White Paper
June 2016

# Green Buildings and Energy Efficiency
## The Benefits of FTTO based IT-Infrastructures

Nexans

# Introduction

How can you equip a new or existing building with a state-of-the-art network whilst also conserving energy? What consequences could 'Green Building' have on your IT infrastructure? Is it possible to introduce a future-proof network infrastructure without creating more waste? How do you get more performance out of your IT infrastructure whilst saving resources, time, power and money?

This document will examine these and many other questions in detail, focusing on the energy efficiency benefits of 'Fibre To The Office' ( FTTO) infrastructures.

# Environmental Concerns

Almost half of all European carbon emissions come from buildings. In fact, according to the International Energy Agency, buildings are responsible for more than 40% of the world's total primary energy consumption as well as 24% of global carbon dioxide emissions[1].

The European Union 2020 plan aims to reduce greenhouse gas emissions by 20% by 2020. 20% of EU energy consumption should come from renewable resources, and energy efficiency has to be improved by 20% by 2020.

Reducing carbon emissions of new buildings and optimising the energy efficiency of existing buildings is vital to achieving this. More and more property developers, facility operators and IT managers think in terms of Green Building and work out solutions to lessen the Building´s Impact on the environment.

## Green Buildings

### What is Green Building?

Green Building, also known as Green Construction or Sustainable Building, refers to structures and processes that remain environmentally responsible and resource-efficient throughout the building's life cycle. This covers everything from sighting to design, construction, operation, maintenance, renovation and demolition. Different rating systems exist to evaluate the sustainability level of buildings, such as LEED (US & Canada), BREEAM (UK), HQE (Fr), DGNB (Germany), Green Star (Australia).

Green Building is all about striking a balance between building and sustainability. Designers, architects, engineers, IT-specialists and end users work closely together at all the stages of the building project. They analyze customer requirements and work out solutions that are not only economical, durable and comfortable but environmentally responsible and energy efficient, or 'green', too. Hence the notion of 'Green Building'.

1 https://de.wikipedia.org/wiki/Energiestandard

*Figure 1. Are we in for a Green Future?*

Solar and wind power, rain water collection, cross flow heat exchangers, Energy Star appliances and equipment, LED and OLED lighting, building automation, electrical cars and recycling - all governed by modern ICT technologies - are there for more sustainability.

Energy costs make up some 25-30% of total expenditures on an average building.

A typical `traditional' building consumes 250-300 kWh per $m^2$ per year. Modern buildings are dsigned to consume about 160 kWh per $m^2$ per year, whereas a construction based on Green Building principles can reduce that to 30 $kWh^2$.

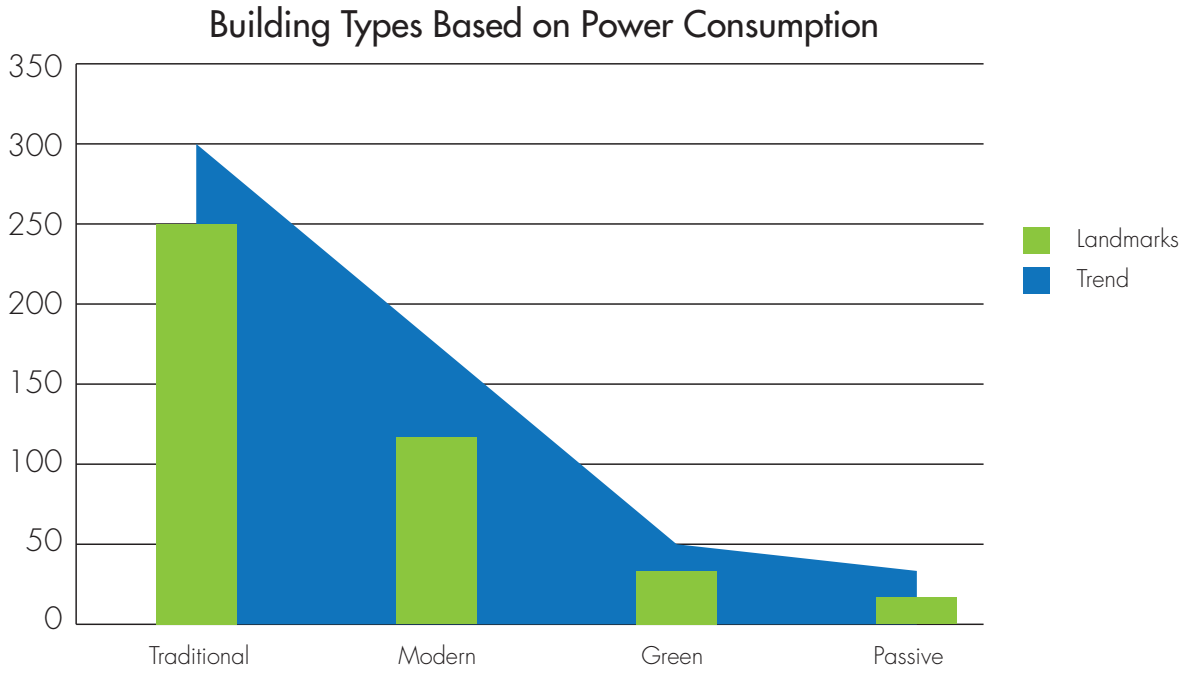



*Figure 2. Types of Buildings based on Basic Power Needs Consumption*

So what makes a Building green?

## Green Building Best Practices

Green Building is, in essence, an approach to reducing the impact of buildings on the environment and human health throughout and beyond their lifecycle. In such a Building, resources are used more efficiently to create and operate homes, commercial facilities or institutions, which are more energy-efficient and healthy for inhabitants.

It includes water and electricity meters, carbon dioxide presence detectors, intelligent light management and HVAC (heating, cooling, air-conditioning and ventilation units), use of low-impact building materials and materials for finishing and interior design. Green roofs, rain gardens, use of solar, wind and geo-thermal power all play a part in this. Production of waste and toxic substances is minimized, waste is recycled.

