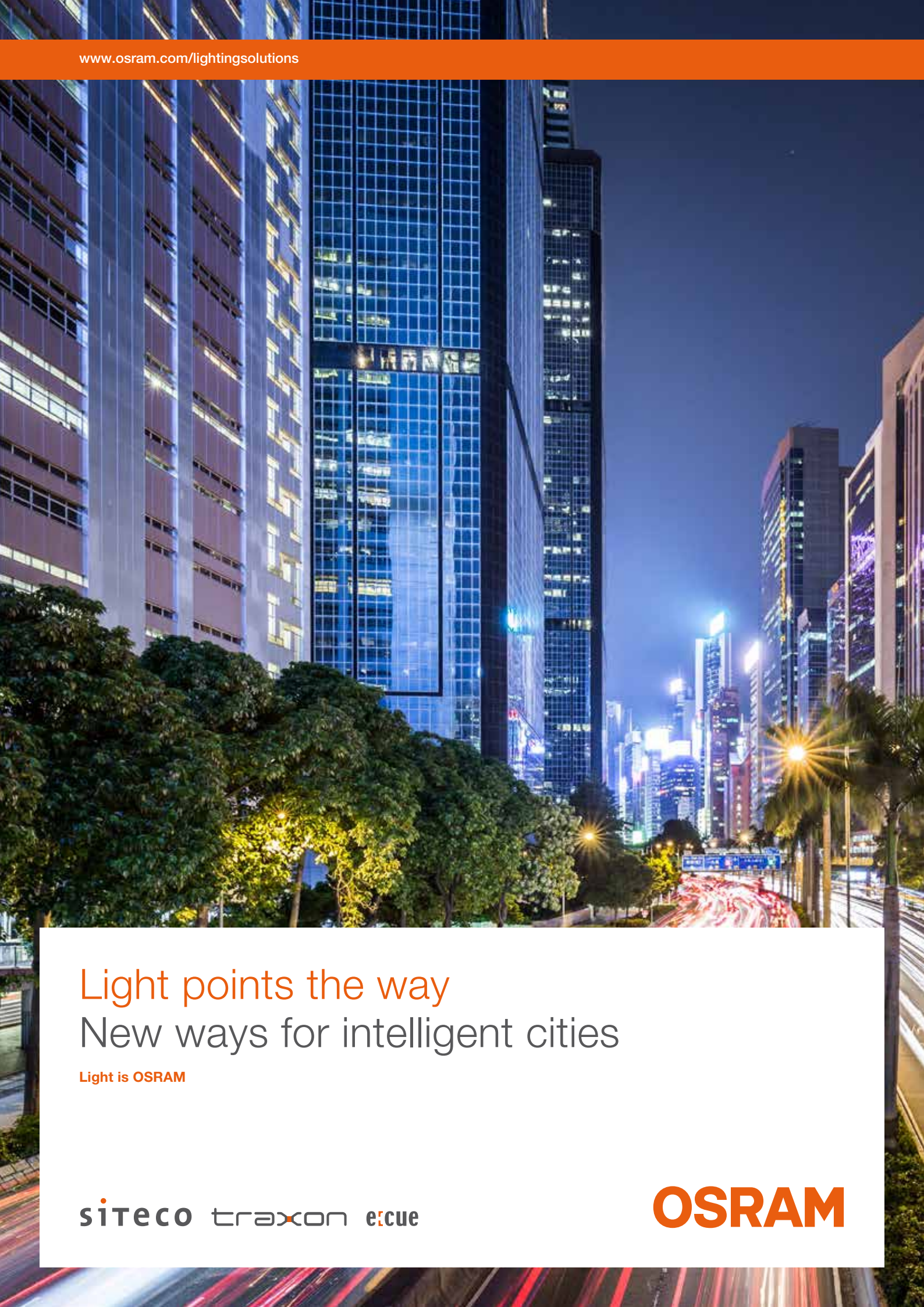


Light points the way
New ways for intelligent cities

Light is OSRAM

siteco traxon e:cue

OSRAM

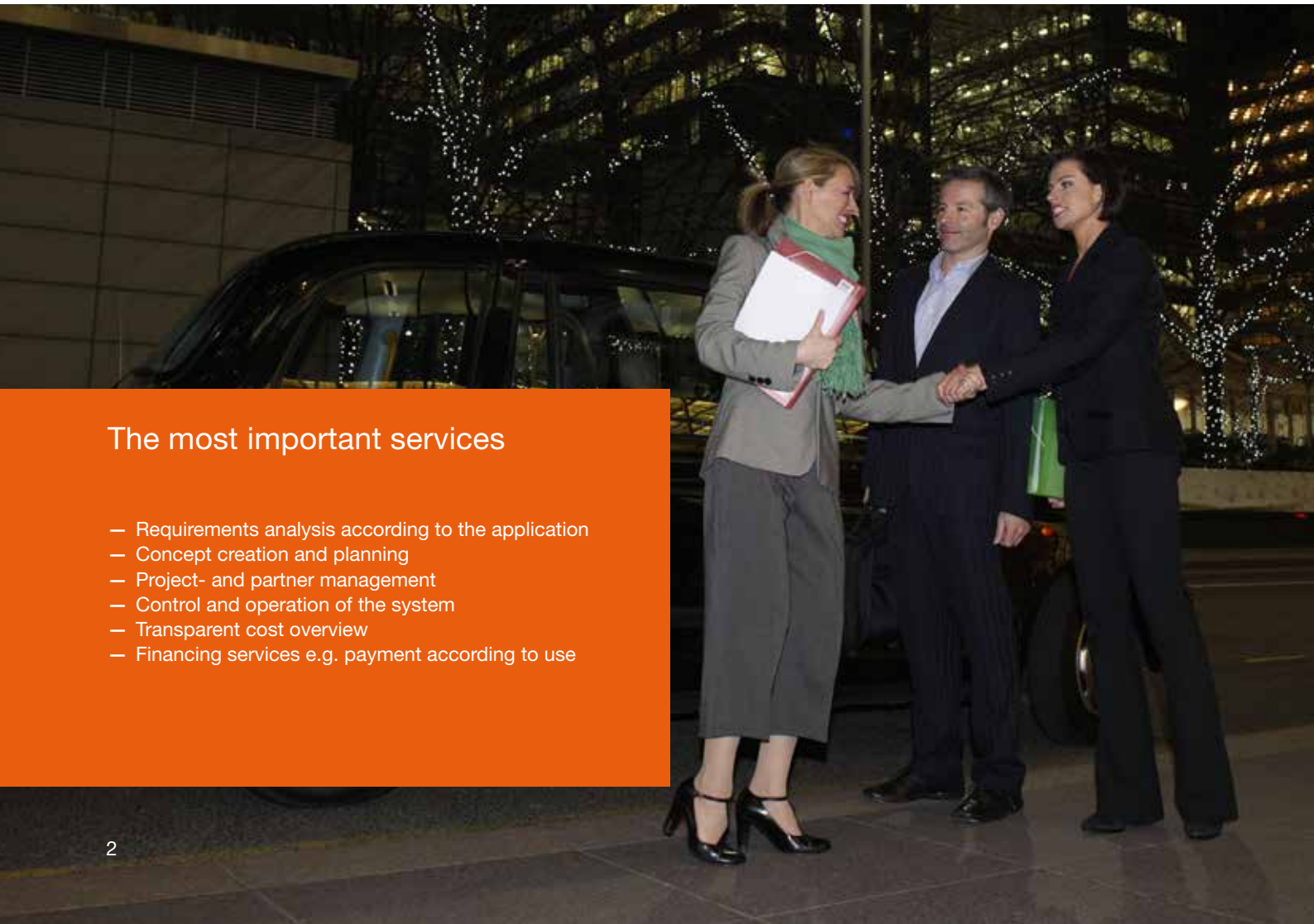
The smart city solution from OSRAM and Tvilight

