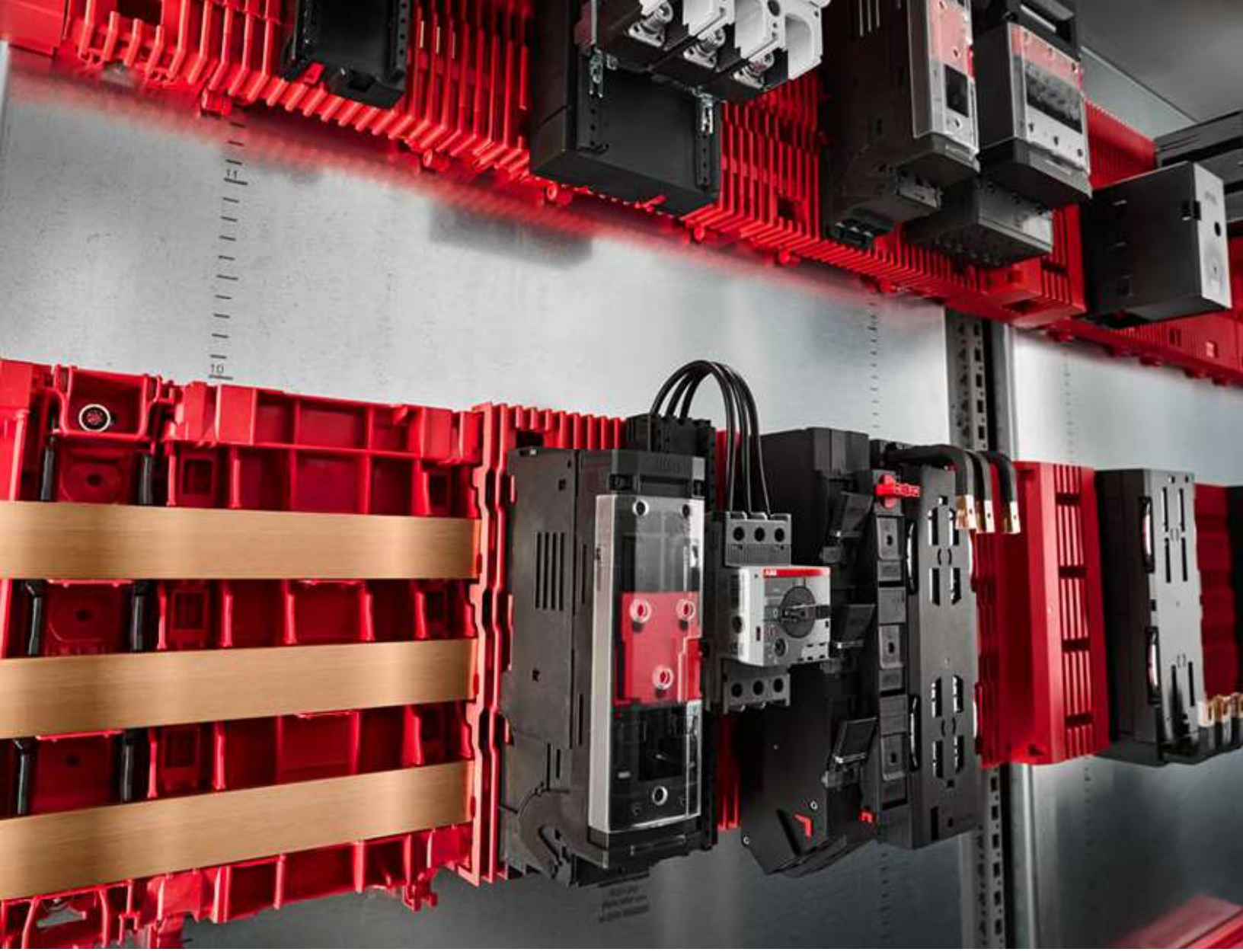


# Busbar

## The Next Evolutionary Step in Control Panel Design

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# 1 | Summary

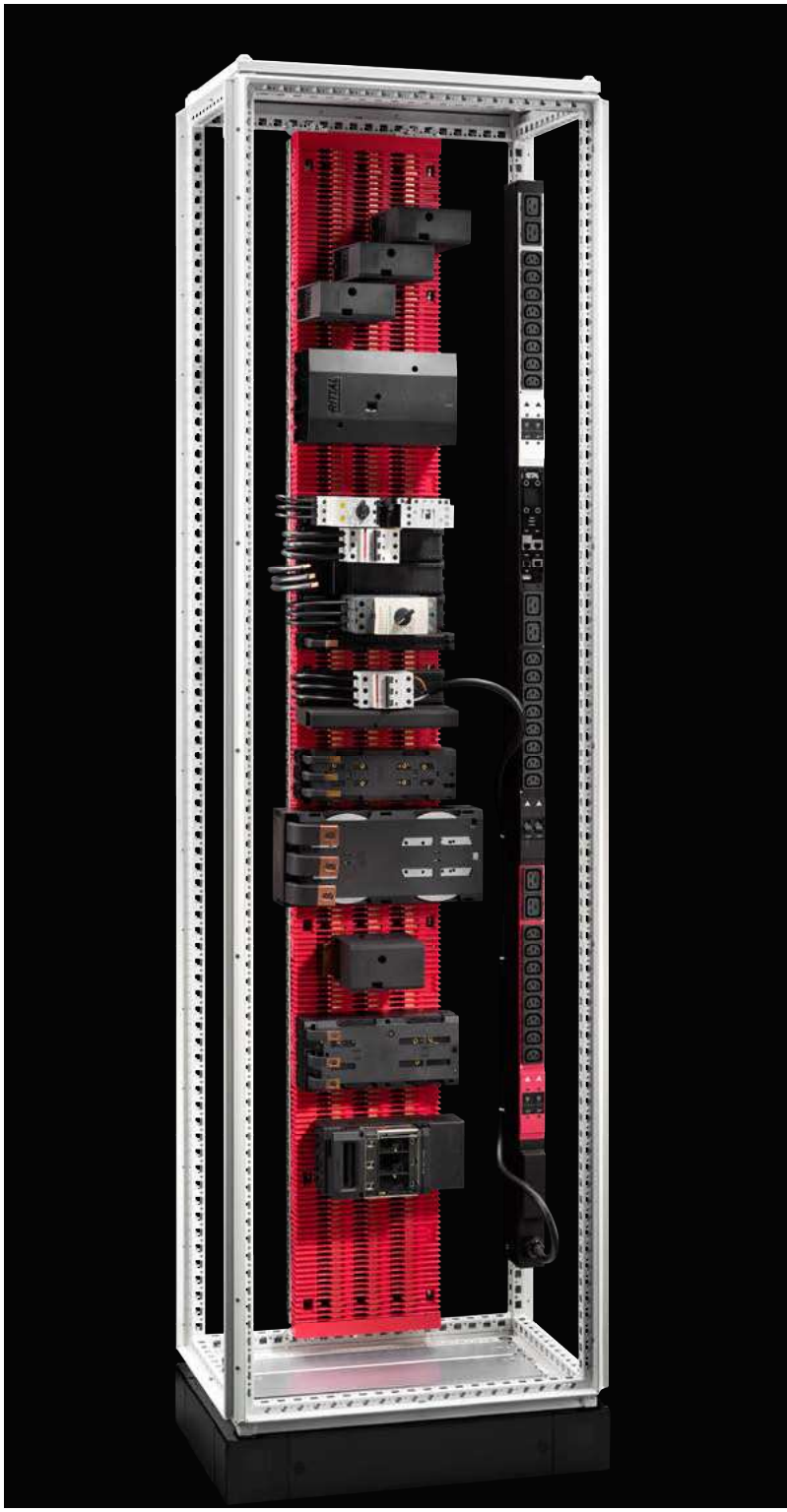
As IEC devices became the preferred choice for designers in the automation industry, the need for a unified standard became increasingly apparent. Since 1989, UL 508 served as the primary U.S. standard for industrial control equipment. In 2017, the harmonization of UL 508 with IEC 60947 for low-voltage switchgear and controlgear resulted in UL 60947, further solidifying IEC devices as the industry standard.