2 https://de.wikipedia.org/wiki/Energiestandard

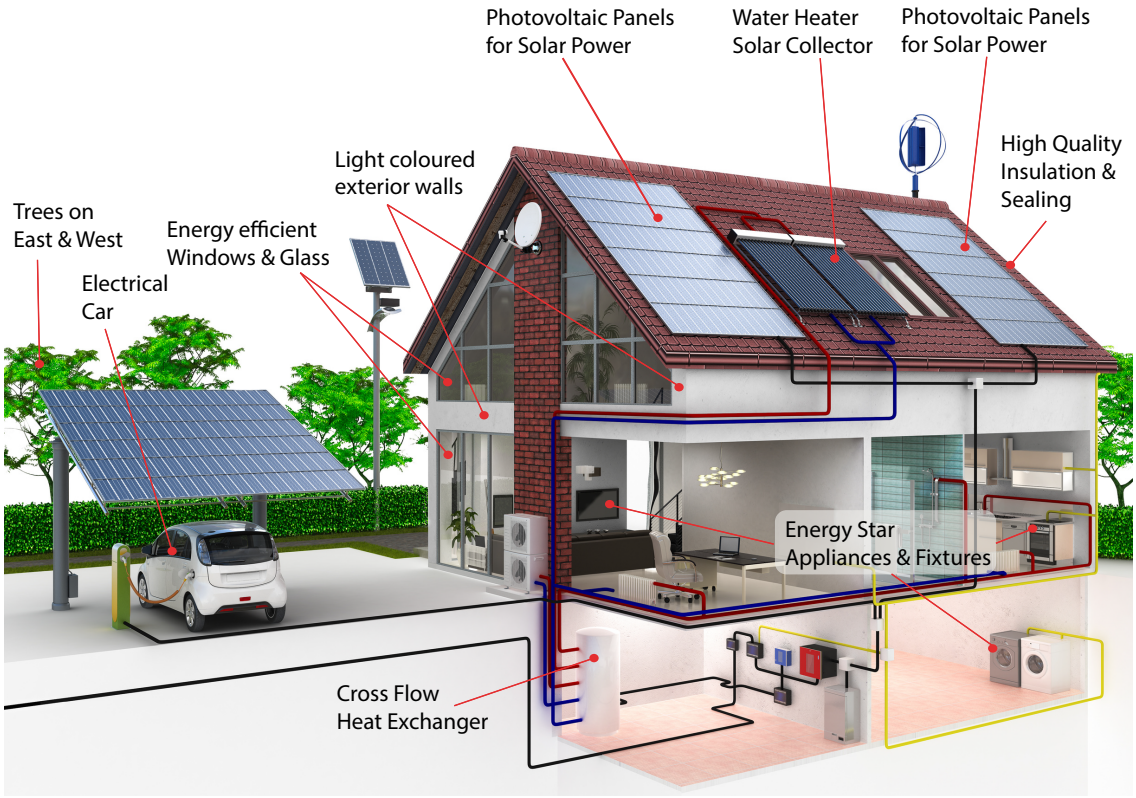



*Figure 3. Modern one family house built on Green Building Principles*

As Information and Telecommunication Technologies are an essential part of today's building infrastructure, it's worth considering how these can play a part in 'greening' the Building.

## Energy-efficient Networks

### What is Green IT?

Green ICT, also referred to as Green IT or ICT sustainability, is a widely-used term describing environmental practices in IT related to energy consumption. This aims to minimize the negative impact of IT operations on the environment during their active use phase. It includes energy efficient products and technologies, i.e. with reduced power consumption and more efficient power supply, data centre redesign, server virtualization concepts with lower $CO_2$ emission, and cloud services. 'Green IT' mainly focuses on Energy Efficiency. To be more accurate, the term 'Green IT' had better be replaced by 'Energy Efficient IT'.

However, the concept incorporates more than just IT technology aspects. It also includes low-emission building materials, recycling and alternative energy sources (solar, wind, biofuels, thermal, etc.) to power data centres and IT infrastructures.

Energy Efficient IT studies, analyses and optimises the performance of computers, servers, power supply units and all associated subsystems and peripheral devices to produce a more responsible network. Besides lowering energy consumption and improving the carbon footprint of a company or institution, Energy Efficient IT makes it possible to save a considerable amount of money.

By taking an integrated approach to ICT, it is possible to support the realization of a smart and responsible building infrastructure. Around the world, the powerful combination of Energy Efficient IT and Green Building Best Practices is already being embraced to address issues related to data centre emissions, building design and urban planning.

## Energy Efficient IT and Green Building

According to analysts, ICT makes up about 20-25% of a building energy bill[3].

There are several ways in which Energy Efficient IT can support Green Building.

For example, it can enable a more efficient allocation of energy and water resources, enhance efficiency through data analysis and algorithms, fine-tune energy consumption, virtualize functions and services, enable teleworking, integrate different in-building systems into a single one, i.e. create one single point of management, and identify areas of improvement. In addition, continuous monitoring and data evaluation over time help considerably optimize existing processes and structures and be better prepared for the future needs.

Specifically in IT Networks we see that 'energy responsible' components and systems, with enabled intelligent functionalities and alarm tracking, significantly outperform their traditional counterparts. They optimize efficiency of infrastructures by scheduling port and wireless access, adjust power usage to the exact user´s needs and shut down ports automatically when they are unused, for example at night or during public holidays.

ICT plays an ever increasing role in Green Building Concepts and should be considered for Building Optimisation as well.

3 Gartner Inc., 'IT Vendors, Service Providers and Users Can lighten IT's Environmental footpint'. Simon Mingay, December 5, 2007.

# What is FTTO?

Clearly, energy efficient IT technologies can make a significant contribution to the successful implementation of the principles of Green Building. One such technology is 'Fibre to the Office', or FTTO.

FTTO is an innovative, fibre-based Local Area Network (LAN) cabling concept, which adds value by focusing on optimizing network´s energy performance.

In an FTTO infrastructure fibre is installed from the central switch to the connection point in the office or workplace. The final 3-5 metres to the end devices are covered by standard RJ45 patch cords, with intelligent managed FTTO Switches ensuring media conversion.