"In intelligent towns and cities, digital technologies are translated into better public services for citizens, improved utilisation of resources and less impact on the environment."
(European Commission, Smart City, 2015)

The smart city concept demands a uniform IT infrastructure that can be intelligently connected to existing systems and enhanced with supplementary functions.

As a result, transport and energy consumption can be effectively planned and sustainable economic growth realised.

OSRAM with Tvilight technology uses the existing infrastructure of software and hardware and supplements this with a wireless, open platform for smart city applications. The open protocols and interfaces allow the integration of third-party hardware and software, enabling many smart city options for traffic management, environment monitoring, asset management and more.



The most important services

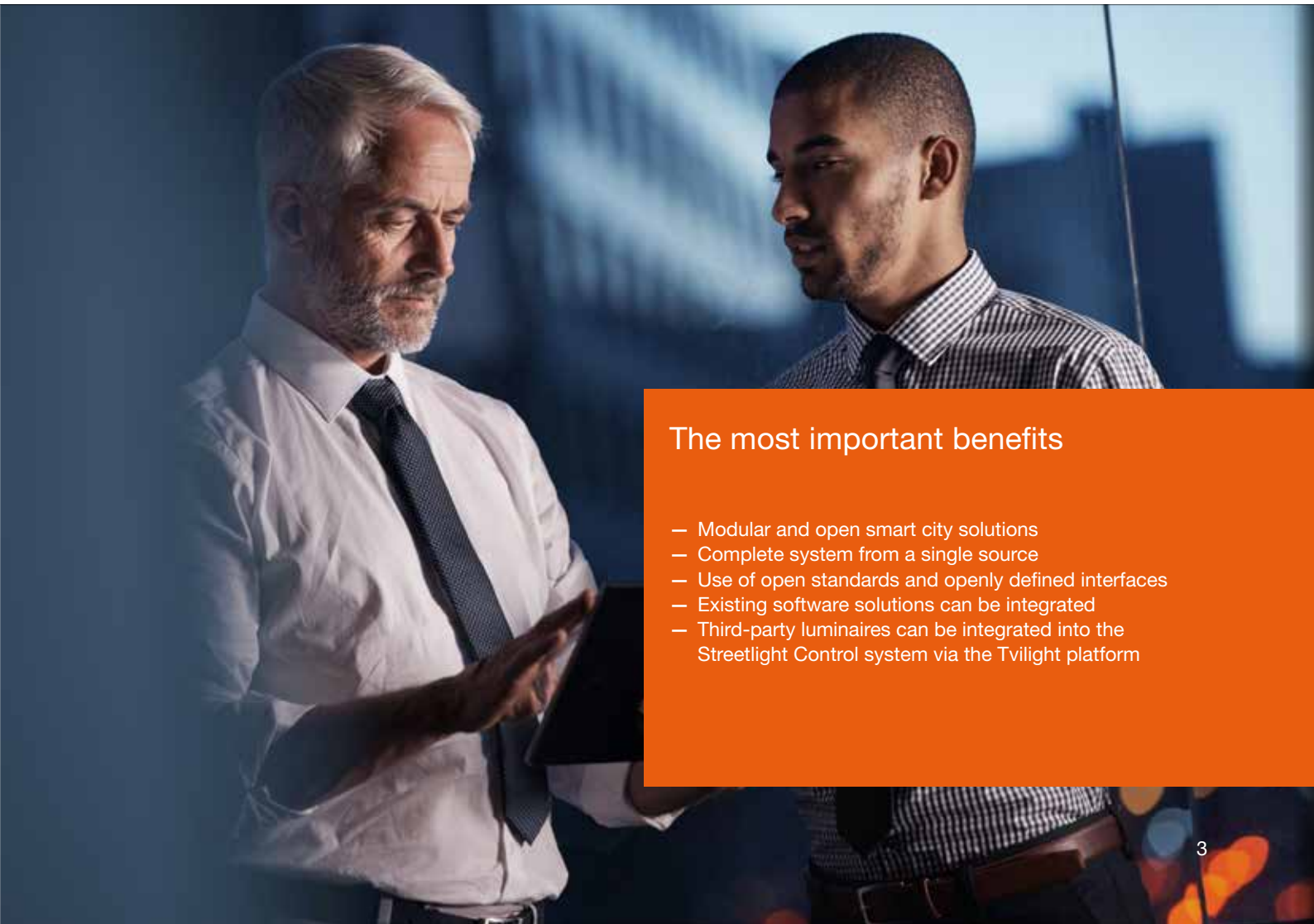
- Requirements analysis according to the application
- Concept creation and planning
- Project- and partner management
- Control and operation of the system
- Transparent cost overview
- Financing services e.g. payment according to use

Tvilight and OSRAM – light becomes even more intelligent

With its involvement with the Dutch software specialist Tvilight, OSRAM Lighting Solutions opens up new perspectives in the smart city sector. This dual service establishes the basis for networked infrastructures in towns and cities that in addition to classic light can also be utilised as networks for digital services.

