IEC TR 63540

Edition 1.0 2024-08

TECHNICAL REPORT

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Lighting systems – Characteristics for selected outdoor applications

IEC TR 63540:2024-08(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 29.140.01; 93.080.40

ISBN 978-2-8322-9501-4

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CONTENTS

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LIGHTING SYSTEMS – CHARACTERISTICS FOR SELECTED OUTDOOR APPLICATIONS

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The text of this Technical Report is based on the following documents:

Draft	Report on voting
34/1184/DTR	34/1205/RVDTR

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Report is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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LIGHTING SYSTEMS – CHARACTERISTICS FOR SELECTED OUTDOOR APPLICATIONS

1 Scope

This document provides information on outdoor lighting systems for selected applications. This document provides an overview of configuration, interfaces with other devices, communications, control strategies and characteristics of various outdoor lighting systems with relevant functionalities.

Applications selected for inclusion are:

- outdoor parking area lighting;
- road and street lighting;
- pedestrian and cycle pathways lighting.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-845, *International Electrotechnical Vocabulary (IEV) – Part 845: Lighting*, available at https://www.electropedia.org/

IEC TS 63105, *Lighting systems and related equipment – Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-845 and IEC TS 63105, and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
astronomical time control
device that actuates a load and adjusts power in steps based on the time of day or based on astronomical events

Note 1 to entry: Astronomical events can be sunset or sunrise, accounting for geographic location and day of the year.

3.2
light sensor
device that detects the quantity of light

4 Outdoor lighting system architecture

According to system architecture, outdoor lighting systems can be classified into three categories, as follows:

- lighting systems consisting of standalone luminaire(s);
- autonomous lighting systems;
- centrally controllable lighting systems.

Typical characteristics of these lighting systems are described in IEC TS 63116:2021/AMD1:2023, Clause 11.

5 Configurations of outdoor lighting systems

5.1 Lighting poles

5.1.1 Lighting poles with luminaires for adaptive lighting

Luminaires and systems for adaptive lighting equipped with sensors and communication modules can provide various lighting control functions to support the city infrastructure. Examples of functionality in adaptive lighting are:

- timer-based light control;
- presence sensor light control;
- motion sensor light control;
- communication between luminaires;
- remote configuration.

5.1.2 Multi-function lighting poles

Various devices such as sensors, CCTV, speakers can be mounted onto a multi-function lighting pole. Besides the capabilities for adaptive lighting controls, a multi-function lighting pole can also provide various functions to support the city infrastructure. Examples of functionality in adaptive lighting are:

- weather conditions;
- air quality monitoring;
- vehicle to X services;
- traffic monitoring;
- traffic light controls;
- smart parking;
- ambient noise registration (e.g. gunshot detection and accident detection);
- public messaging or digital signage;
- high definition (HD) video surveillance (CCTV);
- waste management;
- EV charging station.

An example of a multi-function lighting pole is shown in Figure 1.

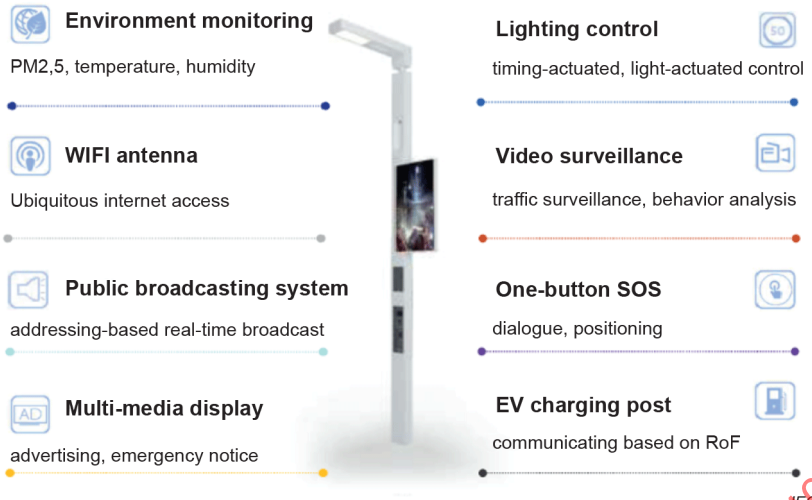

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Figure 1 – Example of a multi-function lighting pole

5.2 Sensors

5.2.1 Sensors for lighting control

Sensors can be used to detect activity in the surrounding area for an adaptive lighting control response. For example, a motion or presence sensor automatically activates when a vehicle or pedestrian is identified entering a specific area and can respond as required. If there is no vehicle or pedestrian in the specific area, the luminaire is adapted automatically to pre-set light levels, or switched off.

