# OS-NET, an Optimized Wireless Lighting Control Solution

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## *Abstract*

Bringing controls to the lighting environment of commercial (non-residential) buildings typically meant extra set of control wire networking, labor intensive installation and wiring connections among system devices, luminaires and central controls, device configurations and system commissioning through proprietary management software. All above are major barriers that restrain broad implementation of lighting control in most commercial buildings, thus wireless lighting control might be the only viable solution. To achieve so-called smart lighting control by wireless technology, regardless of communication protocol applied, establishing a wireless mesh network capable of connecting all sensors and controllers that are broadly deployed within the lighting environment is essential. This is still a challenging task even with current wireless control solutions available in the market. Lighting designers would have to know how to select appropriate luminaires and right devices to achieve the desired controls. Contractors may still require installing a great number of different network devices and exclusive luminaires, together with complicated commissioning through exclusive management software to get the wireless networks up and running. Although the fast emerging LED lighting technology has encouraged retrofitting the legacy lighting with LED technology by promising incentives of energy savings, the lighting industry still requires an optimized wireless lighting control solution that can help deliver lighting products with easy-to-configure smart controls embedded, and more importantly, can be installed in the same way as conventional lighting, without requiring extra equipment or new skill. In this paper, we will highlight the concept and products of an optimized wireless lighting control solution.

# 1. Introduction

For many decades, bringing lighting controls to non-residential buildings typically meant extra sets of control wire networking to every luminaire, labor intensive installation and wiring connection among complex system devices, luminaires and central controls, complicated configuration and system commissioning through proprietary management software. All above result in more time up and down the ladder, separate wiring diagrams, high levels of complexity, and higher project and maintenance costs. These adverse factors are widely known as the major barriers that restrain the implementation of lighting control system. With the availability of advanced wireless mesh network communication protocols, such as Zigbee, Bluetooth Low Energy (BLE), and WiFi, wireless lighting control is therefore considered as the best approach to bring smart lighting controls to commercial buildings, especially for the existing buildings.

While most lighting is built to serve human's needs in comfort, safety and health, smart lighting control is the way to wisely consume precious energy resources without compromising these needs. To achieve a genuine smart lighting control, all luminaires and lighting circuits should be properly controlled according to the occupant's needs, code requirements, local occupancy status and ambient light level. This would rely on a wireless mesh network effectively linking the sensors broadly deployed within the lighting environment that are capable of sensing local occupancy status and ambient light level and controlling the luminaires and lighting circuits accordingly.

Enabling wireless lighting control in commercial building is actually a matter about how to cost effectively deploy a wireless mesh network. Every lighting professional knows that it is a task easier said than done. Even with current wireless control technologies, installers may still require installing a great number of complex network devices and luminaires, followed with complicated commissioning through exclusive management software to get the system networks up and running. These are considered as barriers of limiting the popularity of wireless lighting control. So the real challenge comes from finding a cost effective wireless control solution that can help deploy the required wireless mesh network with ease.

With better lighting quality, deeply lower energy costs and a much longer service life brought by emerging LED lighting technology, McKinsey expects the value-based U.S. market share for LED lighting to reach 70% by 2020[1] as the lighting market moves rapidly toward 100% LED adoption. These incentives effectively encourage more retrofitting the legacy lighting of existing buildings with energy efficient LED lighting whenever a major renovation is taking place. This is undoubtedly the best opportunity to implement wireless lighting control.

Regardless of new buildings or renovation projects, luminaire installation is always a must-do job. It will be the most cost effective way to deploy a wireless mesh network together with luminaire installation. This would require lighting manufacturers to supply more wireless solution enabled luminaires for lighting designers/specifiers to select the applicable luminaires according to the photometric characteristics, and the installers just install the luminaires accordingly.

Therefore, an optimized wireless lighting control solution should be available for the lighting industry to deliver an energy efficient LED lighting system featuring sophisticated sensing and controls via wireless mesh network which can be simultaneously deployed while installing the luminaires and lighting circuits.