Each FTTO Switch is connected to the central switch with one or two SFP-Uplinks and has four user ports. Each of these ports has Gigabit Ethernet capability. This centralised structure of active network components may greatly simplify rollout, management and service of networks, significantly reducing IT-infrastructure costs.

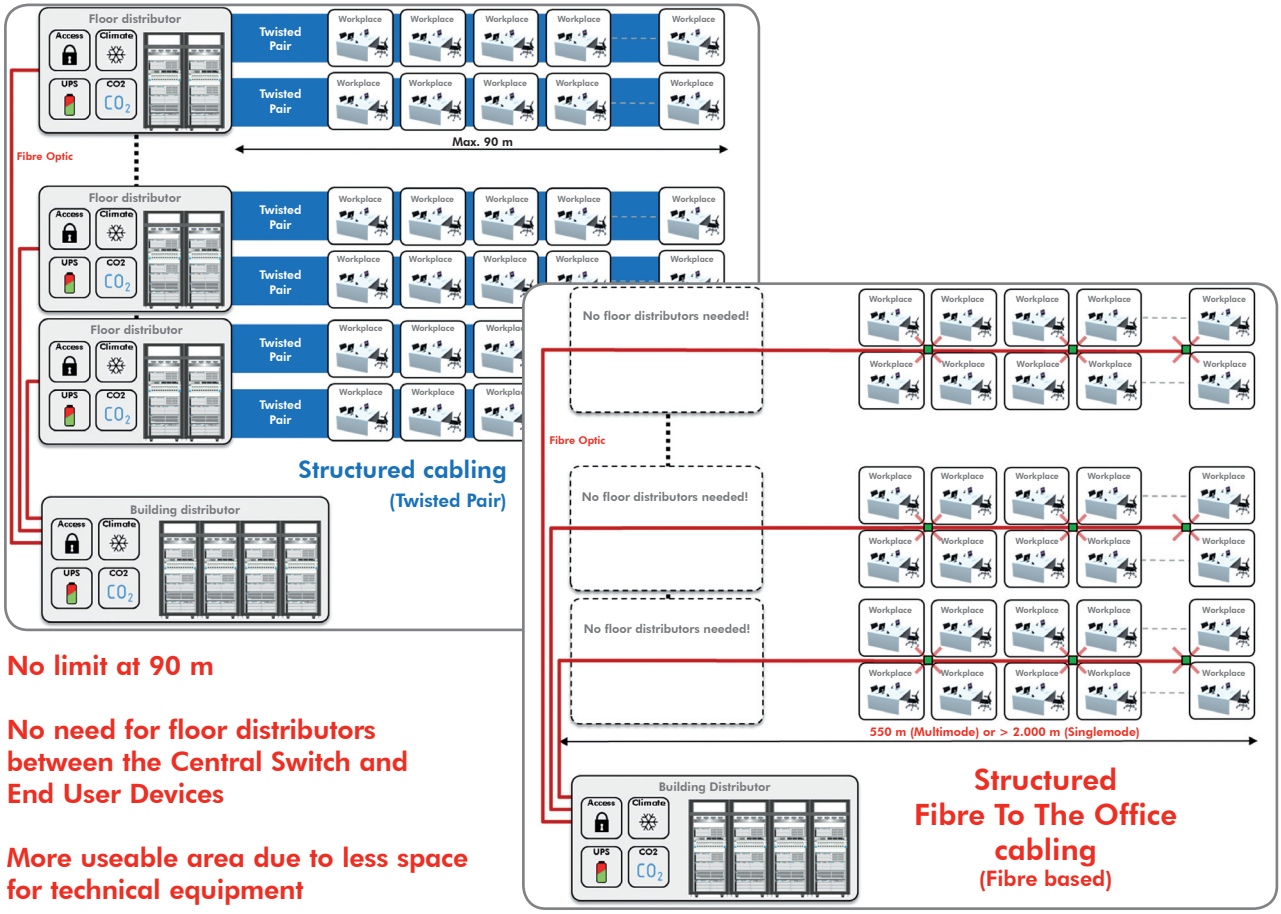



*Figure 4. Traditional vs. FTTO Network Designs*

FTTO offers a simpler, more flexible cabling structure with no need for floor distributors. It combines the benefits of both Twisted Pair and fibre and delivers maximum performance with minimum energy waste. There are several factors, which contribute to energy efficiency of FTTO based networks. We'll examine some of them more closely.

## What Makes FTTO Energy Efficient?

## Fundamental Benefits of FTTO

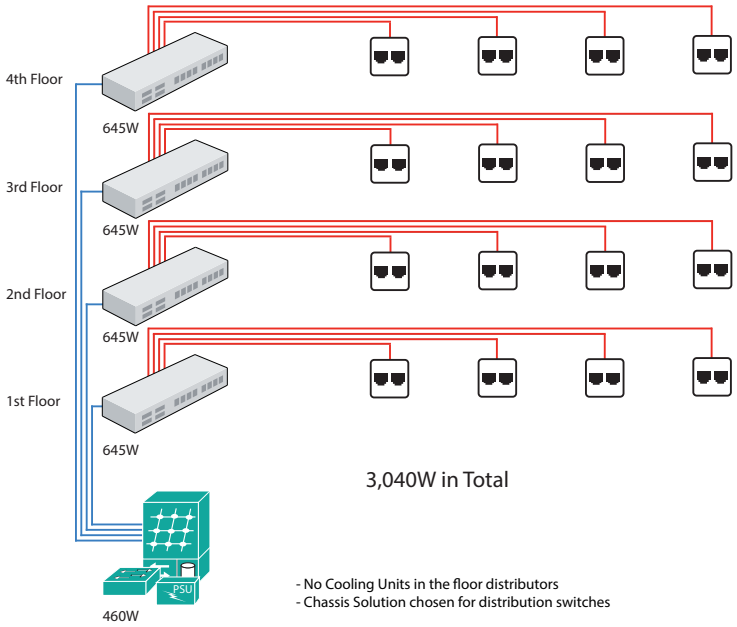
### No Building Distributors Means Less Active & Passive Equipment

FTTO cabling solutions require less passive and active equipment than traditional solutions. This is due to the absence of floor distributors. As there is no need for floor distributors, no investment is needed in the floor distributor equipment.