Intelligent, networked lighting is one of the key topics for OSRAM Lighting Solutions. With outdoor lighting for the public sector we have adopted a leading role with our Siteco, Traxon and e:cue brands. Integrating the Tvilight portfolio enables us to expand our expertise beyond classic lighting solutions in urban environments.
The independent platform enables the creation of a scalable infrastructure. The solution offered by OSRAM Lighting Solutions and Tvilight is highly efficient and maintenance-optimised. Open interfaces allow the flexible integration of a variety of products and services.

Tvilight has an installed base of more than 250 global projects with thousands of intelligent light points in iconic cities including Amsterdam, Seoul, Istanbul, Cologne and Berlin as well as infrastructure hubs such as airports, harbours and railway stations.



The most important benefits

- Modular and open smart city solutions
- Complete system from a single source
- Use of open standards and openly defined interfaces
- Existing software solutions can be integrated
- Third-party luminaires can be integrated into the Streetlight Control system via the Tvilight platform

Individual services for intelligent cities

OSRAM Lighting Solutions offers various services for intelligent towns and cities. These range from the remote management of streetlighting to complete operation of the lighting infrastructure. The client pays instalments for "light as a service" – depending on the performance of the system.

Precise energy calculations

CityManager can generate precise energy consumption- and savings data based on saved luminaire data.

Automatic failure reports:

Automatic reports provide responsible managers with clean documentation for their contracting entities without the need for personnel-intensive testing of luminaires. This enables technicians to concentrate on important tasks.

Concise and informative:

You gain extensive insights into the lighting network. Smart Analytics and concise graphics help you to make important decisions about your lighting infrastructure.

Map-based visualisations:

Outdoor lighting is depicted on Google Maps via a graphic interface and positioned via GPS, enabling the simple localisation, monitoring and control of single luminaires.

Precise real-time data:

Data and analyses are generated for single or several luminaires. Data is available regarding luminaire type, driver, luminaire settings and operating times compliant to the various dimming levels.

Site-related options: *

Illuminance levels can be set according to context to reflect local conditions such as peak and off-peak times, sunrise and sunset, weather changes, special events and emergency situations.

* functions currently in development

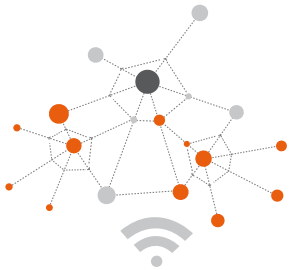
Continuous support:

Regular free updates and the possibility to integrate further functions (may be chargeable) achieve safety, optimum functionality and system efficiency.

A SIM card (1GB), WiFi or Ethernet can be used for connection to the smart city system.

Completely wireless communication:

We have developed a robust, wireless communication solution ideally suited to surroundings with high demands. The wireless, self-configuring and self-healing networks based on 2.4 GHz utilise a broadband communication signal optimal for outdoor applications and tunnel-like surroundings.



Wireless sensor network

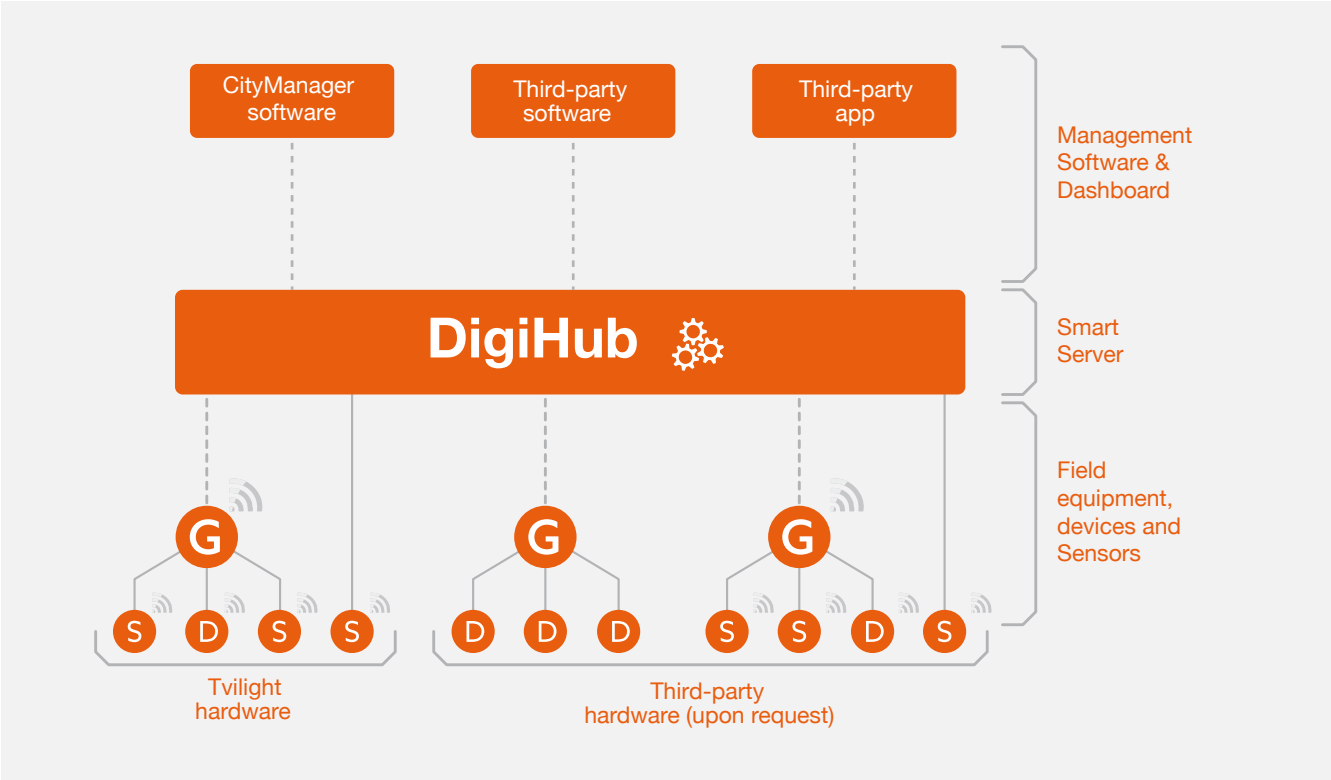
Overview of the Tvilight wireless sensor network