Design engineers, system integrators, and original equipment manufacturers (OEMs) have long recognized the advantages of IEC technology, including reduced costs, improved safety, and more efficient panel designs. Today, the next evolutionary step in control panel design is the adoption of busbar systems. Much like the transition from NEMA to IEC devices, busbar technology offers significant opportunities to improve panel performance, simplify design, and reduce overall costs.

The factors that drove widespread adoption of IEC equipment are the same factors driving the growing use of busbar systems in modern control panels:

1. Easier design
2. Smaller size
3. Lower cost
4. Enhanced performance
5. Improved safety
6. Global market acceptance

This paper explores how busbar systems extend the advantages of IEC technology and why the combination of IEC devices and busbar architecture represents the next step in optimizing control panel design for efficiency, safety, and long-term competitiveness.



# 2 What Is Busbar?

Before we get into how busbar offers the same benefits as IEC devices within a control panel, it is important to understand what a busbar system is and how one is used today. **A busbar is defined as an electrically conductive strip or bar used to distribute power to multiple circuits in parallel.** Busbar can also be used as a common tapping point for multiple ground or neutral terminals.

Typical parts comprising a busbar system for control panels are as follows:

- Copper busbar and splice connectors
- Busbar supports
- Cover system for contact hazard protection
- Connection accessories such as connection adapters, cable clamps, and plate clamps
- Component adapters for items that mount to DIN rail
- Circuit breaker adapters
- Fuse base adapters
- Insulated flexible busbar

The use of busbar for switchgear goes back to the dawn of electricity generation and is very common in both residential load centers of 200A and less and in industrial motor control center (MCC) applications of more than 1200A. Busbar is used within control cabinets of 200 to 1600A by panel builders and OEMs.

However, busbar isn't always the first option for several reasons, including:

**1. Initial Cost vs. Total Installed Cost**
The cost of busbar can be a deterring factor unless the right conditions are met. Identifying the tipping point can be challenging, however, having more branch circuits makes for a more effective busbar system when it comes to panel space and cost savings. Of course, if saving space is paramount at any cost, a busbar system will achieve this for virtually any application.

**2. Panel Standardization**
Residential load centers across manufacturers are similar in design – 200A and 100A load center designs are basically the same, but the 200A bus will be thicker and have more space for circuits. Likewise, the modular capabilities of most MCCs have similar designs regardless of the application. In contrast, a control panel is purpose-built, and it is unlikely that any two are exactly the same making it difficult for panel builders and / or engineers to standardize on any control panel installation technique.