## 2. Challenges of Implementing Wireless Lighting Control

Despite clear advantages in comparison with traditional wired type lighting control solutions, the implementation of wireless lighting control has not been really successful. There are still some challenges requiring good solutions to make the wireless lighting control broadly accepted and welcome by all interested parties in the lighting control market. 10 major challenges and solutions of implementing wireless lighting control are summarized below.

### 2.1. Device Complexity

Most wireless solutions require installing complex network devices to achieve sophisticated controls. The more sophisticated control is required, the higher level of complexity. Specifying the right devices for different applications and installing at the right places to achieve the desired controls can be both challenging for general lighting designers and installers.

*Solution*: The network devices should be the simpler, the better.

### 2.2. Integration Flexibility

Most devices of current wireless network solutions are designed for achieving specific control in mind; few have taken the ease of integration into account. The luminaires required for different lighting environments in commercial buildings can be versatile and with different form factors, integrating complex network devices with different luminaires and circuits can be challenging.

*Solution*: The fundamental network device should contain all functionalities with a high level of integration flexibility.

### 2.3. Ease of Installation

Most wireless solutions require installing local sensors, control devices and luminaires separately which will result in higher labour cost due to more time up and down the ladder and wiring connection. Ease of installation is an important measure of the market acceptability.

*Solution*: Every luminaire should have a full functional network device integrated, so that it can be installed in the exactly same way as the conventional luminaire.

### 2.4. Proprietary Software

Many wireless solutions require proprietary management software or apps to configure or run the systems. This requirement may increase the cost of ownership, complicate the configuration with extra equipment, and also raise the concern of total reliance on a specific manufacturer.

*Solution*: All network devices should be able to reliably operate and independently control local lighting based on occupancy/vacancy status and ambient light level.

### 2.5. Power Supply Availability

Power supply availability can be another challenge for deploying the wireless mesh network, which requires sensors and control devices to be broadly distributed over the lighting environment, especially for the retrofit projects with difficulty to get constant power for all network devices.

*Solution*: All network devices should be constantly powered by general lighting circuits. Any additional line voltage or battery power supply is not preferred.

## 2.6.  Complicated Commissioning

Many wireless solutions would require extra equipment and proprietary management software to search and link all network devices through a complicated commissioning process. Compared to the wired type controls, commissioning wireless network devices is not always an easier task.

*Solution*: The commissioning of all network devices should be done through some simple and intuitive operations on a handheld programmer with 2-way communication capability.


## 2.7.  Luminaire Supply Availability

The fast emerging LED lighting technology results in faster product renewal and phase-out. There are not many manufacturers who dare guarantee long-term supply availability for general LED lighting, not to mention the luminaires for wireless lighting control. Supply continuation and non-binding with specific lighting manufacturers are typical concerns of facility management personnel.

*Solution*: The network devices should be applicable with most luminaires commonly used in non-residential buildings. No more absolute reliance on specific lighting manufacturer.


## 2.8.  Ease of Maintenance

Most wireless solutions are not designed for OEM luminaire integration, but for proprietary systems which normally require a professional engineer for maintenance. Battery operated network devices would require repetitive battery replacement management to ensure reliable system operation.

*Solution*: The network devices should be reliably operating with minimal or no maintenance.


## 2.9.  Broadest Application

Most wireless solutions have limited application due to the technical or physical limitation of network devices. Take the most commonly used PIR based occupancy sensors as an example, different spaces with different mounting heights would require the sensors to provide the desired detection coverage. Selecting the right devices for so many different applications in commercial buildings will be a challenging task for most designers/specifiers.

*Solution*: The network devices should have the widest possible applications with the highest level of flexibility for luminaire and lighting circuit control integration.


## 2.10. Future Scalability

Adding new luminaires onto an existing lighting system with wireless control can be an uncertain issue as the integration between network devices and new luminaires is not always a sure thing. Prior to the expansion, someone would have to verify that the new luminaires and additional lighting circuits can seamlessly merge with the existing control system.