Independent technology

Compatibility with third-party suppliers (software and hardware)

Where possible we use manufacturer-independent standards or enable the integration of third-party systems via open interfaces (APIs).

Diagram: DigiHub open architecture for third-party provider compatibility



The main advantages of this open system based on the Tvilight platform:

- Guarantee of a standard level regarding performance and functionality between providers.
- Avoidance of provider dependency and guaranteed future capability of the system.
- Possibility of integrating existing software solutions e.g. asset management software into a holistic software solution for managing and controlling the lighting installation.

Universal luminaire compatibility
The control system can be combined with all dimmable luminaires. Complete functionality is enabled by the bidirectional DALI communication, whereby all luminaire status messages can be queried and displayed in the management software used.

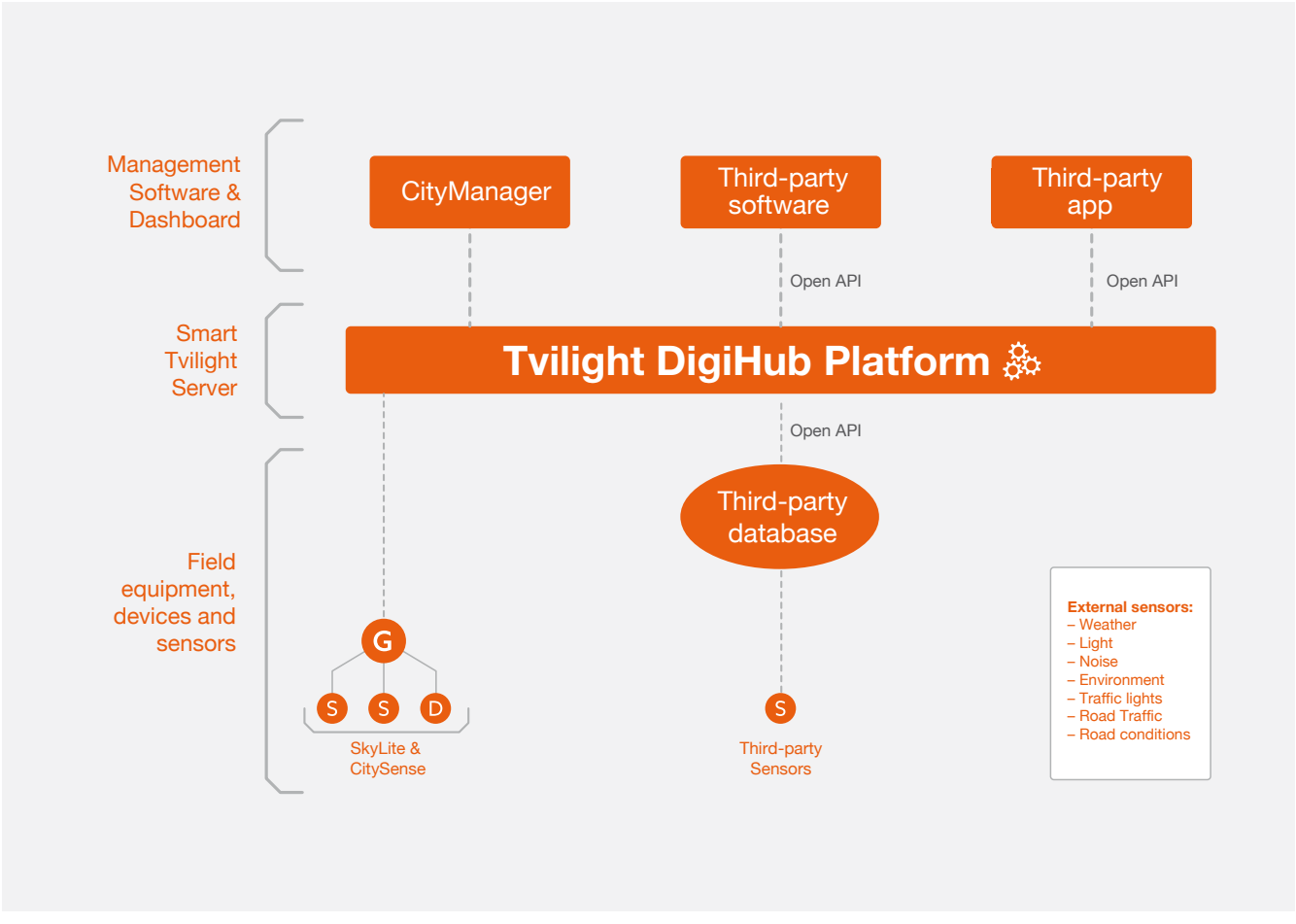
The external controller/sensor enables all dimmable luminaires to also be retroactively integrated into the control system for upgrading with additional functions.