Another possibility is an ambient light sensor that can be used to control light levels. When an area to be illuminated is bright enough (according to the light level required by application standards such as CIE 115 or other regional lighting standards, such as the EN 13201 series), then the luminaire can be controlled to reduce light levels. This can help to save energy and provide an adequate amount of light regardless of weather conditions.

Various types of sensors can be added to the system to provide additional functions to the application. Examples of sensor inputs are as follows:

- weather conditions (e.g. temperature, humidity, wind, fog and air pressure);
- air quality;
- traffic monitoring;
- ambient noise;
- available parking space;
- pole tilt;
- flood detection;
- UV radiation.

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5.2.2 Sensor mounting configurations

In general, sensors are mounted where they can best capture the needed information. Sensors can be either integrated into the luminaire directly or connected to the luminaire by (standardized) interfaces (i.e. non-integrated). Sensors can be categorized as pole mounted or luminaire mounted.

Non-integrated sensors with standardized interfaces have specific requirements for physical and electrical interfaces to facilitate interchangeability. Examples of standardized interfaces for sensors are given in ANSI C136.41:2021 and IEC PAS 63421.

NOTE IEC PAS 63421 is being converted into IEC 63494-2-1.

5.3 Communication modules

A communication module is used to interact with other luminaires and to share data with a central management system (CMS). Currently, both wired communication technology and wireless communication technology already exist in the field. Integrated communication modules such as for power line communication, are normally built into luminaires at the factory.

Non-integrated communication modules with interfaces as listed in 5.2.2 can be used to upgrade outdoor lighting systems.

5.4 Central management system

5.4.1 General

The main functions of a central management system are given in 5.4.2 and 5.4.3.

5.4.2 Luminaire control

An individual outdoor luminaire or a group of luminaires can be controlled by a central management system. For instance, one of the motion sensors detects the movement of a vehicle or pedestrian on the road then the central management system can control the group of luminaires in a sequential way to increase the light level of the affected area. Or, using the information from multiple light sensors, the central management system can control several groups of luminaires individually with different light levels to provide recommended light levels.

A central management system can also control an individual or a group of luminaires remotely in accordance with the following:

- specific event;
- pre-arranged calendars;
- astronomical time control with geographical information;
- presence of pedestrians or vehicles;
- work on road;
- traffic accident;
- emergency transport.

5.4.3 Luminaire monitoring

In addition to such advanced control functions, a central management system can also exchange information on the status of individual luminaires to maintain the outdoor lighting system more effectively.

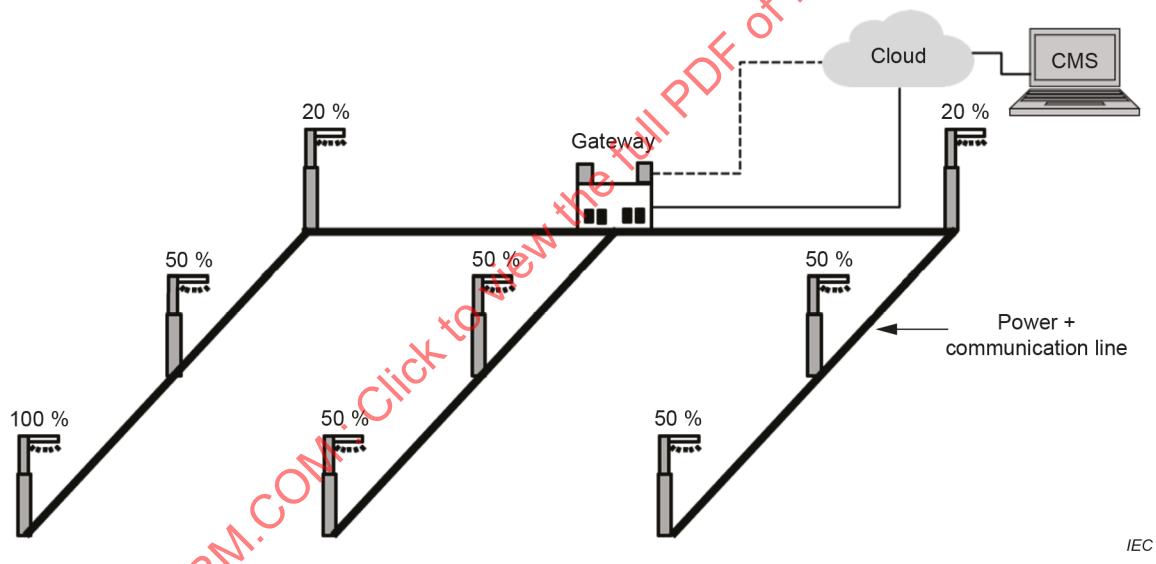
This information can include:

