VERTIV WHITE PAPER

# Optimizing Data Center Power Distribution Through Innovative Busway Design

## Introduction

This white paper explores power distribution in the changing data center landscape, highlighting the emerging trends impacting the industry and evaluating the suitability of innovative busway solutions as an optimized approach to power distribution.

A comparison is drawn between traditional and modern power distribution architectures to determine their efficiency in satisfying modern data center requirements. Finally, this paper highlights the significance of arc flash risk in the data center and discusses how improved arc resistance can be achieved through innovative busway power distribution architecture.

## The Changing Data Center Landscape

Over the past decade data centers have become one of the world's fastest growing industries, with the market expected to **grow with a CAGR of 15.1% between 2019 – 2025.** Despite being little understood by the population it serves, the data center industry plays a critical role in modern society by storing, processing, communicating, and distributing the data we produce every second of every day.

### The Driving Force

In recent years there has been a paradigm shift towards a new digital era which has changed the dynamic of how we process, consume, and communicate information. The emergence of the IoT, big data and machine learning amongst other developments has digitized our every day lives, resulting in an increase in data consumption patterns. **In fact, it is estimated that the global datasphere will grow to over 175 zettabytes by 2025.** As a result, data centers must seek to employ higher capacity power distribution networks with higher rack densities and higher efficiency designs to satisfy demand.


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### The Challenges

Many data centers are struggling to keep up with rapid rate of change in the digital landscape. According to a report by Forbes, **less than 30% of data center decision makers state their data center meets their current needs and only 11% say that data centers are updated ahead of their needs.** The issue is that many of today's data centers still employ the same power distribution systems that were installed on day one.

**Power distribution is a huge investment for any data center, and it is typically expected to have a minimum lifespan of 10 years. In contrast, the IT equipment it powers typically has a lifespan of 2-3 years,** sometimes even shorter. As a result, older power distribution systems can become outdated if they cannot be easily adapted and integrated with these newer technologies, resulting in rigid, inefficient, and fragmented data center operations. Similarly, there is a concern that data center capacity may become overloaded as organizations struggle to keep up with the increasing levels of data consumption, causing increased risk to uptime and safety in the data center.

**The primary objective of any data center is to achieve 100% availability of safe and reliable power.** As the digitization of services continues to drive the global demand for data, this is becoming increasingly difficult for data centers across the world, who are being forced to change their DNA and seek out smarter power distribution solutions to overcome these new challenges.


*"Less than 30% of data center decision makers state their data center meets their current needs".*

## Scalability

Regardless of the type of data center – Hyperscale, Co-location, Enterprise, or Edge – **Scalability should always be a key priority when specifying power distribution architecture.** Today, society expects seamless transitions and instant access to data, so it is vital that data centers have sufficient elasticity to expand or contract their available power capacity in line with demand. As data consumption trends continue to fluctuate and grow at an unprecedented rate, it is more important than ever for data centers to employ infrastructure that can quickly adapt to changes in the market without putting operating efficiencies at risk.

## Efficiency

Data centers require uninterrupted and efficient power supply to remain competitive in today's market. **A key issue facing businesses is the risk of unplanned downtime,** which can have a potentially devastating impact on both profitability and brand reputation. Data centers must strive to employ improved efficiency design to increase the level of power available to their IT infrastructure.

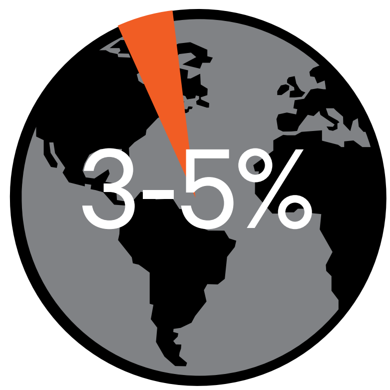
**To ensure continuity of efficient power, data centers must have full visibility of the power distribution system and all connected infrastructure.** This can be achieved through bespoke monitoring architecture that can anticipate and react to impending issues that may compromise the power supply, thus reducing the risk of costly downtime.

## Space Optimization

**White space is at a premium in the data center** as this is where core infrastructure such as server cabinets, storage, network gear, racks, air-conditioning units, and power-distribution systems are located. As the demand for data increases so too does the IT infrastructure required. Therefore, usage of the white space must be carefully planned and optimized to reduce wasted space and must be easily reconfigured to facilitate the addition of new IT infrastructure as and when required.