### FTTO Networks Consume Less Power

In traditional network designs, floor distribution switches may consume a lot of power and require efficient cooling to dissipate heat.

In a network project with 1,000 user ports, floor distribution switches may consume 2,74 kWh (when all ports are active) per hour. Another 3.21 kWh per hour is required for cooling (for the central switch), resulting in a total power consumption of 5.95 kWh per hour (52,084 kWh per year)[4]. In FTTO Network Designs there are no floor distribution switches, so that a minimum of 31,498 kWh per year can be saved[5]!

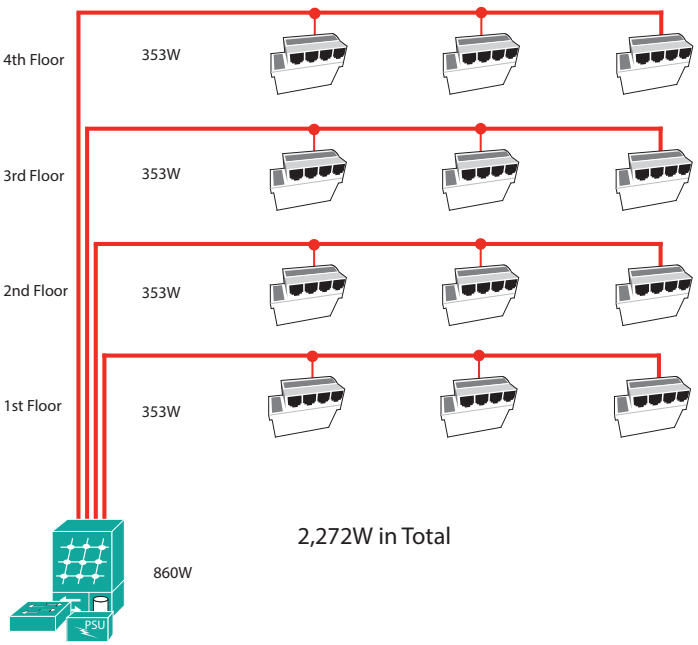



**75% of ports are active.**

*Figure 5. Traditional Network Power Consumption*

4 Values taken from a real customer project with 1000 ports.

5 considering the use phase consumption




**FTTO is about 29% more energy efficient.**

*Figure 6. FTTO Network Power Consumption*

**Please note:** These values refer only to the switching power consumption, without cooling for distribution switches! Chassis solution is chosen for the distribution switches[6].

Moreover, FTTO Switches consume very little power: 3.5-3.6 Watts per switch and only 0.7-0.8 W per port[7] (average). This is nearly half of the total power consumption of floor distribution switches in traditional networks.

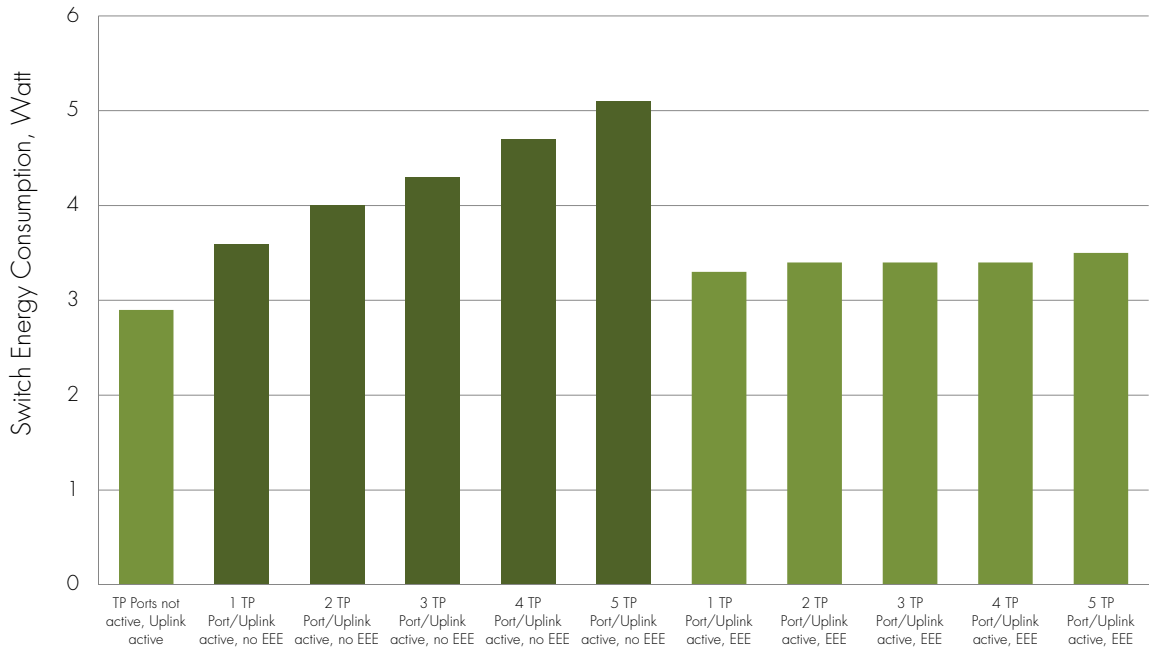



*Figure 7. Energy Consumption of FTTO Switches*

6 Specific calculation examples and other scenarios can be found in the Appendix at the end of the Document (P. 18-19).

7 With Energy Efficient Ethernet Function activated.

The special design of FTTO Switches also enables better heat dissipation without cooling. Their statistically defined 'Mean Time Before Failure' in office environments amounts to over 400 years.

### More Space

The absence of floor distribution rooms (required to house technical equipment in traditional network designs) means FTTO gives more useable area. A floor distribution room takes up 9-18 $m^2$ per floor[8] and even more, - space which could be used instead for e.g. shared centres for printing and photocopying!

These square metres saved do mean a lot to a shopping centre operator, business centre manager, hotel or an educational facility. In hospitals with their chronic lack of space less technical area actually means more area for patient healthcare and wellbeing.