- failures;
- thermal status;
- energy consumption;
- relative light level;
- presence of pedestrians or vehicles;
- traffic flow;
- other environmental information;
- burning hours.

6 Communication protocols

6.1 Wired communication protocols

Wired communication protocols such as powerline communication share communication signals with the mains voltage power supply wires. By communicating via lines, luminaires can communicate with other luminaires or a central management system as shown in Figure 2.



Key

CMS central management system

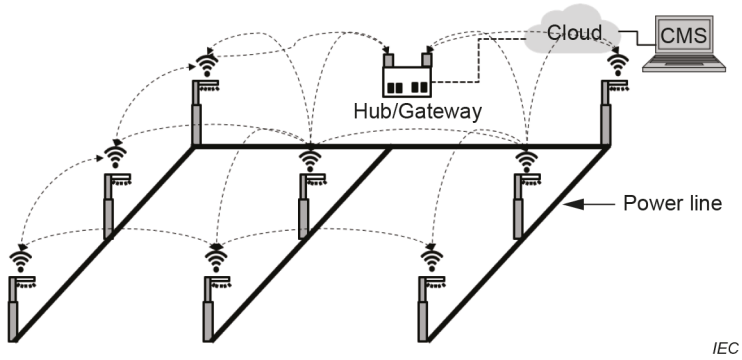
Figure 2 – Example (for illustration only) of outdoor lighting system based on wired communication protocol

6.2 Wireless communication protocols

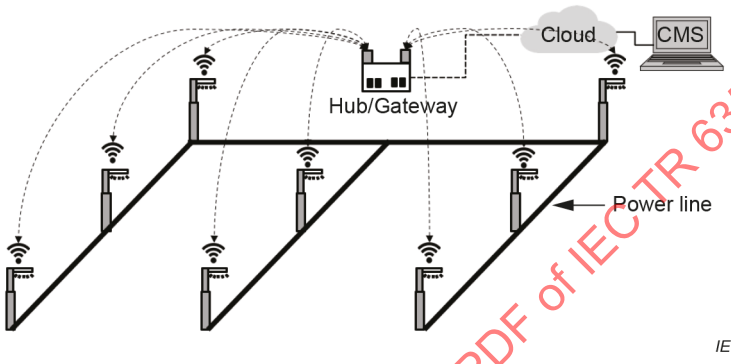
Wireless communication protocols have an advantage over the physical limitations of wired communication protocols. These wireless communication protocols can be categorized into three cases as shown in Figure 3.

- Short range mesh communication protocols: Short range mesh protocol based networks are well suited for areas with uniform coverage. They can be used in applications having relatively high data traffic. All nodes in the networks are connected to each other, thus a self-healing network can be achieved. Examples of such protocols are those of IEEE Std 802.15.4™ and Wi-SUN[2].
- Long range star communication protocols: Long range star protocol based networks are suitable for low density urban or rural areas. They can be used in applications having relatively low data traffic with relatively low power. An example of such a protocol is LoRa.
- Cellular communication protocols: Cellular communication protocol based networks can be used in large cities. Examples of such protocols are NB-IoT, LTE-M and 4G. Data traffic rate and power consumption are taken into consideration.