## Cost

As the landscape is changing so rapidly in terms of new technology and demand, **investments in power infrastructure must be carefully considered to ensure the investment will not become obsolete before its value has been recouped.** Operating costs are also a growing expenditure for data centers as they are estimated to consume between three and five percent of the world's power by 2025. As power capacity increases, so too does the associated energy costs, therefore data centers must seek to offset this increased expenditure, if profits are to be protected. As a result, Data center managers are seeking out power solutions with both relatively low capital and operating costs.




*Operating costs are also a growing expenditure for data centers as they are estimated to consume between three and five percent of the world's power by 2025*

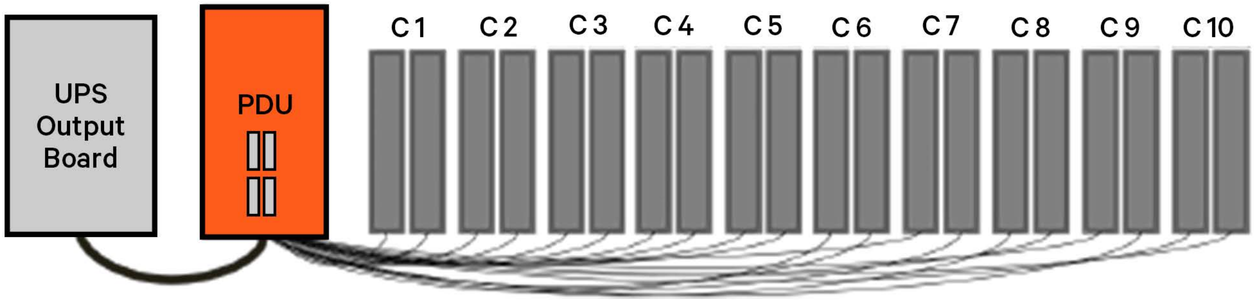
## Safety

Safety always has and always will be a key concern in the data center, as not only can electrical faults result in costly downtime, but they can also cause serious harm to human life.

However, **as power densities and capacities increase, the scale of electrical infrastructure within the data center increases too, which in turn increases the potential risk during standard installation, operation and maintenance procedures.** For instance, the more time spent repairing or upgrading a piece of infrastructure, the more likely it is that human error will occur. This error could be something as small as dropping a tool into a live PDU or not correctly disconnecting a circuit breaker before maintenance, which can have potentially fatal consequences.

## Traditional Power Distribution Architecture

**Many of today's data center facilities still rely on traditional power distribution architectures that pre-date the digitization of the industry.** When traditional power distribution systems were designed, data centers were a lot less complex than they are today, consisting of a small number of large IT devices, where changes or upgrades were infrequent and lower power densities required less cooling.




Traditionally, power in the data center was distributed through power distribution units (PDU). PDU's are typically rated from 50kW to 500kW and consist of a main input circuit breaker, branch circuit panel boards, a power transformer, output power cables, surge arrestor and the monitoring and communication modules. PDU systems can be designed with an inbuilt or standalone transformer to convert the incoming voltage and distributes the appropriate voltage to the branch circuits to power the IT load. **PDU's designed with an inbuilt transformer will have a much larger footprint, consuming approximately 2.5m² per 100kW of IT load.**

To accommodate the long lengths of cabling required to distribute power from point A to point B, data centers can be designed with a raised floor access or overhead cable trays. One of the main uses for raised floor access is to create an air plenum for cooling. Air flow is typically managed via vented floor tiles with aluminum grills. The under-floor void provides a space to route cabling and pipework including electrical wiring, data and telecoms wiring, security wiring and HVAC/air conditioning system components.

