hydrargyrum medium-arc iodide (HMI), a metal-halide gas discharge medium arc-length lamp. The specific mix of gases in a HMI closely matches natural sunlight. HMIs are often used when recreating or augmenting sunlight shining into interiors, or for exterior lighting. Powerful HMIs can be used to illuminate large areas. While these lights are more energy efficient than incandescent lamps, they also have a few disadvantages. Like other metal halide bulbs, they require a ballast for arc ignition. If dropped while lit, an HMI bulb can explode releasing very hot quartz glass and mercury vapour. IEC TC 34 issues IEC 62035, which is the relevant safety standard for such lamps.

→ Fluorescent film lighting is most often used in fixtures containing banks of tubes. Such lamps produce a soft and even light and can be used in relatively close proximity to the subject. Fluorescent systems are often employed to light interiors and have the advantage of being more compact and cooler in operation than tungsten or HMI lighting. They are also more energy efficient. TC 34 publishes a safety standard for fluorescent tubes, IEC 61195.

→ Until recently, LED light sources did not provide enough lighting power for film sets. They are still limited in overall light output when compared to any of the other light sources used by film crews. However, LEDs are becoming more commonplace due to their convenience. Because they can be battery-powered, they are ideal portable lighting systems. They also require no separate ballasts or heavy cabling. Panels made from LED lights can be small or large and are suitable for a variety of situations. IEC TC 34 publishes both a performance standard, IEC 62717, and a safety standard, IEC 62031, for LED modules.

Lighting the way

IEC International Standards and CA systems are paving the way for lights to be safe, sustainable and smart. Simply by switching to LED, cities can significantly reduce their CO_2 emissions. Smart automated lighting systems can also help reduce energy consumption and perform tasks that are not directly related to lighting. The humble light bulb has always helped humanity to move forward and continues to do so, now more than ever.



About the IEC

The IEC, headquartered in Geneva, Switzerland, is the world's leading publisher of international standards for electrical and electronic technologies. It is a global, independent, not-for-profit, membership organization (funded by membership fees and sales). The IEC includes 173 countries that represent 99% of world population and energy generation.

The IEC provides a worldwide, neutral and independent platform where 20 000 experts from the private and public sectors cooperate to develop state-of-the-art, globally relevant IEC International Standards. These form the basis for testing and certification, and support economic development, protecting people and the environment.

IEC work impacts around 20% of global trade (in value) and looks at aspects such as safety, interoperability, performance and other essential requirements for a vast range of technology areas, including energy, manufacturing, transportation, healthcare, homes, buildings or cities.

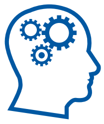
The IEC administers four conformity assessment systems and provides a standardized approach to the testing and certification of components, products, systems, as well as the competence of persons.

IEC work is essential for safety, quality and risk management. It helps make cities smarter, supports universal energy access and improves energy efficiency of devices and systems. It allows industry to consistently build better products, helps governments ensure long-term viability of infrastructure investments and reassures investors and insurers.

A global network of 173 countries that covers 99% of world population and electricity generation

Offers an affiliate country programme to encourage developing countries to get involved in the IEC free of charge

Develops international standards and runs four conformity assessment systems to verify that electronic and electrical products work safely and as they are intended to



IEC International Standards represent a global consensus of state-of-the-art know-how and expertise

A not-for-profit organization enabling global trade and universal electricity access

Key figures

173
members and affiliates

>200
technical committees

20 000
experts from industry, test and research labs, government, academia and consumer groups

>10 000
international standards published

4
global conformity assessment systems

>1 million
conformity assessment certificates issued

>100
years of expertise

Further information

Please visit the IEC website at www.iec.ch for further information. In the "About the IEC" section, you can contact your local IEC National Committee directly. Alternatively, please contact the IEC Central Office in Geneva, Switzerland or the nearest IEC Regional Centre.

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IEC Conformity Assessment Systems

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IEC Smart lighting:2020-02(en)