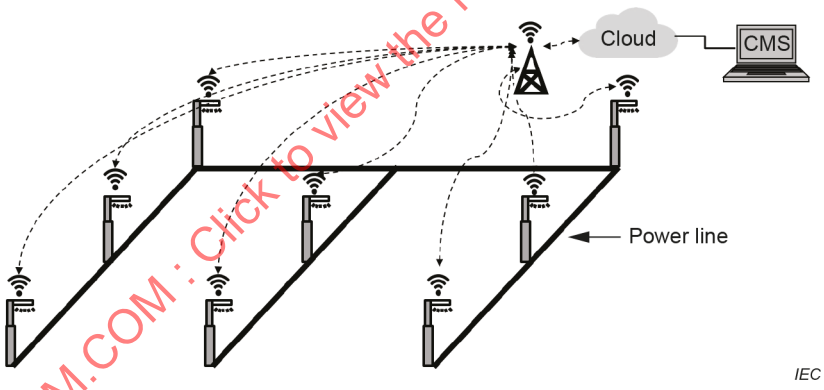
[2] Wi-SUN, LoRa, NB-IoT, LTE-M and 4G are examples of suitable communication protocols available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of these communication protocols.



a) Short range mesh communication protocols



b) Long range star communication protocols



c) Cellular communication protocols

Key

CMS central management system

Figure 3 – Examples of outdoor lighting system based wireless communication protocols

6.3 Hybrid communication protocols

Generally, in the city, there are many kinds of natural and constructed obstacles such as hills, walls, tunnels and buildings. In these cases, wireless communication protocols could be inefficient because these natural and constructed obstacles affect the transmission of radio waves in wireless communication, resulting in poor reception areas. In such cases wired communication protocols are preferred. Thus, a hybrid of wired and wireless communication protocols can be a solution that provides more flexible and robust networks.

In other cases, power line communication protocols are not practical, due to the losses caused by additional loads on the mains supply systems. In these cases, power line communication can be integrated with wireless communication protocols.

Additionally, star and mesh wireless protocols can be suitable hybrid configurations.

7 Characteristics of outdoor lighting systems

7.1 Lighting controls

There are various characteristics of outdoor lighting systems related to advanced lighting controls and combinations thereof, including but not limited to:

- Lighting control with an astronomical time control: An astronomical time control can be used to control luminaires to reduce unnecessary operation, which leads to energy savings, light pollution reduction and product lifetime extension. In this case, the luminaire can be controlled by time-based scheduling to turn on at sunset and turn off at sunrise. Programming the astronomical time control can be based on the geographical location and topology.
- Lighting control with light sensor: Lighting systems equipped with light sensors can be used to detect the amount of ambient light. When sufficient ambient light is available, the luminaire can be controlled to reduce unnecessary light. This can provide an adequate amount of light regardless of weather conditions.
- Lighting control with motion sensor: Motion sensors detect movement of objects within the field-of-view. If there are no moving objects such as vehicles or pedestrians in the observed space, the luminaire is controlled to a preset light level. When the sensor detects motion of a vehicle or pedestrian in the observed space, the luminaire is controlled to a preset light level. When the sensor detects a vehicle or pedestrian in the observed space, the luminaire is controlled to the necessary light level.
- Lighting control with variable traffic conditions: The amount of traffic on roads and streets can vary depending on the time and the situation. Using the information about the amount of traffic and the speed of the moving vehicles, an appropriate light level can be applied.
- Grouping of luminaires: Luminaires can be assigned to one or more groups for the lighting control methods above.

7.2 Luminaire monitoring

Data acquisition from luminaires enables various functions including:

- Energy consumption reporting: Information on energy consumption of a luminaire or a group of luminaires can be reported periodically to the central management system.
- Device monitoring: Monitoring the operation of luminaires provides performance information. This information can include the light output level of each luminaire, operating voltage, ambient temperature, and data from various sensors.
- Remote diagnostics: Remote diagnostics of a luminaire can be achieved via communication, for example communication issues, abnormal status of the luminaire such as switching status, errors and failures.
- Asset management: Access to luminaire specification and configuration information to facilitate efficient maintenance.