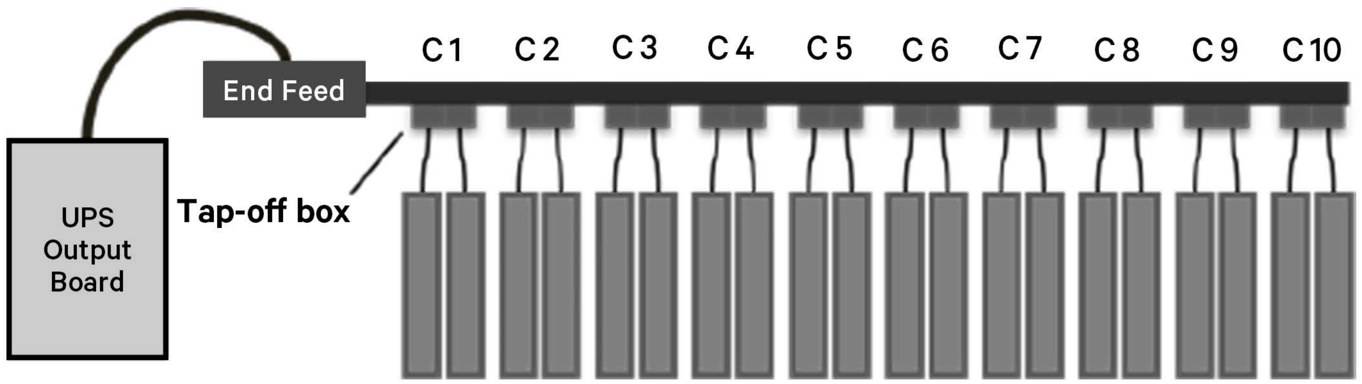
However, in applications with limited room height or heavy equipment. Raised floor access may not always be a feasible choice. An alternative practice is to create an overhead cable pathway via cable trays that are mounted above the racks or suspended from the ceiling.

**Although these traditional architectures have evolved over the years, the fundamentals of their design are fast becoming incompatible with the fast-paced and volatile nature of the industry,** resulting in the following inefficiencies.

- The scalability of underfloor applications reduce as they expand and underfloor cable space becomes limited.
- Large footprint of the PDU reduces the space available for additional power/ IT infrastructure in the white space.
- Due to underfloor cabling, circuits can have poor traceability, making it difficult to monitor which circuits are near overload.
- Large transformer based PDU units generate waste heat that must be cooled, decreasing data center efficiency.
- Circuit addition is slow, therefore any additions or changes to the power network will require significant lead time.
- Limited underfloor space can have a negative impact on efficiency as cooling plenums become blocked with large amount of cable, reducing air to flow risk and increasing heat loss.
- Rigid layout due to complex architecture and reduced cable access, making it very time consuming to facilitate new data center layouts.
- The overall electrical design of the room may require a re-think with under-floor electrical cables rerouted to accommodate new infrastructure layouts.
- Electricians may be forced to carry out live work during maintenance, increasing the risk of an arc flash incidents.
- There is always the danger that a worker will accidentally touch a live circuit, or drop a metal tool, resulting in an arc flash incident.
- Power availability is reduced as systems must be powered down for maintenance or system changes to be undertaken safely.
- Complex installation and configuration processes require significant time to complete, increasing labor costs.
- Low day 1 cost, however the cost of adding new circuits can be high due to the lengthy process required to route new cables.
- Lack of scalability results in power distribution systems being either overbuilt or under built; both of which reduce operational efficiency.

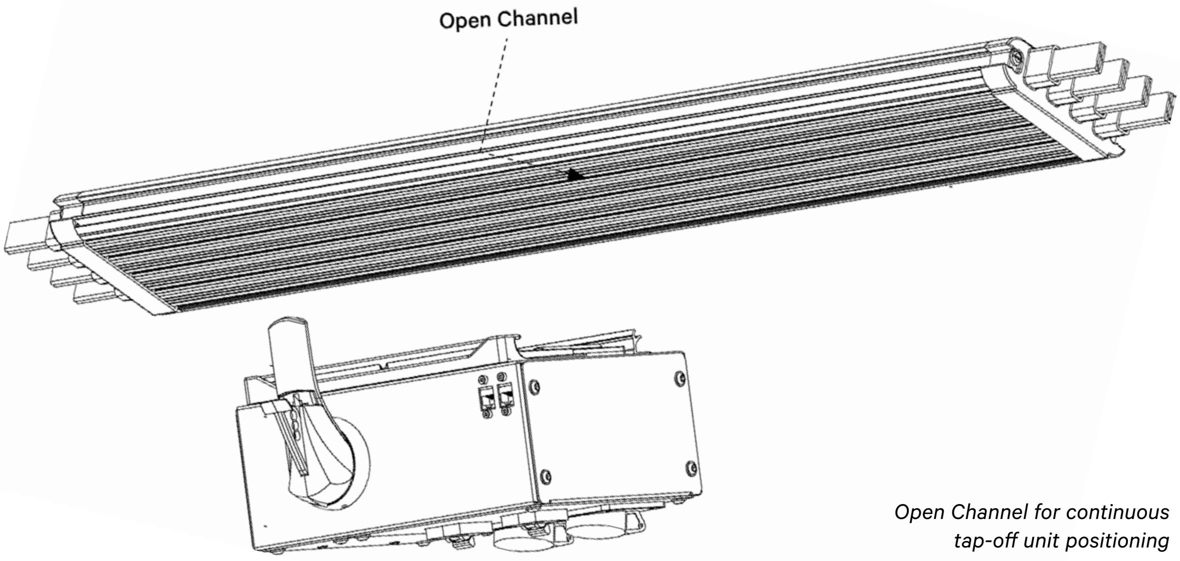
## Modern Power Distribution Architecture

