Preface

There is a way to do it better—find it

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In Europe, energy consumption in the field of illumination represents a significant percentage of global consumptions. More generally, it is estimated that 14 % of electricity is used for lighting. It is therefore important to intervene in this sector not only because of the need to save energy but also for limiting light pollution and for reducing costs of maintenance. The improvement of lighting systems entails a multidisciplinary operation on all components, exploiting the results of technological progresses. Hence the design of lighting fixtures must take into account basically the amount of emitted light, but especially the mode of its distribution, avoiding to recover light rays in areas where they are not necessary. Concerning the light sources, these are rapidly evolving toward very high efficiency and long-lifetime devices, with a view to bring down the replacement operation for faults and aging. The illumination system efficiency is also improved with targeted interventions on the electricity grid and on control systems and remote monitoring. New architectural strategies of ecological design, applying high-efficiency technological components, can contribute to reach higher levels of energy saving and environmental sustainability. Besides, it is important to note that in the perspective of a sustainable development the research for more efficient lighting devices and more efficient buildings is today stimulated and incentivized also with political action.

The book presentation strategy foresees to initially introduce photometry, radiometry, colorimetry, and color rendering. Successively, the main technological components for indoor illumination are shown, describing in detail luminous sources, lighting luminaires, building glasses, and optical fibers. The second part of the book is devoted to discuss a large variety of applications centered on energetic saving, sustainable illumination, and renewable energy exploitation. These illuminations, mostly for interiors, are obtained applying in practice the mentioned theoretical concepts and utilizing the described technologies, materials, and components.

Quantities and laws of radiometry are fundamental to comprehend the working principles of luminous sources and how to measure their light emission. Optical parameters, relationships, and fundamental laws are the bases for the comprehension of light measurements. So it is useful to describe radiometric, photometric, and colorimetric quantities by the practical point of view of their application in optical measurements and tests. The most important relationship is the passage from radiometric to photometric quantities: the photometric parameters are obtained from the radiometric ones taking into account the human eye sensitivity. Besides, human vision is extremely sensitive to colors, therefore colorimetry and color rendering are two central aspects to be considered in developing luminous devices and designing interior illuminations. Colorimetry can be identified as the scientific-technological discipline physically describing and quantifying human color perception. It exploits spectrophotometric tests and curves to extract the colorimetric quantities, finally expressing the results as chromatic coordinates and classifying the data in color spaces. The importance of color rendering is evident for a work of art, but light color can also be important for food, textiles, architecture, etc. To understand the color rendering of a light source it is necessary to start from the explanation of the human visual perception, including the neural processes; then some numerical indicators related to color rendering must be introduced. From the biological and psychophysical points of view, it was recently discovered that the mammal's eye has photoreceptors specialized to detect light and related to the circadian rhythm of human beings. The study of the frequency range of these photoreceptors' sensitivity can open important new perspectives for the psychological well-being of all of us. Classically, optical tests performed on lamps and luminaires are aimed to evaluate, catalog, and monitor the luminous emission. The light is spectrally analyzed, then photometric measurements assess the luminous flux: typically the flux is measured on the bare source and on the source after putting it inside the luminaire, thus obtaining the overall efficiency of the real source. The source emission characterization is completed by colorimetric tests and the evaluation of color rendering index and chromaticity. Additional features can be investigated, from the color dependence on direction or on temperature, to the psychophysical impact of light.

The purpose of sustainable light sources is to convert electrical energy into visible light as efficiently as possible. Then their arrangement should be optimized using a lighting software to simulate the interiors, considering light spatial distribution and color. In the development of artificial luminous sources, driven by the market competition, novel lighting technologies are emerging in the residential sector, including fluorescence lamps and Light Emitting Diodes. To choose among the large variety of available sources and to maximize their exploitation it is essential to examine the specific lighting characteristics of the various lamp typologies. The emerging technology is the Light Emitting Diode (LED), which appears more efficient than fluorescent lamps, discharge lamps, halogen tungsten lamps, and traditional incandescent lamps. However, for power saving and environmental aspects, the fluorescent lamp was considered the most appropriate solution in many lighting design applications. More recently, LED-based illumination is increasingly becoming the most efficient light source, replacing both incandescent and fluorescent lamps. The main property of LEDs is the emission spectrum, but a limit in its diffusion was the unsatisfactory color rendering. The application of a source involves a lighting luminaire, which is a device aimed to transform electric energy into luminous energy and to spatially distribute the generated light, in a coherent and controlled way, guaranteeing minimum losses in the energetic transformation and the maximum safety for the user. In this field, the progress is addressed toward a future generation of lighting luminaires completely sustainable, nonpolluting, power saving, user-friendly and environmentally compatible.

Artificial light can be less energy consuming, but for a true sustainable lighting project for indoor environments, the central element is daylighting. In the research projects aimed to design and realize low-energy buildings it is crucial to study the relationship between daylighting and architecture. Lately, a new useful approach to assess daylighting systems performance in the perspective of buildings sustainability was introduced. Daylight exploitation is becoming an important solution to reduce energy consumption for electric lighting in buildings. Improving building performances in a sustainable perspective implies also to design appropriate daylighting schemes, systems, or components to optimize daylight exploitation while controlling its potential negative effects. Daylighting systems should be examined from the analysis of their functions to the definition of the parameters used to assess their optical and thermal properties; from the description of traditional glazing and shading solutions to the explanations of the characteristics of more innovative components or guidance systems. Sustainable indoor illumination is essentially a smart combination among luminous sources, lighting luminaries, architectural design, and technological elements. Modern glass or polymeric coverings provide very high thermal insulation and mitigate the part of the solar spectrum useless for vision, which in summer heats the building interior. Optical fibers and light pipes are two interesting technological elements related to the practical installation of illumination plants. Light pipes are internally reflecting tubes, while optical fibers are based on the luminous propagation rays inside a glass cylinder. Optical fibers are typically used to separate the lighting terminations from the source. Light pipes or partially diffusing pipes can be used for lighting, but the total pipe length is limited to a few meters. Finally, the lighting system control plays an essential role. Respecting the specific requirements of each structure, the lighting control should give benefits in terms of building energy efficiency, enhance environmental visual appearance, and increase building functionality and flexibility. Especially for autonomous units supply, various renewable resources can be profitably combined, however selecting the most suitable energy. First in the architectural design phase, then in the building construction phase, and finally during utilization, all energetic resources should be combined to find a trade-off between maximization of natural solar illumination, minimization of thermal losses, and optimization of energy exploitation.

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