8 Examples of outdoor lighting systems

8.1 Outdoor lighting system for parking areas

Outdoor parking areas require sufficient lighting to ensure visibility for the driver to the parking spaces and for identification of moving objects. However, most of the time, when there is no user or vehicle movement, energy can be significantly saved by reducing unnecessary lighting as much as possible. An outdoor lighting system can illuminate the path leading to available parking areas like a navigator to minimize unnecessary movement and provide visibility when the driver enters the parking area, as shown in Figure 4.

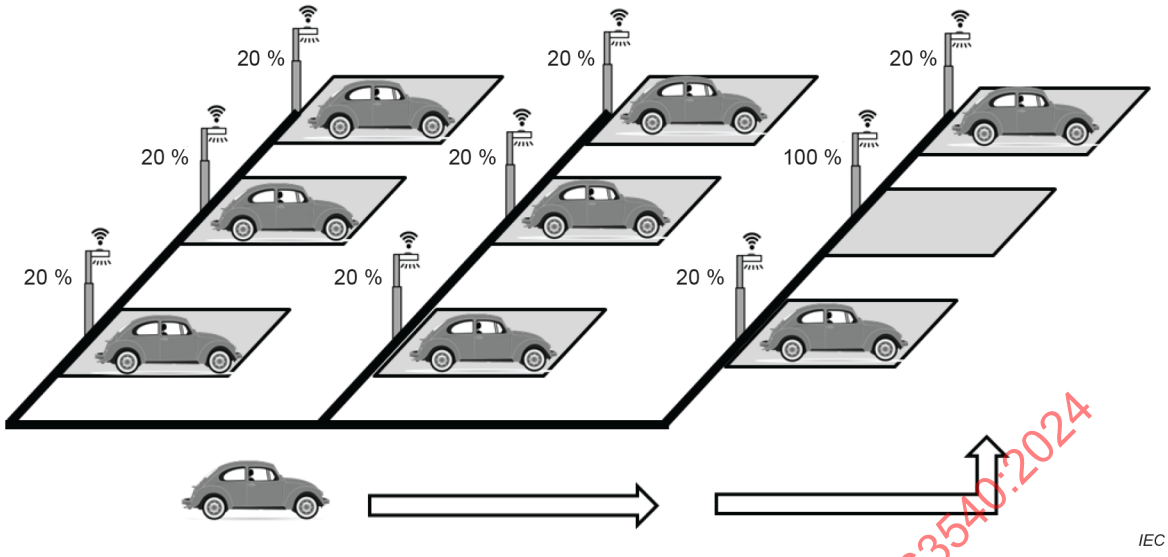


Figure 4 – Example (for illustration only) of outdoor lighting system for outdoor parking area

8.2 Outdoor lighting system for street lighting for vehicles

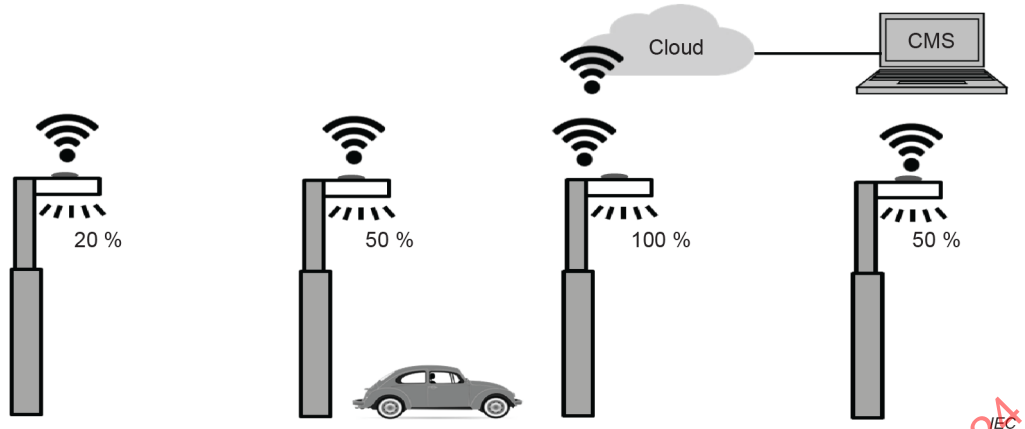
For the application of street lighting, appropriate lighting conditions ensure that safe and effective visual conditions are provided. However, late at night or on streets with less traffic, providing lighting at all times means unnecessary energy consumption.