Integration of supplementary hardware and software (from third-party suppliers)

Tvilight's smart city platform allows the integration of additional software and hardware thanks to system architecture optimised for the specific requirements. Software can be simply integrated via application programming interfaces (APIs) and hardware integrated via GPIO interfaces (general purpose input/output) or I2C interfaces (standard bus interface). GPIO interfaces are mainly used for on/off switches and/or relays. I2C interfaces are used for data exchange between components, e.g. with sensors for measuring environmental loads, noise levels etc.

The special feature of the system architecture is based on Tvilight's DigiHub, a platform enabling simple, uniform communication between the integrated software and hardware. This enables lighting control units and other hardware to be simply connected to other software applications without major programming complexity.

Diagram: SKYLITE controllers provide an open platform for integrating various external sensors



Public safety and technical safety

Safety is a universal concept that we take very seriously. Our intelligent lighting solutions enable improved public safety and security at night that benefits residents. Technical and communication security is vitally important, and this is reflected in our focus on cyber security and the protection of user data.

Light according to needs

The uncontrolled deactivation of public lighting during the night is a danger to public safety and possibly infringes public lighting regulations and directives. Instead of this, our intelligent light network dims the lighting with sensors during times of low traffic if nobody is nearby. As soon as human activity is detected (pedestrians, cyclists or vehicles), all defined luminaires in the vicinity light up to a specific level preset by the user.

Disruption factors such as animals, leaves or wind are filtered out to avoid erroneous triggering stimuli and therefore unnecessary energy consumption. In the future luminous intensity will automatically adapt to weather conditions such as rain or snow, thereby not adversely impacting the safety of residents and traffic participants. The principle of 'intelligent light according to needs' therefore reduces the energy costs of the lighting infrastructure in a safe and convenient way.

In this way, energy- and maintenance-efficient operational management is united with optimum lighting quality and safety.

Safe roads and towns

The presence-based, adaptive lighting concept can also be used for security applications. A sudden increase in lighting intensity in remote areas can contribute to identifying e.g. (unauthorised) activity. This not only supports night-time security personnel but increases the feeling of safety and security with pedestrians and road users, as these are promptly informed about third party presence. Furthermore, installed security cameras can record more efficiently due to higher lighting intensity, thus further improving safety.

Secure data connections

Our vision is to transform security into a truly broad concept. This applies not only to digital internet security but also to the handling of user information – because we take data protection very seriously. Our data connections are therefore secured according to state-of-the-art standards. A three-level backup system also prevents unintended deactivation of the luminaires in the improbable situation of system failure.

Secure Data Connection

Light control level	Luminaires can intercommunicate rapidly, securely and wirelessly by using a highly stable 2.4 GHZ mesh network. In the improbable case of a fault or the failure of a luminaire controller, the affected luminaire automatically switches to 100% illuminance. Other luminaires are not influenced.
Gateway level	The gateway is connected to the server via Secure Websockets (wss protocol RFC 6455). To guarantee integrity, we also use a variant of the OAuth 2.0 protocol in addition to SSL. This prevents gateways from being hacked by third parties even if the connection is not encrypted. In the improbable case of a fault/failure of a gateway, all luminaires automatically switch to 100% illuminance.
Server and software level	The CityManager utilises REST API. OAuth 2.0 is used for communication between the API and the CityManager. HTTPS ensures a reliable connection. In the improbable case of a fault/failure of the server or with a missing connection, gateways and luminaire controllers continue to operate with the predefined dimming profile. Only access to the system is temporarily not possible (via remote control).

The Tvilight servers are located in the TCN data hotels in the Netherlands. Since 2001, 99.9999% availability has been achieved and therefore TCN is a familiar entity in the data centre market. TCN designs, constructs and markets 100% data-neutral, reliable centres serving as an optimum basis for secure data storage. Critical components including connections to the power grid have at least N+1 redundancy.

The TCN data hotel is also self-regulating: if mains power fails the complete energy supply can be made available via UPS and emergency systems. Security is given maximum priority and the server centres are protected against external attack. Physical security is guaranteed 24/7/365 days in the year and is supported via various control systems.

The table below provides an overview of the Tvilight security infrastructure:

Level	Element	Measures for maximum safety
Physical environment	Access limitation	— High security data centre — Multi-server environment with automatic roll-over protection
Connection layer	API Third-party supply integration	— Account and access control — Connected devices and applications require pre-authorisation
Software	with point-to-point encryption	— AES 256 encryption and VPN — Resistant to man-in-the-middle attacks
Hardware	Devices/nodes	— 3-level back-up system — Overvoltage protection
	Connection between devices/nodes	— AES 128 encryption — Multi-device fail-safe mesh network — Disruption signal-resistant