Busway is an alternative to traditional PDU and RPP power distribution. Modern busway power distribution architecture typically includes an end feed unit connected to an upstream LV electrical switchboard, busway and tap-off units equipped with over-current protection devices, connection fittings and their accessories.




Busways are most often seen in high-density data center applications providing flexible overhead power distribution where scalability is vital to success. Busways can be installed horizontally, vertically, overhead or underfloor depending on power requirements however they are typically installed overhead in data centers to power the IT racks. **Busway alone can provide all LV power distribution from the LV switchgear/switchboard to IT racks, eliminating the need for bulky PDU's.**

Busway trunking solutions use feeder lengths to distribute power to rack level. Each feeder length will be designed with a set amount of tap off points as specified by the client. **Alternatively, modern open channel busway solutions are designed with a continuous open path that delivers power along the entire length so tap off units can be installed without restriction.**




*Open Channel for continuous tap-off unit positioning*

The development of open channel busway systems has revolutionized the data center industry, offering an optimized power distribution architecture that can distribute and manage power capacity in line with current and future requirements. This innovation in power distribution enhances data center safety, flexibility, availability and cost efficiency through the following characteristics.

- Integrated branch circuit power metering means that capacity and redundancy are managed on every circuit.
- Flexibility to reconfigure data center layouts by adding additional tap off boxes or relocating existing tap offs on the busway.
- Lifetime cost is lower due to improved scalability and reduced installation time required.
- Zero footprint design – Increased availability for IT infrastructure in the white space.
- Improved traceability - Tap off units are located above racks and circuit protection is located exactly above the load.
- 'Hot swappable' plug and play installation means circuits can be quickly added and removed while the busbar is live, reducing data center downtime.
- Pre-assembled tap off units improve efficiency by eliminating field wire cutting and terminating branch circuits
- Finger safe protection from conductors improves operator safety.
- Higher integrity than cable applications. Aluminum/steel housing protects the conductors from physical stresses.
- Overhead positioning of the busway allows for unrestricted system cooling.

## Comparing Power Distribution Approaches

Having discussed the key challenges faced by modern data center managers and evaluating the application of both traditional and modern busway solutions, we will now compare how each power distribution architecture satisfies the challenges previously discussed.

The table above clearly highlights how **modern open channel busway solutions provide optimized power distribution in terms of scalability, power availability and space optimization.** Whilst open channel busway also provides improved safety, the risk of arc flash is not completely eliminated without the use of additional OCPD. Complexities also arise when assessing the cost efficiencies achieved by each architecture, as this will be largely dependent on the size of the individual data center and unique specification.

| | TRADITIONAL PDU ARCHITECTURE | MODERN OPEN CHANNEL BUSWAY |
|---|---|---|
| **SCALABILITY** | Adding or removing circuits is complex and requires an electrician, resulting in longer lead times to scale power up or down. | Plug and play installation allows for quicker capacity deployment. Capacity can be added more gradually, as and when required. |
| **POWER AVAILABILITY** | Limited space for underfloor cabling can restrict airflow reducing electrical efficiency of the system.<br>Scheduled downtime is required to make any changes to the system. | Superior cooling and material properties result in a more power efficient system.<br>Hot swappable tap off units eliminate the need for downtime. |
| **SPACE** | Floor mounted PDU's have a significant footprint which eats into the premium 'white space'. | Zero footprint design offers increased space availability for key IT infrastructure. |
| **SAFETY** | Cables are subject to wear and tear which can cause breaks in electrical insulation.<br>Live working may be required during maintenance to avoid downtime - There is a risk of tools being dropped into the PDU resulting in an arc flash. | Less exposure to live circuits, due to the finger safe design of busway.<br>Solid conductors are more durable and less likely to wear, reducing electrical risk.<br>Higher efficiency design of the busway can increase arc flash risk if suitable OCPD are integrated. |
| **COST** | Low initial cost of PDU, however the labor intensive and time consuming process of adding new circuits can be very costly. | Power capacity can be gradually scaled up with ease, reducing upfront costs. Minimum labor is required for circuit addition providing lucrative cost savings. |