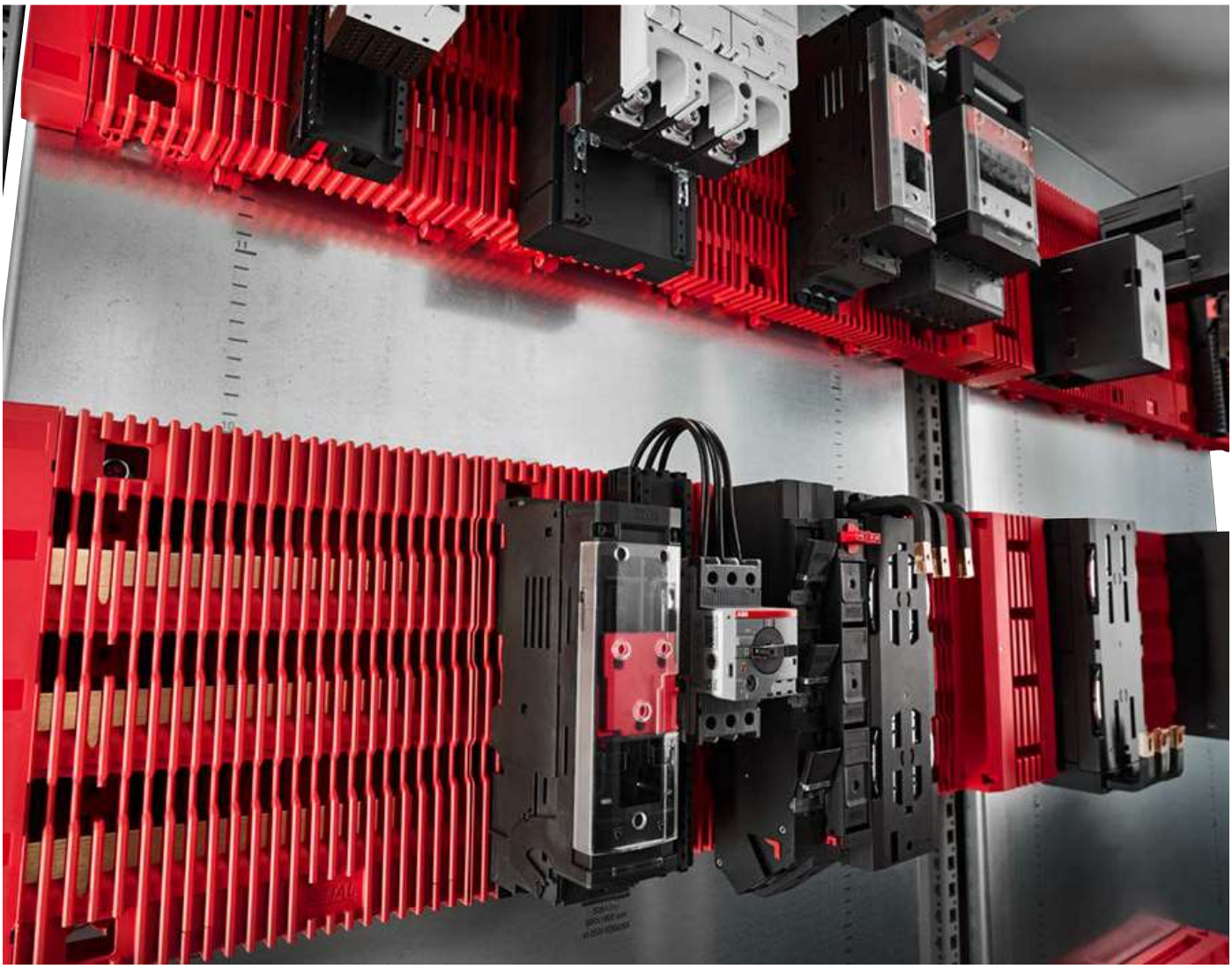
**3. Unfamiliarity with Busbar**
Many North American engineers and panel builders are unfamiliar with busbar systems, and therefore continue to rely on traditional wiring methods.

Modular busbar systems for control panels consist of pre-engineered components designed to make power connections with common solid copper conductors. The system can be configured in varying sizes and lengths, optimizing the panel space for a given application.



# 3 | Busbar System Benefits for Panel Builds

While the factors above can make busbar systems seem difficult to justify at first glance, they are not limitations of the technology itself. Rather, they reflect common considerations in applying busbar to purpose-built control panels where design requirements, available space, branch circuit count, and standardization practices can vary significantly from one application to the next. When these factors are evaluated at the system level, busbar offers a compelling path to more efficient panel design and construction. In many ways, busbar systems deliver the same advantages that helped IEC devices become the preferred choice for control panels: easier design, smaller size, lower cost, enhanced performance, improved safety, and broader global market acceptance.



# 4 | Easier Design

Busbar systems are designed to support the standardized ratings/size of IEC devices.

IEC components have a standardized modular design with widths consistent along product lines. For example, 2-pole devices are twice the width of a 1-pole, while a 3-pole version is three times the width.

In general, motor starters:

- Rated 37A and below are 45 mm wide
- Rated between 40A and 55A are 54 mm wide
- Rated 60A to 100A are 72 mm wide

In addition, most accessories like auxiliary contacts can be used with devices regardless of rating / size. This standardization allows designers to configure panel layouts across various device manufacturers much easier. Pre-engineered busbar systems take full advantage of these standardized metric widths. For the most part, finding an adapter to work with a particular component simply involves checking for a matching width and current rating.



# 5 | Smaller Size

IEC motor controls under 100A, which make up more than 80% of the market, are generally **30–70% dimensionally smaller** than equivalent NEMA controls. The primary reason is improved arc suppression.