Financial benefits

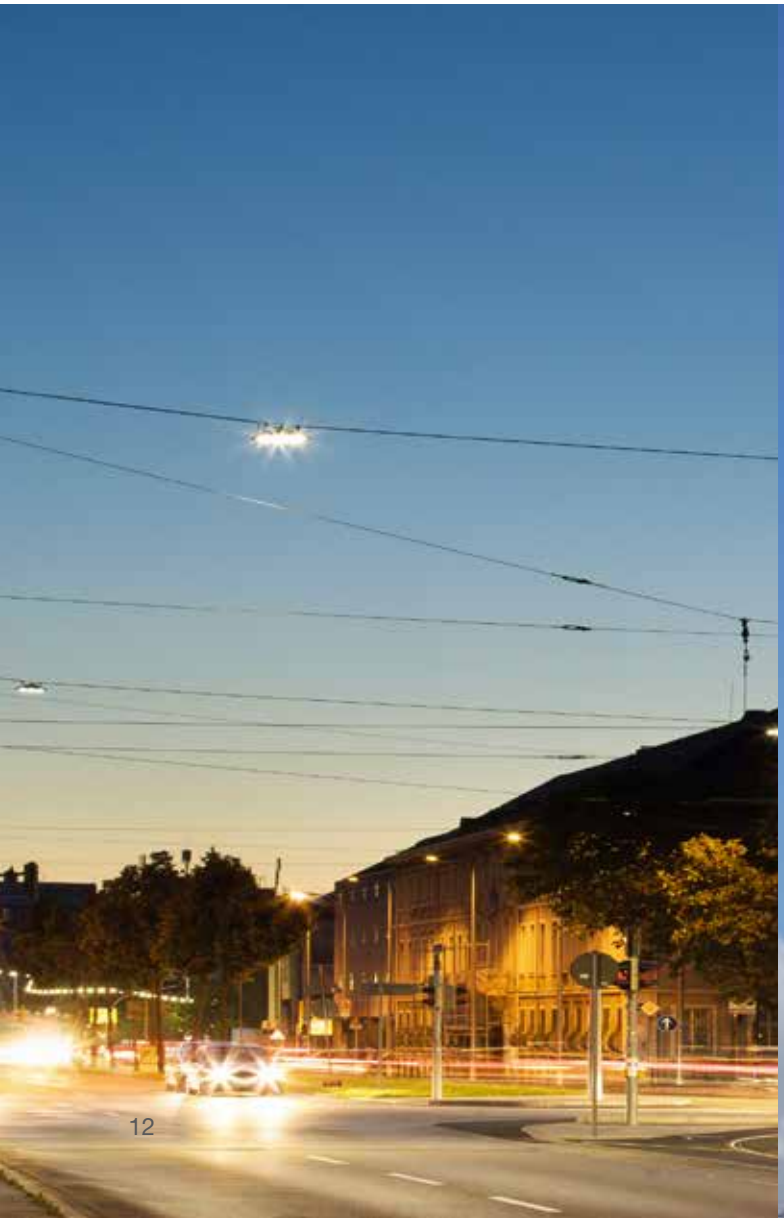
The financial advantages can be subdivided into two main areas:

40-90% energy cost savings:

- Intelligent light control and LED luminaires allow energy consumption to be cut by up to 90%
- The control enables a balance between energy savings and good, safe quality of light

20-50% savings with maintenance- and operating costs:

- The automatic reporting of faults saves time and effort in case of malfunctions
- Intelligent evaluations enable efficient, coordinated maintenance
- Continuous recording of the system state enables cost-efficient documentation and the useful unburdening of technical resources
- Payment according to use
- Customer-designed solution according to needs – light as a service



Rapid installation

Plug & play installation
Installation and upkeep of wireless communication of the systems is simple because electricity providers must not be involved. This eliminates several regulatory and legislative limitations because no extraneous signals must be transmitted over the power grid.

Our plug & play turnkey solutions enable rapid implementation without extensive construction/conversion work, special equipment, modifications to ground cabling or specialist personnel.

GPS data from existing GIS systems can be used for the rapid, precise logging of each light mast. This is carried out either once by the importing of coordinates or by setting up a uni/bidirectional data flow (information exchange with the OLCs via an API).

This makes the manual input of data superfluous – particularly beneficial for large-scale systems. Commissioning work on location can be carried out by the installer. Simple registering of hardware via the Scan&Go app (iOS / Android).

Various installation options:
Tvilight places high importance on flexibility and simplicity. For this reason we offer various installation options for our products:

Product	IP rating	Mounting
Luminaire controller SkyLite (OLC[1])	IP65 (outdoor use)	– Externally on the mast (various heights)
Motion sensor CitySense (OLC + integrated sensor)	IP 65	– Externally on the mast (various heights)
Gateway (communication module)	IP 65	– Externally on the mast (wall mounting)

See the product overview for further technical specifications
[1]OLC = Outdoor Lighting Control

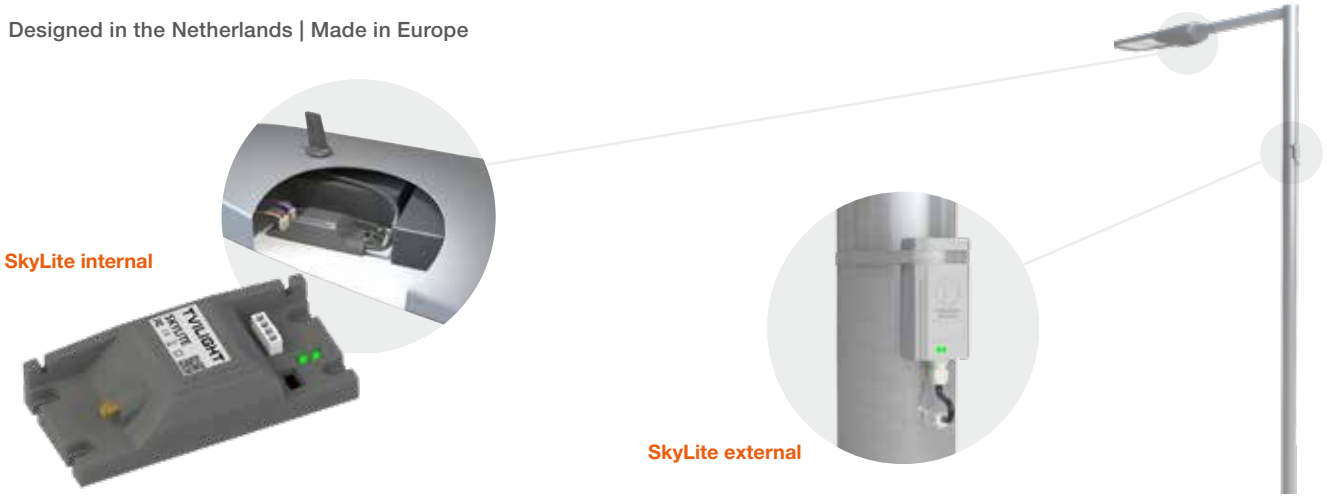
SkyLite V3

SkyLite is a wireless RF controller for monitoring and controlling the outdoor lighting. SkyLite enables an intelligent, energy-efficient and secure environment to be created as the ideal basis for a smart city. SkyLite supports wireless communication with other Tvilight products such as Tvilight CitySense and Tvilight Gateway, and can be conveniently managed using the Tvilight CityManager software from any location.

Freely configurable dimming profiles and lighting plans allow users to reduce energy consumption in a safe and convenient way. The device generates feedback required for status displays in the software tools, e.g. with a light source or ECG failure. This reduces the necessity for costly visual checks and allows reductions in operating and maintenance costs.