### Less Cabling Volume and Better Fire Load

In FTTO infrastructures, cabling volume can also be reduced by up to three quarters (vs. traditional network designs). Fibre doesn't require grounding. Moreover, it has a very low fire load, which is critical for old historical buildings with their special requirements in terms of fire safety.

## Add-on Benefits of FTTO

### Best Infrastructure for PoE/PoE+

*What is PoE?*

PoE, or Power over Ethernet, is a protocol that allows electrical power to be sent along with data over Ethernet cabling. This allows a single standard RJ45 twisted pair cord to provide data connections as well as electrical power to a variety of electronic devices, such as desktops, IP Phones, Wireless Access Points or IP cameras. No extra power sockets are required, as both power and data can be transferred over the same network cable.

In FTTO networks, a fibre connection is realized up to the work station and only the last 2-5 metres to the end user device are covered by copper wires. As the distance between the PSE (Power Source Equipment, i.e. the FTTO Switch) and PD (Power Device, i.e. end user device) is minimal, power losses may be reduced by up to 80% in comparison with Cat.5E cabling[9].

8 Experience based value derived from over 30 years of Nexans experience in networking projects.

9 Based on internal R&D calculations. Generally, the shorter is the distance between PSE and PD, the better is the efficiency of the power supply.

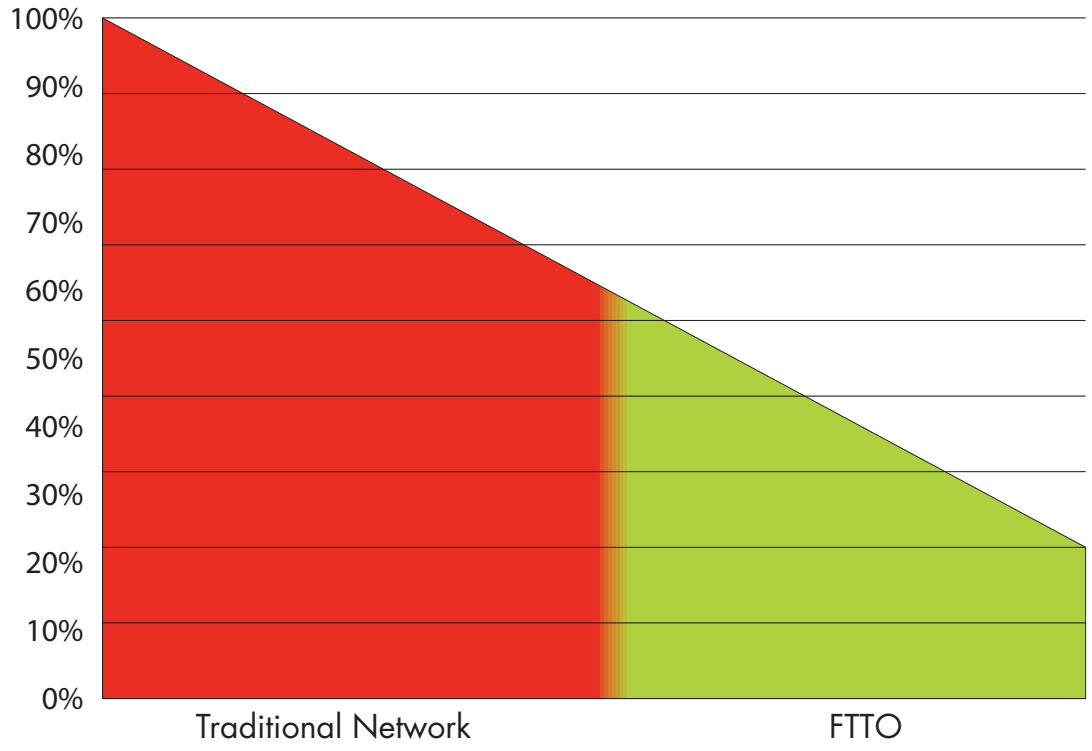



*Figure 8. Power Losses, Traditional Network Designs vs. FTTO*

## Energy Efficient Ethernet (EEE)

Modern FTTO Switches support EEE.

EEE is a standard (IEEE 802.3az) in network technology based on the idea that a communication link should only consume power when data is being sent or received.

Since the 1990s, most wire line protocols have used continuous transmission, consuming power when no data is sent. EEE signalling protocol changes this by allowing a transmitter to point out gaps in the data transfer and setting the link into the 'idle' mode. Thus power supply is resumed when data reappears, following a pre-defined delay.

The idea is to reduce power consumption by a factor of two, while retaining full system functionality. Research shows that power savings of up to 45 - 80% may be expected when using EEE enabled switches[10]. This translates in turn into a longer MTBF of switching equipment and a slimmer energy bill for the Building.

## Energy-efficient Mode

Some FTTO Switches, for example LANactive FTTO Switches developed by Nexans, can optimize data transfer rates based on users´ actual needs and preferences. The so called 'energy-efficient mode' reduces data transfer rates (from 1,000 Mbps to 100 Mbps) either manually or automatically following a preset time schedule, just like with automated lights.

10 D-Link First Company to Offer 'Green Ethernet™' Technology for Network Connectivity, Embrace Energy-Saving Initiatives. D-Link. October 24, 2007. Retrieved July 5, 2011.

## The Bottom Line

Analysis shows that FTTO helps realize two important goals on the way to the Green Building:

**Overall Network Power Consumption in FTTO Network Designs is reduced.** As can be seen above, FTTO is a very energy efficient solution. FTTO networks are typically 30% more energy efficient than traditional networks and can sometimes reduce power consumption of IT infrastructures by up to 70%. The more users there are in the system, and the more applications there are on the network, the bigger are the benefits brought by FTTO.