## Safety by Design: Arc Resistant Open Channel Busway

As power capacity and rack densities increase, so too does the available fault current. I**ronically, the quest for higher efficiency designs can also increase the risk of arc flash in the data center.** The low impedance design of modern busbar trunking systems, reduces resistance to the current traveling along the busway. Although this is beneficial for reducing heat loss and voltage drop, it also increases prospective fault current levels which can trigger dangerous arc flash incidents.

Vertiv's Intelligent Medium Powerbar is an open channel busway system designed for use in data centers and other mission critical environments. **The arc resistant design of the iMPB product is achieved through an extensive range of inbuilt safety features that can be tailored to meet the requirements of individual specifications:**

- Fully UL Certified and IEC / CE approved
- Rated operational voltage: 600A
- Rated insulation voltage: 1000A
- Rated current: 160A – 1,000A
- Short Circuit Rating: Minimum of 50KAIC
- Individual Tap-Offs rated up to 125 Amps for each phase

## Over Current Protection Devices

Overcurrent protection devices are designed to detect fault conditions in an electrical system and automatically disconnect the electrical equipment from the power source, where the fault current exceeds the current capacity of the busway. The two devices used to protect circuits from overcurrent are fuses and circuit breakers.

Fuses operate by breaking the flow of fault current through the busway to restore normal operating conditions. Each fuse contains a metal wire element, designed to carry a limited current. When a high fault current flows through the fuse it will generate heat causing the fuse element to melt. This creates a gap in current flow, protecting the busway system from high incident energies that could trigger an arc flash incident. Once the fuse has blown, it can no longer serve as a protection device and must be replaced.

Although circuit breakers serve the same purpose, they operate differently, using an electromagnetic force triggered by a high fault current to automatically disconnect the electrical equipment from the voltage source. Although they take more time to clear the fault than a fuse, circuit breakers have the added benefit of being reset so they can be used multiple times.

**Vertiv's Intelligent Medium Powerbar can be designed with an extensive range of MCCB's, switch fuses and isolators to ensure maximum protection against potential fault currents,** tailored to your specific specification ratings.

## Continuous Monitoring

**Continuous monitoring is extremely important in modern data center power distribution,** where densities, capacities and electrical efficiencies are increasing. This gives data center managers complete visibility over the power system, detecting potentially harmful operational abnormalities before continuity of power is compromised.

**Vertiv's Powerbar iMPB is equipped with advanced metering technologies at final circuit, end feed and tap off level, ensuring maximum control and energy efficiency across the entire power distribution journey.**

In addition to electrical monitoring, **Vertiv offers optional continuous thermal monitoring** at end feeds and other power conduction points that have the potential to develop hot spots over time. This will provide **real-time heat rise data for each cable landing.** Heat rise data shall be provided to the EPMS system via Modbus TCP protocol.

### Thermal monitoring options available include;

- IR/Contact Continuous Temperature Monitoring
- Wireless Continuous Temperature Monitoring
- Infrared Windows for Periodic Manual Scanning

| End Feed Monitoring Capabilities | Tap Off Unit Monitoring Capabilities |
|---|---|
| Input voltage (L/L and L/N) | Input voltage per phases (L/L and L/N) |
| Current per phase (Min/Max) | Current per phase (Min/Max) |
| Voltage per phase (Min/Max) | Voltage per phase (Min/Max) |
| Neutral current | Power factor |
| Power factor | Frequency |
| Frequency | Power (active, reactive, apparent) |
| Power (active, reactive, apparent) | Demand / energy consumption (kWH) |
| Demand(kWh) | Current peak demand |
| Voltage and current THD% | THD – Total Harmonic Distortion (Optional) |
| Current peak demand | Status monitoring (Optional) |