 *Solution*: The network devices should provide the most commonly used control outputs for general luminaire and lighting circuit integration.

## 3.  Concept, Products, and Benefits of an Optimized Solution

The need of an optimized wireless lighting control solution is undoubtedly strong, especially the existing commercial buildings that look for retrofitting the legacy lighting with outdated controls to the LED lighting with advanced controls. To help the lighting industry supply more commercial luminaires with embedded intelligence to the market, we developed an optimized solution that can practically overcome all the above challenges.

This solution is named OS-NET, which is abbreviated from OccuSens Network. The OS-NET also refers to an Occupancy Sensing Network, a wireless mesh network formed by a number of wirelessly linked occupancy sensors that are broadly deployed in the lighting environment.

### 3.1.  Concept of OS-NET Solution

Every lighting project, regardless of new building or renovation, requires installing luminaires and power circuits in all lighting environments. It will be the most cost effective way to deploy a wireless mesh network through the process of lighting installation. This is the core concept behind OS-NET wireless lighting control solution, i.e. *simultaneously deploy a wireless mesh network while installing OS-NET enabled lighting\*.*
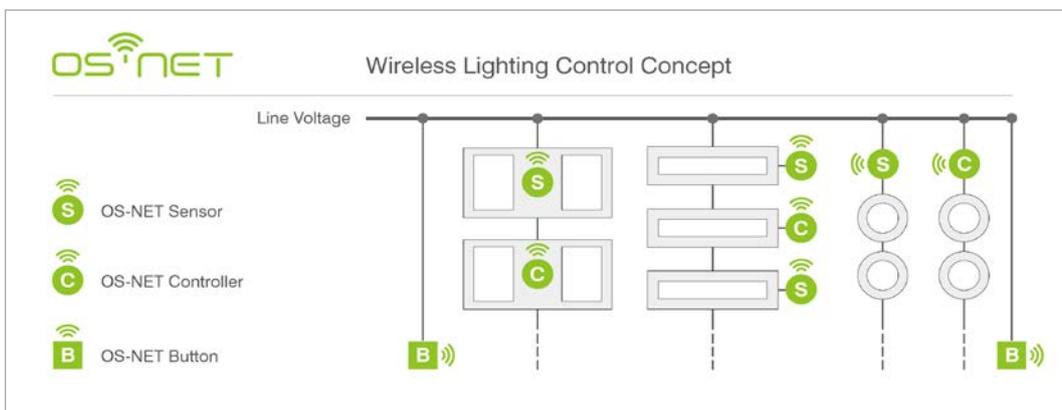


*Figure 1. OS-NET Wireless Lighting Control Concept*

After the installation is completed, an OS-NET can be easily created through the process of grouping all network devices by a 2-way handheld remote programmer. Each device can be assigned to be member of up to 4 control groups according to the requirement. The sensor of OS-NET enabled lighting is capable of sensing the presence of an occupant or vehicle and the ambient light levels within its coverage, and executing the programmed control to the connected lighting in a principle of "*individual sensing and control, group activation*".

"*Individual sensing and control, group activation*" means that every sensor of the group will detect occupant's activities within its respective range. When any sensor detects the presence of occupant or vehicle, it not only controls the connected lighting as set, but also broadcasts the occupancy signal to other sensors and controllers of the group to execute the programmed controls to the connected lightings. If any sensor detects occupancy before delay time elapses, the whole lighting group will remain controlled as occupied. After the area is totally vacated and delay time elapsed, the grouped sensors and controllers will then individually control the connected lighting as set.

*\*OS-NET enabled lighting refers to the luminaires integrated with OS-NET devices or lighting circuits that are electrically controlled by OS-NET devices.*

### 3.2. Products of OS-NET Solution

To fulfil the concept to reality, three types of OS-NET devices with distinctive functionalities are developed. They are categorized as OS-NET Sensor (hereinafter called **ONS**), OS-NET Controller (hereinafter called **ONC**), and OS-NET Button (hereinafter called **ONB**).