SkyLite controllers serve as the perfect platform for various smart city devices and applications (from Tvilight or third-party providers) enabling e.g. environmental monitoring, traffic monitoring or asset management.

Designed in the Netherlands | Made in Europe



Characteristics

Wireless outdoor lighting control

Remote management / control via CityManager or third-party software

Innovative dimming and adaptive lighting plans

Energy monitoring

Universal lamp compatibility

Open interfaces for third-party provider compatibility

Automatic fault- and status reports via CityManager or third-party software

Integrated astronomical clock with reserve battery

Plug & play installation

Fail-safe:
3-level backup system

Technical specifications

Product	Embedded wireless communication, light controls Model B: power and control cable with length 5.5m for simple installation
Input voltage	230 VAC 50/60 Hz
Energy consumption	<2 W
DALI devices	Max. 2
Dim interface	1-10 V or DALI (insulated for safety)
Overvoltage protection	110 joules (6 kA), 3 kV combination waves
Controller	ARM Cortex-M3 CPU
Electrical protection	Class II (overload- and short-circuit protection)
Electrical safety	Electrical isolation between high voltage and low voltage connections
Operating conditions	-20° C to +70° C, 20% to 90% relative humidity, Rh non-condensating
Product installation	Model A: in the luminaire, model B: on the mast
Housing	IP20 (model A), IP65 (model B)
Antenna	Model A: external antenna, model B: internal antenna
Dimensions	120mm x 55mm x 29mm (model A), 160mm x 110mm x 60mm (model B)
Product compatibility	Direct wireless communication with SkyLite, CitySense and Gateway. Communication with CityManager via Gateway
Wireless communication	2.4 GHz IEEE 802.15.4 self-healing wireless network +10 dBm max. transmitting power, -98 dBm max. range to 1 km in optimum conditions Up to 250 kbps RF data rate 32 bit microcontroller, 64 kB Flash and 16 kB RAM
Network security	128 AES | multi-layer security with end-to-end
Over-the-air update	Encryption configurations, software and complete firmware can be updated remotely to guarantee latest state of network infrastructure
Controller to gateway ratio	200:1
Management software	Via the CityManager (or via third-party lighting management software on request) enabling remote management, monitoring, control, configuration and reporting of luminaires individually or in groups
Safety mode	Auto-safe - luminaires dim down to predefined illuminance in case of faults
Certification	RoHS, CE, EN301489-1/3, EN61547, EN55015, EN300328, EN60950, EN50121-5 RF transceiver compatible with European, American and Canadian (IC) standards
Manufacture	ISO 9001:2008, manufactured in Europe
Astro clock	Real-time astrological clock with reserve battery Advanced calendar- and location-based planning (including automatic sunrise/sunset and summer/winter clock). Lamp can be switched on/off at sunrise/sunset, whereby the conventional photocell is no longer required.

Note: luminaires with integrated SkyLite controller on request

CitySense Plus

CitySense is a revolutionary, wireless and sensor-based light control enabling light according to needs with the presence-based monitoring and control of outdoor lighting applications. The product is compatible with both existing and new luminaires (e.g. LED).

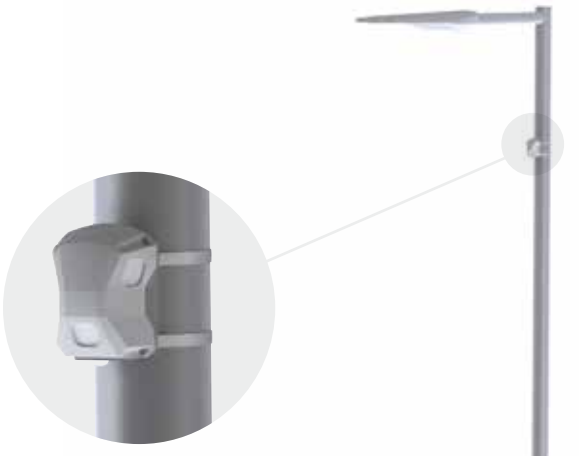
CitySense offers lighting according to requirements with luminous intensity being modified to the presence of pedestrians, cyclists and vehicles. The luminaires are dimmed outside of peak traffic periods when nobody is in the vicinity. Upon presence detection the luminaires switch from dimming level 1 (rest state) up to a second pre-set dimming value. In this way energy consumption is reduced safely and conveniently.

With the CityManager software, luminaires can be individually controlled, managed and remotely monitored.

CityManager records e.g. real-time data for energy consumption, maintenance needs and local utilisation loads. CityManager also enables insightful analyses of the various data. This reduces the requirement for expensive manual inspection, in turn reducing operating and maintenance costs.