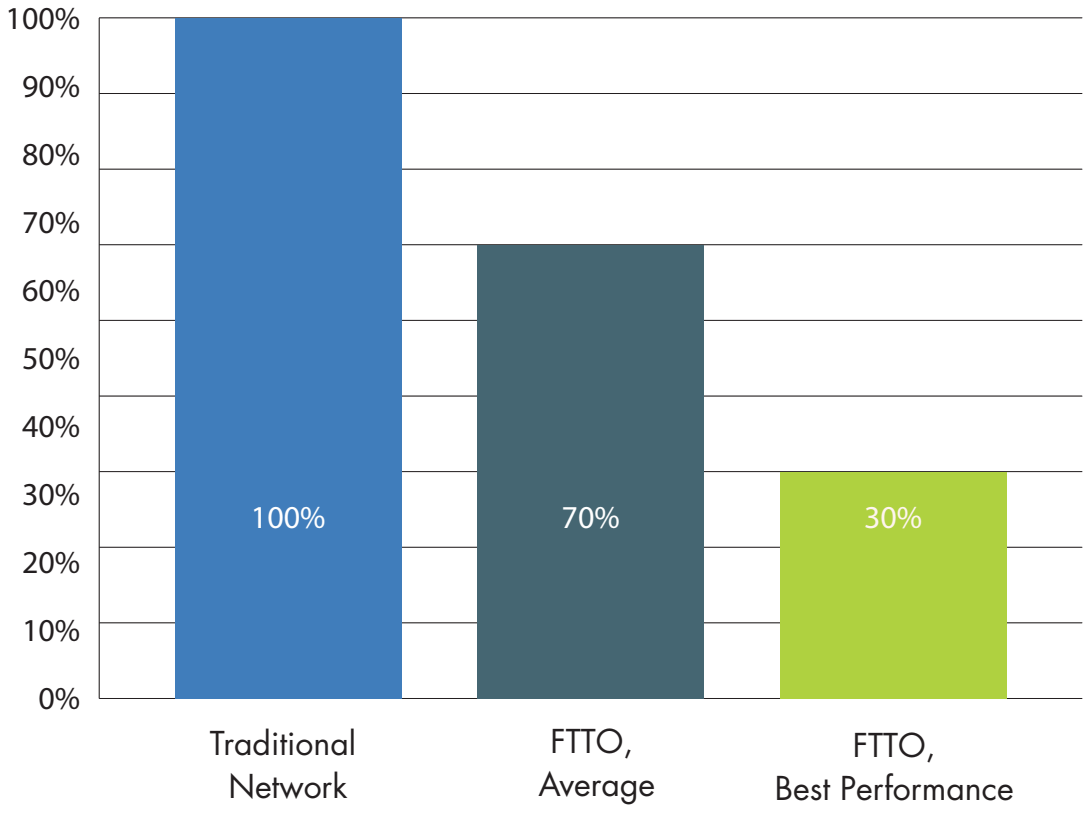



*Figure 9. Power Consumption, Traditional Network Designs vs. FTTO*

Figure 9 shows graphically the relationships between traditional networks, average FTTO solutions and best FTTO performance in terms of power consumption. The power consumption of traditional networks is taken for 100%.

## FTTO lowers CO2 Footprint

Less Energy usage means lower $CO_2$ emissions and therefore less carbon footprint.

An example below looks at kWh usage in relation to tons of $CO_2$ produced.

In traditional network designs - for example with 1,000 ports and with cooling units installed in the floor distributors - power consumption would total some 91,454 kWh per year (in a switch stacking scenario with cooling units in the floor distributors), which equals 50-60 metric tons of $CO_2$. FTTO, however, can reduce this to 32,937 kWh per year, which is 19-23 metric tons $CO_2$, or even lower[11].

Please see Calculations in the Appendix for reference.

FTTO networks tend to have a lower carbon footprint compared with traditional networks, even in models where there are no cooling units in the floor distributor.

Please note: $CO_2$ output is different in each country, as it is based on a national energy mix value.

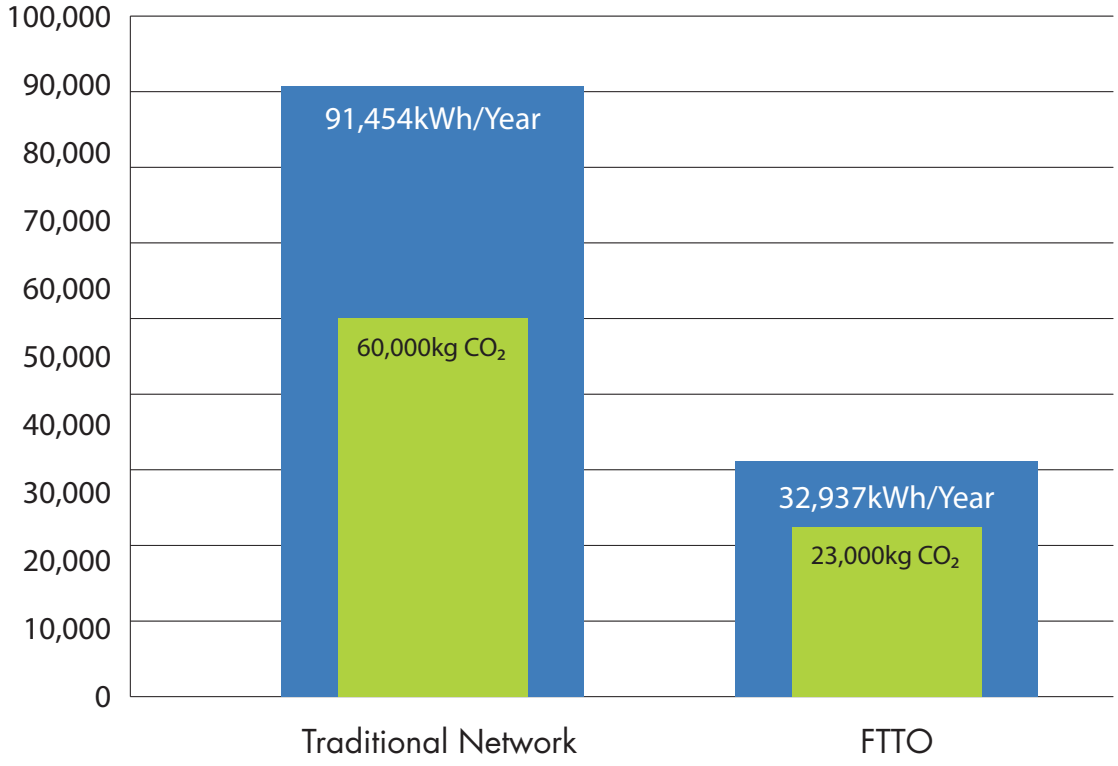



*Figure 10. $CO_2$ Output, Traditional Network Designs vs. FTTO*

11 $CO_2$ Calculators, https://www.prima-klima-weltweit.de/co2/kompens-berechnen.php; http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results