The table below highlights the functionality of all OS-NET devices.

| Network Devices | Functional Description |
|---|---|
| **OS-NET Sensor (ONS)** | ONS is the fundamental device of OS-NET solution. It is a self-contained device which combines wireless network connectivity, occupancy sensor, daylight sensor, and lighting control output in a compact housing to provide sophisticated controls to the connected lighting on an individual or group basis. All network configurations and control settings can be done via a 2-way handheld remote programmer from the floor.<br><br>The device can be flexibly integrated with an OEM luminaire or mounted on the ceiling in various options. Different lenses are available for providing different coverage from different mounting heights. |
| **OS-NET Controller (ONC)** | ONC is a supplementary device of OS-NET solution. This device contains all functionalities of an ONS, but without occupancy sensing capability. It can be used to provide associated or separate control to the connected luminaires or lighting circuits in the same area by receiving the occupancy signal transmitted from the ONS of the same group.<br><br>The ONC is an alternative network device of ONS, which can also be flexibly integrated with a luminaire or mounted on the ceiling in various options. |
| **OS-NET Button (ONB)** | ONB is an optional device of OS-NET solution. It is designed to replace the existing wall switch and provide manual control (on/off/dim) to the lighting of the assigned group by broadcasting the wireless commands to the ONS and ONC of the group.<br><br>Different ONB are available for mounting into a standard NEMA or EURO type wall box, all powered by general AC mains for users to turn on/off or dim the grouped lighting by simple and intuitive button operations. |

*Table 1. Network Devices of OS-NET Solution*

### 3.3. Benefits of OS-NET Solution

The OS-NET can provide top-notch energy efficient, code-compliant, sophisticated controls without requiring extra sets of control wire networking to each luminaire and circuit. These include occupancy, vacancy, or daylight sensing based controls with on-off switching, multi-mode bi-level or continuous dimming to the connected lighting in standalone or group basis.

- To the **OEM lighting manufacturer,** OS-NET can help easily deliver state-of-the-art energy efficient smart lighting with wireless connectivity by simply integrating an ONS or ONC with the luminaire.

- To the **lighting designer or specifier,** OS-NET can help complete a code-compliant design project by simply selecting OS-NET enabled luminaires or ONS for lighting circuit control, and place them according to the photometric characteristic and sensing coverage.

- To the **lighting installer,** you can install a wireless network controlled lighting system in the same way as installing the conventional lighting, sensors and switches. No extra wiring, no extra labeling on the complicated control wires, all you need is a simple and intuitive setting by a handheld remote programmer.

In addition, the OS-NET solution can effectively save time, money and energy for all interested parties!

A multi-purpose wireless sensor mesh network can be effortlessly deployed while installing the luminaires and circuits which is a must-do job for a new building or renovation project. The OS-NET solution eliminates extra sets of wiring diagram, control wires networking to each device, complicated wiring connections and commissioning time typically required by conventional lighting control systems. So time is effectively saved!

The OS-NET solution does not require centralized control panel, routers, interfaces, power adaptors, separate sensors, load controllers, and proprietary management software which normally contribute to higher project costs. All you need are OS-NET enabled luminaires or lighting circuits controlled by flexibly mounted ONS/ONC, and a universal handheld remote programmer. So money is effectively saved!

With OS-NET, all lighting can be smartly controlled by a number of wirelessly linked ONS/ONC integrated with luminaires or lighting circuits on an individual or group basis. Every sensor or controller controls the connected lighting as programmed based on the occupancy status and ambient light level of the area, while also broadcast the occupancy signal to other sensors and controllers of the group to execute the associated controls. So energy is effectively saved!