Designed in the Netherlands | Made in Europe

CitySense



Characteristics

Revolutionary outdoor sensor with embedded wireless lighting control

Innovative presence detection technology for light according to needs

Heat maps for display of the various dimming levels

An integrated solution: plug & play installation

Universal lamp compatibility

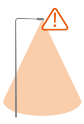
Energy monitoring

Integrated astronomical clock with reserve battery

Complete remote management and control via CityManager or third-party software

Open interfaces for third-party software

Fail-safe: 3-level backup system



Technical specifications

Product	Motion sensors, wireless communication and lighting control are integrated in the product, enabling simple plug & play installation
Motion detection	Detection of pedestrians, cycles and vehicles (range: 4-120 km/h) Recommended mounting height: 5 m above ground Detects up to 15m on each side, 9m in front of and 3m behind the mast Detection angle: >270° (acc. to mast circumference) Triggers 1-10 adjacent luminaires on detection (can be configured by the user)
Input voltage	230 VAC 50/60 Hz
Energy consumption	<3W
DALI devices	Max. of 2
Dim interface	1-10V or DALI (insulated for safety)
Overvoltage protection	110 joules (6 kA), 2 kV combination waves
Controller	ARM Cortex-M3 CPU
Electrical protection	Class II (overload- and short-circuit protection)
Electrical safety	Electrical isolation between high voltage and low voltage connections
Operating condition	-20° C to +70° C, 20% to 90% relative humidity, Rh non-condensating
Product mounting	to mast
Housing	IP65, weather-resistant, fire-resistant
Antenna	Internal
Dimensions	100mm x 125mm x 95mm
Product compatibility	Mounting plate adjustable through +/- 10° to compensate for mast inclinations; automatic wireless communication; compatibility with SkyLite, Gateway and CityManager via Gateway
Wireless communication	2.4 GHz IEEE 802.15.4 self-healing wireless network +10 dBm max. transmitting power, -98 dBm max. receiver sensitivity under optimum conditions Up to 250 kbps RF data rate 32 bit microcontroller, 64 kB Flash and 16 kB RAM
Network security	128 AES | multi-layer security with end-to-end encryption
Over-the-air update	Configurations, software and complete firmware can be remotely updated; guarantees network infrastructure
Server communication	Via Gateway
Controller to gateway ratio	200:1
Remote monitoring	Via the CityManager (or via third-party lighting management software on request) enabling remote management, monitoring, control, configuration and reporting of luminaires
Safety mode	Luminaires dim down to predefined illuminance in case of faults
Certification	RoHS, CE, EN301489-1/3, EN61547, EN55015, EN300328, EN60950, EN50121-5 RF transceiver compatible with European, American and Canadian (IC) standardss
Manufacture	ISO 9001:2008, produced in Europe
Lamp switching capacity	1400 VA (relay), 16A max. voltage
Astro clock	Real-time astrological clock supported by power battery Luminaires can be switched on and off at sunset and sunrise, whereby a conventional photocell is no longer required

Gateway

Internet communication

Server communication	2G GSM/GPRS/EDGE Quadband, 3G six band UMTS/HSPA Supplementary connections: Ethernet 3G six band UMTS / HSPA
Network security	128 AES, WebSocket (with SSL) and VPN Multi-layer security with end-to-end encryption Dual security for connection between light control and gateway Certified, secure WebSocket- and VPN connection
Functions	Real-time monitoring of control and network faults Several internet connection options (Ethernet/WiFi) and automatic connection selection Automatic recovery of mobile connection SNTP time synchronisation between the gateway and DigiHub server Regular recording of system operation (selectable time intervals) Real-time connection between gateway and controls Complete remote fault elimination of the gateway and controls Over-the-air update for gateway and controls (software & firmware) Can be configured in fault-tolerant mode for higher network availability Large local data storage for avoidance of data loss if connection fails
Over-the-air update	Configurations, software and complete firmware always up-to-date thanks to remote updates
Remote control	CityManager (or via third-party software) enables remote management, -monitoring, and -reporting at individual and group level

Wireless network

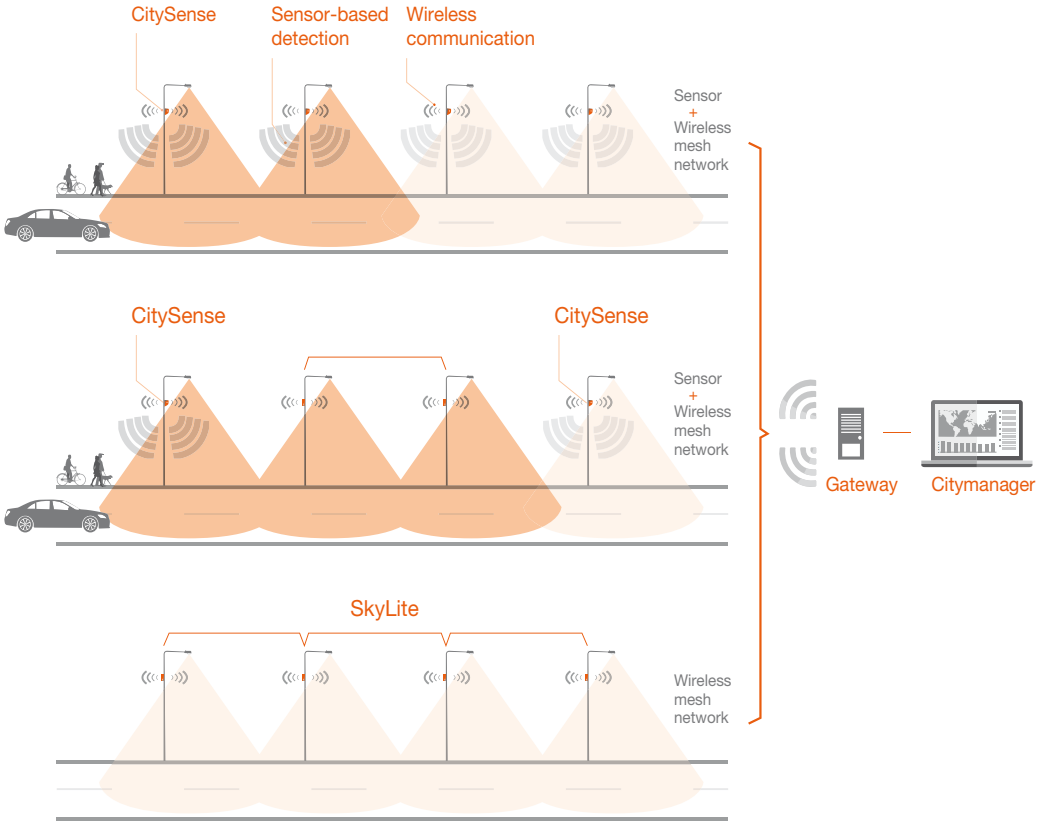
Wireless network	2.4 GHz IEEE 802.15.4 self-healing wireless network +10 dBm max. transmitting power, range up to 1 km (in open field), up to 250 kbps RF data rate
Controller to gateway ratio	200:1
Product compatibility	Plug & play compatibility with SkyLite, CitySense and CityManager

Intelligent lighting: system architecture

Smart city network
Based on CitySense

Standard
SkyLite & CitySense

Smart city plattform
SkyLite



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