In this case, it is possible to sense the movement of a vehicle and control the light levels of relevant luminaires according to the direction of travel to ensure adequate visual conditions for the driver and save energy. For instance, one of the motion sensors can detect the movement of a vehicle and then the central management system can control the group of luminaires to adapt the light levels, as shown in Figure 5 a). This process can also be handled locally by the luminaires and then reported to the CMS.

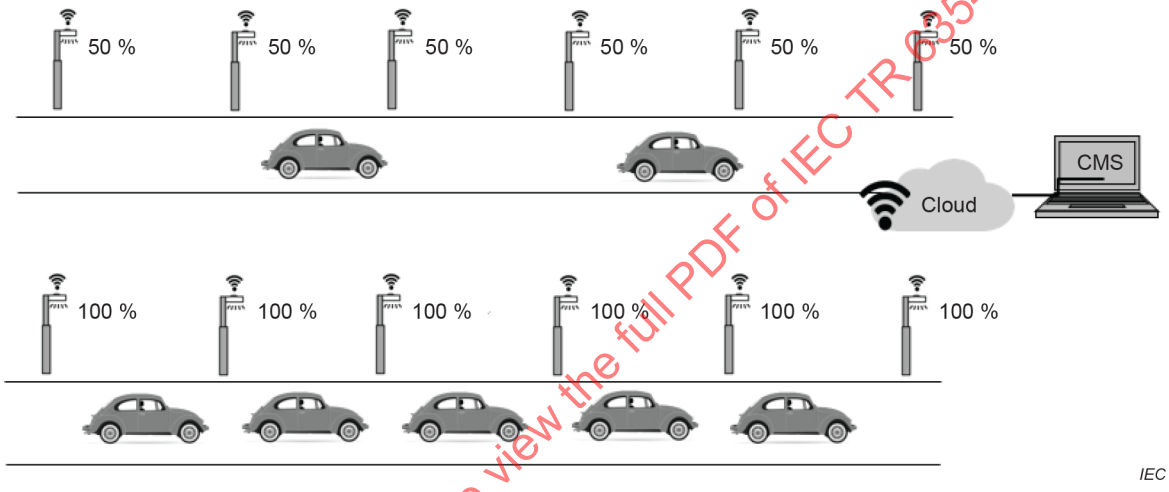
A central management system can also adjust the lighting level of luminaires depending on the volume of traffic, as shown in Figure 5 b). In the case of high road traffic, luminaires can be adjusted to provide adequate light levels. However, with low road traffic conditions, luminaires can be adjusted to provide lower light level compared to the high-volume traffic case. Appropriate light levels are specified in lighting design standards such as CIE 115 or other regional lighting standards, such as the EN 13201 series.

To operate these functions properly, the following conditions for the temporarily illuminated road section are taken into consideration:

- forward illumination to provide suitable visual conditions for safety;
- rearward illumination to provide suitable visual conditions for safety;
- dynamic adaptive lighting parameters to ensure visual comfort;
- system faults.



a) Outdoor lighting system for street lighting



b) Adaptive control of luminaires depending on the volume of traffic

Key

CMS central management system

Figure 5 – Examples (for illustration only) of outdoor lighting system for street lighting and adaptive control of luminaires depending on the volume of traffic

8.3 Outdoor lighting system for road lighting for pedestrian and cycle pathways

In the case of pedestrian and cycle pathways, the traffic volume can be significantly lower at certain periods. In such a case, an autonomous outdoor lighting system can be more appropriate for pedestrian and cycle pathways. This means that energy can be saved without a central management system being present. This is a simple solution, not requiring significant management. The purpose is to save energy by reducing light levels when pedestrian or cycle users are not present.

This is accomplished by sensing the presence of a pedestrian or cyclist at each luminaire and distributing the information via wireless (or wired) communication to neighbouring luminaires to increase and decrease light levels around the pedestrian or cyclist moving down the path. Each luminaire will communicate with its neighbours so that when a person approaches one luminaire, it will react by increasing light levels, not only this luminaire but also for the neighbouring luminaires, creating an illumination wave that follows the progress of pedestrians or cyclists along the pathway, as shown in Figure 6.