## 4. How Does OS-NET Solution Overcome the Challenges

Section 2 has summarized 10 major challenges of implementing wireless lighting control together with respective solutions. The OS-NET concept and products are purposely developed to overcome these challenges. The table below highlights the edges of OS-NET solution.

| Challenges | How OS-NET Solution Overcomes |
|---|---|
| **1. Device Complexity** | Only ONS is essential to form the wireless sensor mesh network and provide all required sensing and controls for smart lighting. The ONC and ONB are just supplementary and optional devices for associated and manual controls. |
| **2. Integration Flexibility** | Numerous design innovations enable the ONS and ONC to be flexibly integrated with OEM luminiares or mounted on the ceiling from low to high bay in a variety of options.  The ONB is an alternative device of the traditional wall switch. |
| **3. Ease of Installation** | All OS-NET devices can be simultaneously and effortlessly deployed in various applications  through installing the OS-NET enabled luminaires and lighting circuits in the exact same way as conventional luminaires. |
| **4. Proprietary Software** | OS-NET requires only a handheld remote programmer to establish the network, grouping and conducting necessary control settings for all devices. No proprietary computer software or app is required. |
| **5. Power Supply Availability** | All OS-NET devices are constantly powered by general AC mains electricity of typical lighting circuits to ensure all-time operation. The network can be available at wherever mains power is available. No battery powered device. |
| **6. Complicated Commissioning** | The commissioning of all OS-NET devices can be done through simple and intuitive operations via a handheld IR remote programmer with 2-way communication capability for uploading/downloading the settings on an individual or group basis. |
| **7. Luminaire Supply Availability** | Both ONS and ONC can be flexibly integrated with most luminaires commonly used in commercial buildings. No more absolute reliance on specific luminaire supply from single or limited source. |
| **8. Ease of Maintenance** | The maintenance of OS-NET enabled lighting system can be exactly same as the existing conventional lighting, and simpler than other wireless solutions which may require periodical battery replacement. |
| **9. Broadest Application** | Both ONS and ONC can be flexibly integrated with OEM luminaires for indoor or outdoor lighting environments. If luminaire integration is not available, both devices can be flexibly mounted on the ceiling. |
| **10. Future Scalability** | Both ONS and ONC are designed to provide the most commonly used controls to the integrated luminaires or lighting circuits. Future scalability is therefore secured regardless of how fast that LED lighting technology is emerging. |

*Table 2. How does OS-NET Solution Overcome the Challenges*

## 5. Conclusions

With all the advantages and benefits of wireless lighting control, an optimized solution with high levels of flexibility, functionality and simplicity in deployment has been awaited by all interested parties in the lighting industry for a long time.

The OS-NET is an optimized wireless lighting control solution capable of providing sophisticated, code-compliant lighting controls among luminaires and lighting circuits through a wireless mesh network formed by a group of wirelessly linked OS-NET devices, primarily the OS-NET sensors and controllers. What makes the OS-NET an optimized solution is its exceptional ease of deployment, without the extra design, installation and setup time typical of conventional lighting control systems.

Both OS-NET sensors and controllers can be flexibly integrated with OEM lighting luminaires and/or mounted on the ceiling in a variety of options. Each OS-NET sensor or controller not only controls the connected luminaire or lighting circuit in the way as programmed, but also acts as a network node to transmit, forward, or receive the radio commands for group control and network communication. A universal 2-way IR remote programmer offers simple and intuitive grouping and control setting for all OS-NET devices. Each device can be assigned to be member of up to 4 control group to achieve energy efficient lighting control while maintaining a high level of occupant comfort. With OS-NET solution, bringing smart lighting controls to all lighting environments of commercial buildings just requires completing 3 works below;

1) **Installing the OS-NET enabled luminiares and lighting circuits as usual**

2) **Grouping all OS-NET devices via a handheld remote programmer**

3) **Setting the device controls as desired via the same remote programmer**

IR-TEC's OS-NET is not only an easy solution for OEM lighting manufacturers to upgrade their luminaires with smart sensor control embedded and state-of-the-art wireless mesh network connectivity, but also an unsurpassed choice for retrofitting the legacy lighting with energy efficient LED lighting featuring code-compliant controls.

## 6. References

[1]    McKinsey & Company, *Lighting the way: Perspectives on the global lighting market.*