Each time a contactor opens or closes, an arc forms and slowly degrades the metal contacts. NEMA contactors use larger conducting surfaces to account for this wear. IEC contactors, with better arc suppression, require less material and are therefore smaller. While larger NEMA units typically offer longer life spans with higher rated mechanical and electrical operations, IEC standards define specific utilization categories for contactor and relay load and duty cycles, making it easier to select the proper controls for a given application.

At its core, a busbar system is designed to replace the line-side wiring and associated accessories in an electrical panel. In a traditionally wired panel:

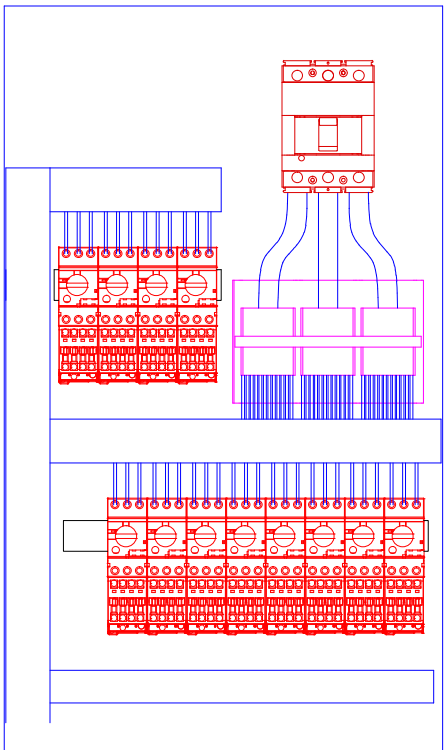
- Large, high-amperage feed cables run to power distribution blocks (PDBs)
- PDBs convert high-amperage cables into multiple smaller, low-amperage cables
- These smaller cables are routed through wire duct to each individual device

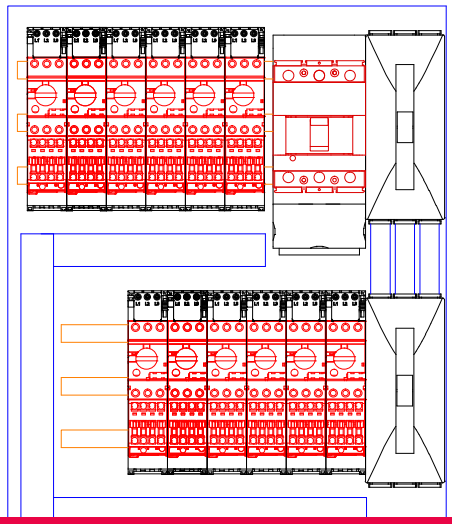
**A busbar can replace these components while offering several key advantages over a traditional block-and-cable design.**

Except for rare main-lug-only applications, most control panels include a main overcurrent protective device (OCPD), such as a circuit breaker or fused disconnect. In most installations, the main OCPD is panel-mounted, with controls, line-side wiring, distribution blocks, and wire duct located beneath it. However, when the main OCPD is small enough, generally 600A or less, it may be mounted directly onto the bus. This places the OCPD on the same row as the control devices, saving valuable panel space.

If the OCPD is too large or otherwise unable to mount directly to the busbar with an adapter, the bus must be energized with feed cables. Larger installations often require multiple cables per phase. In these cases, insulated **flexible busbar can replace multiple cables with a single conductor**. It carries the necessary certifications and ratings for an easy transition from standard round cable, while also saving panel space and reducing integration time by eliminating the need to cut and strip multiple cables. Flexible busbar also offers a wire bend radius as small as 1/8 inch.

**Traditional Wiring System** **vs.** **Busbar System**





- 12 motor starter application
- Same 20 inch panel width
- OCPD mounted at the same height on each
- Busbar system has smaller footprint with room for expansion
- Traditional PDB is full, limiting future circuit expansion

# 6 | Lower Cost

IEC equipment often proves less costly than NEMA equipment because of differences in design philosophy. NEMA standards are more generalized, resulting in robust controls built to handle a wide range of applications. IEC standards are more specific, allowing components to save space and cost by providing more precise control for the given application.