# Energy-efficient & High Performing

## FTTO: the Best Performing Network Technology Today

Generally, FTTO offers similar levels of network performance to that found in traditional networks. However, in some cases FTTO can outperform traditional solutions, for example where large distances have to be covered or where special restrictions apply, e.g. in historical buildings. FTTO benefits grow with the rate of port utilisation: the more users there are, and the more active ports are in use (not idle), the larger are the benefits. FTTO is the optimal, 'green' technology with a mixture of benefits brought by fibre and Twisted Pair copper cabling.

## Gigabit Ethernet Speeds, Flexibility and High Availability

Besides significantly improving energy efficiency in the use phase, FTTO offers full Gigabit Performance on its Twisted Pair Port interfaces. It brings high bandwidth reserves and makes advanced redundancies possible. Intelligent features help increase the security of the network and minimize service costs.

Furthermore, FTTO adds flexibility. There is no need to have large quantities of network components in stock, instead you 'Pay as You Grow', by simply investing in the network as it expands. Moreover, there is no 90 metre Channel Link limitation, and network planning is simplified. So fewer resources are wasted, and network upgrades, add-ons and changes can be implemented quickly and easily, without stopping operation.

## Easier Path to ALL IP

FTTO is prepared for any type of IP convergence and new applications, such as working from a home office, BYOD, IP video surveillance, access control, VoIP, WLAN, IPTV (4k/3 D), building automation, and teleconferencing. Experience shows that FTTO enables highly digitalized, highly automated and highly flexible networks on the basis of TCP/IP.

# Green Network Pays off

## Green Building and TCO: a Global Perspective

Most green buildings command a premium of 2%, but yield ten times as much over their entire lifetime. Cash savings stem from more efficient and balanced use of available resources, resulting in a decreased energy bill. Over a span of 20 years, the financial payback typically exceeds the additional cost of developing a Green Building by a

factor of 4-6[12]. Benefits don't only include a lower energy bill and lower greenhouse gas output, but also a higher employee productivity (for example, thanks to a quicker network) and satisfaction[13].

## Up to 40% less TCO (Opex+Capex) with FTTO

With FTTO, energy bills can be up to 70% lower, TCO can be reduced by up to 40% and installation time may be reduced by up to 60%. These are the top values observed in customer projects Nexans has seen over the last 30 years.

Please note: an accurate estimatation of each specific project is possible only after site inspection and situation analysis!

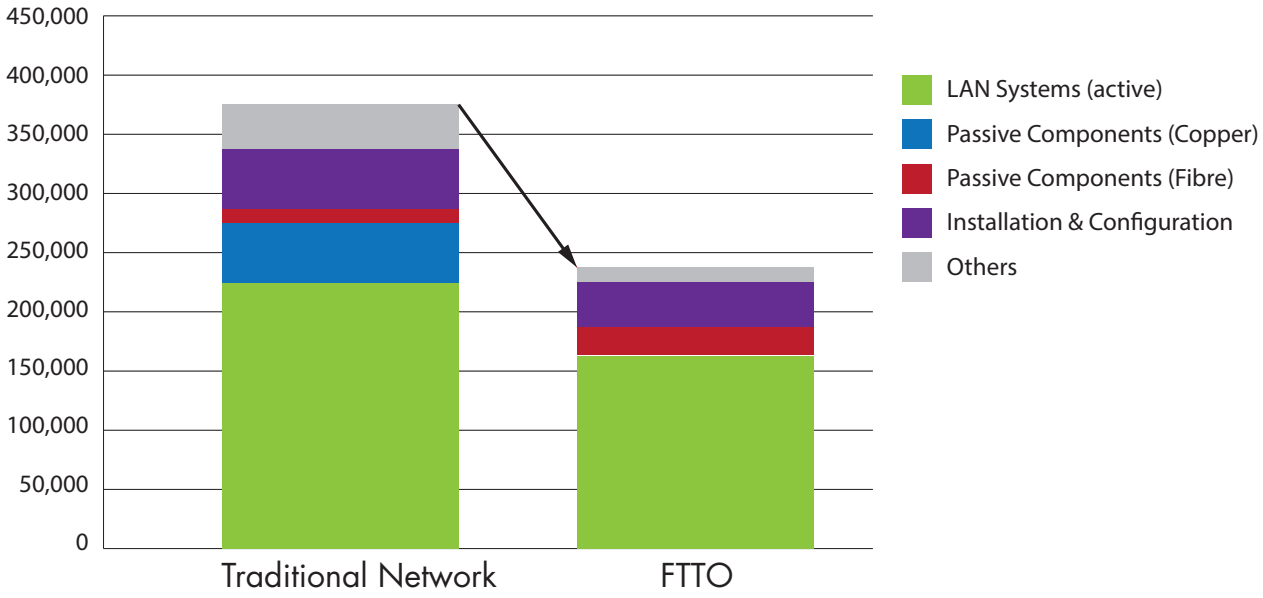



*Figure 11. Money Matters*

Furthermore, thanks to the centralised structure of FTTO, which makes floor distributors unnecessary, it is much easier to service the network and reduce service costs. For example, there are no service costs for the attendance and maintenance of air-conditioning, fire protection, uninterruptible power supply units, etc. in the distribution room. This 1:4 network ratio (one core switch to four end user devices) makes the system scalable, high available and flexible.

12 Kats, Gregory. (September 24, 2010). Costs and Benefits of Green Buildings [Web Log Post]. Retrieved from http://thinkprogress.org/climate/2010/09/24/205805/costs-and-benefits-of-green-buildings/#.