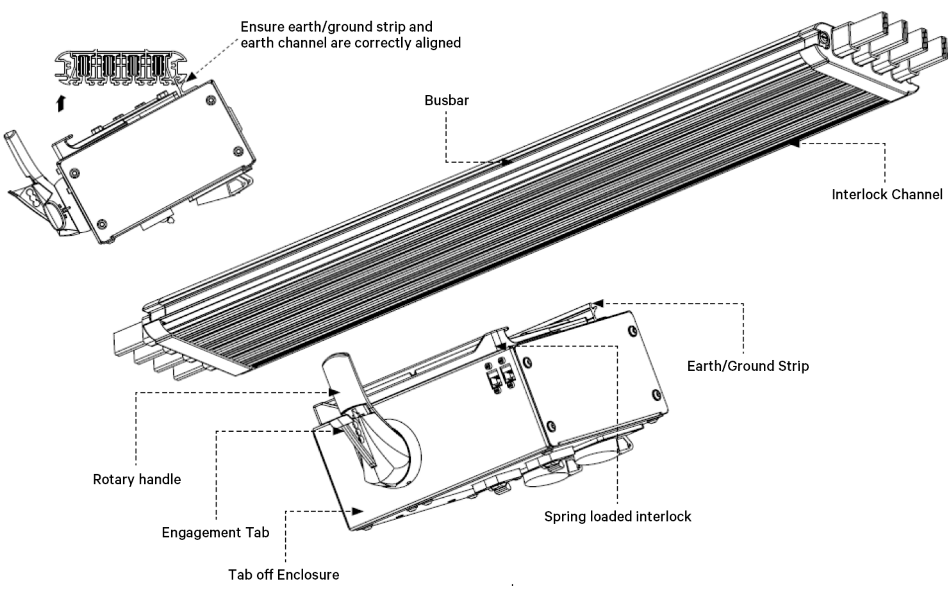
## Mechanical Interlocking

**An MCB Safety Interlock can be integrated into Vertiv's Powerbar iMPB product to prevent the tap off unit being fitted to the bar while the MCB is in the 'On' position.** Similarly, the tap off unit can only be removed from the busbar when the MCB is in the 'Off' position. The MCB can only be switched on when the contacts are fully engaged with the busbar. **This provides users with an extra layer of safety when fitting/removing tap off boxes from the busbar.**

The mechanical interlock secures the tap off box to the busbar using high tensile strength lockable hardware which cannot be fitted incorrectly. Once fitted to the bar, the engaged handle can be turned. This lifts the contacts into the busbar and has a positive lock once fully rotated.

This mechanical connection between the tap off unit and the busway prior to any electrical connection, ensure that there is no risk of an arc flash incident when installing iMPB tap off boxes to the busbar.

**iMPB tap off units are fitted to the busbar using a three step installation process and E+I Engineering's unique 'earth first, break last' safety feature.** Each tap off unit interlocks onto the distribution length with a ground strip. This ensures that the ground is the first point of contact with the busbar system during installation, achieving a lower fault current and lower fault clearance time as excess current will always exit the busway system through the grounding strip.




### STEP 1

The units interlock into the busway with a ground strip. This ensures that the ground is the first point of contact with the busway system during installation

### STEP 2

The mechanical interlock secures the unit to the bar using spring loaded hardware which cannot be fitted incorrectly. It is impossible to engage the Tap Off Box to the wrong phase.

### STEP 3

Once fitted to the bar, the engaged handle can be turned. This lifts contacts into the busway and locks once fully rotated.

## Conclusion

As the increase in global data consumption continues to challenge the status quo of the data center industry, organizations are being forced to change their DNA in search of smarter power distribution solutions that are better equipped to change and adapt in line with the operational needs of the modern data center.

Having explored the key characteristics of traditional data center power architecture, it can be concluded that the fundamentals of legacy architecture are fast becoming incompatible with the ever-changing nature of the industry, lacking the high level of flexibility and power availability required in today's market. In response to this, modern architectures such as open channel busway systems have been developed to overcome the power distribution challenges faced by todays data center operators.

The comparison conducted between both traditional and modern architectures, clearly highlights how modern open channel busway solutions have revolutionized power distribution in the data center industry in terms of scalability, power availability, space optimization and safety; With particular consideration given to the enhanced safety measures available to facilitate higher rack densities and higher efficiency in modern power distribution designs.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