13 Fedrizzi, Rick,'Intro – What LEED Measures.' United States Green Building Council, October 11, 2009.

*Rough Cost Estimate, values taken from a real customer project*

| Cost Estimate | Total Costs, Euro | Difference, % | Install. time, hours | Watts per Port |
|---|---|---|---|---|
| Traditional Network Design | 757.694 € | 100.0% | 1835.5 | 4.5 |
| FTTO Network Design | 487.950 € | 64.4% | 833.6 | 2.2 |

### Longer Lifespan

An FTTO solution represents a long term investment with an excellent ROI. Choosing this type of network can have a marked effect on the Total Cost of Ownership (TCO) of the IT Network.

FTTO infrastructures support several generations of active equipment and last well over 20 years. The longer life cycle of FTTO networks means less waste is caused by products being disposed of and less need for new components to be manufactured and purchased. Also, with FTTO it is easier and less expensive to implement redundancy topologies.

## Summary

FTTO is a modern solution for optimizing the energy performance of the IT network and the Building. It does not compromise network performance, but empowers all sorts of modern applications. When it comes to speed, security, flexibility and availability, FTTO network performance is unparalleled.

Most of its energy benefits are due to less passive and active equipment on the network, and particularly due to the absence of energy-hungry distribution rooms. Rolled out in the Building, it takes up less space and resources, and yields more useable area for Building users.

At the same time, FTTO brilliantly combines the benefits of both copper and fibre and brings a future-proof solution with high bandwidth and PoE functionality. Its low fire load and flexibility in planning, rolling out and administration are particularly beneficial in situations, where large distances have to be bridged, when there are multiple users on the network or when building requirements impose specific restrictions.

FTTO is an efficient solution in terms of energy and $CO_2$ footprint. It cuts energy consumption by 30-70% compared to traditional networks and saves space that technical service rooms would otherwise require.

So FTTO contributes to a future with more sustainable buildings and is part and parcel of Green Building Best Practices.

# APPENDIX

Calculating Energy Efficiency of traditional and FTTO networks (on P. 18-19)

## Network Design, Key Assumptions:

| | |
|---|---|
| **Core** | Cisco Core Chassis with 10 G blades |
| **Port utilisation** | two scenarios, 100% and 40% Ports in the active state |
| **Building** | 1,000 Ports, distributed over 4 Floors |
| **Traditional Network Design** | Switch Stacking in the Distribution Room, with and without cooling unit (HVAC) in the distribution room<br><br>1,000 Ports in use, 4 Building Distributors, 5- 6 Switches per Distribution Room,<br>each Switch x 48 Ports |
| **FTTO** | 1,000 Ports, 250 Access Switches, no Distribution Rooms |
| **HVAC** | Heating, Ventilation, Air-Conditioning, Cooling; generic term. |

## Commentaries

| | 100% port utilisation (All ports active) | 40% port utilisation |
|---|---|---|
| **Case (1)**, with HVAC units in the Distribution Rooms on the Floors for the Traditional Design | *Difference*<br>= 6,682W, or 64%<br><br>**FTTO is 64% more energy efficient** | *Difference*<br>= 2,706.4W, or 65%<br><br>**FTTO is 65% more energy effieicient** |
| **Case (2)**, no HVAC units in the Distribution Rooms on the Floors for the Traditonal Design | *Difference*<br>= 2,135W, or 36%<br><br>**FTTO is 36% more energy efficient** | *Diffenrece*<br>= 887.6W, or 38%<br><br>**FTTO is 38% more energy efficient** |

# I. 100% Ports Active, FTTO vs. Traditional Network Design

## (1) Calculation Example, with HVAC in the Floor Distribution Room

### Central Distribution Room, Core Switch

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | 810 | 875 | 1,685 |
| FTTO | 1,000 | 1,080 | 2,080 |

### Floor Distribution Room

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | 4,210 | 4,547 | 8,757 |
| FTTO | 0 | 0 | 0 |

### Access Switches

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | 0 | 0 | 0 |
| FTTO | 1,680 | 0 | 1,680 |

### Total

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | **5,020** | **5,422** | **10,442** |
| FTTO | **2,680** | **1,080** | **3,760** |

## (2) Calculation Example, no HVAC in the Floor Distribution Room

### Central Distribution Room, Core Switch

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | 810 | 875 | 1,685 |
| FTTO | 1,000 | 1,080 | 2,080 |

### Floor Distribution Room

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | 4,210 | 0 | 4,210 |
| FTTO | 0 | 0 | 0 |

### Access Switches

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | 0 | 0 | 0 |
| FTTO | 1,680 | 0 | 1,680 |

### Total

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | **5,020** | **875** | **5,895** |
| FTTO | **2,680** | **1,080** | **3,760** |

## II. 40% Ports Active, FTTO vs. Traditional Network Design

### (1) Calculation Example, with HVAC in the Floor Distribution Room

#### Central Distribution Room, Core Switch

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | 324 | 350 | 674 |
| FTTO | 400 | 432 | 832 |

#### Floor Distribution Room

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | 1,684 | 1,818 | 3,502 |
| FTTO | 0 | 0 | 0 |

#### Access Switches

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | 0 | 0 | 0 |
| FTTO | 638 | 0 | 638 |

#### Total

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | **2,008** | **2,168** | **4,176** |
| FTTO | **1,038** | **432** | **1,470** |

### (2) Calculation Example, no HVAC in the Floor Distribution Room

#### Central Distribution Room, Core Switch

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | 324 | 350 | 674 |
| FTTO | 400 | 432 | 832 |

#### Floor Distribution Room

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | 1,684 | 0 | 1.684 |
| FTTO | 0 | 0 | 0 |

#### Access Switches

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | 0 | 0 | 0 |
| FTTO | 638 | 0 | 638 |

#### Total

| | Power by Switches, W | Power by Cooling, W | Total Power, W |
|---|---|---|---|
| Traditional Network | **2,008** | **350** | **2,358** |
| FTTO | **1,038** | **432** | **1,470** |

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