Busbar systems apply this same principle to power distribution within the panel. Rather than building each power connection with individually routed wire, terminal blocks, and manual terminations, busbar creates a more standardized and scalable method for distributing power to multiple IEC devices.

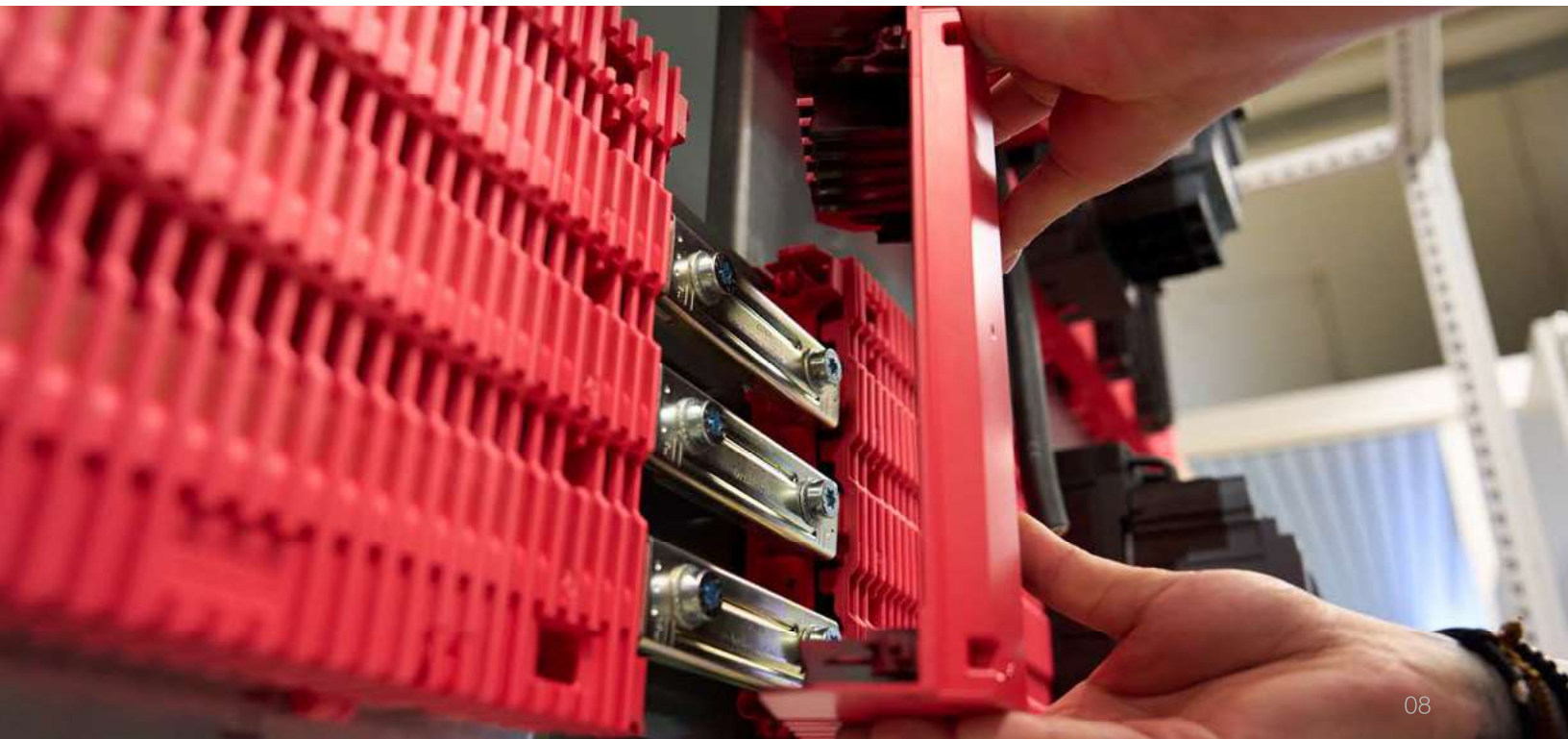
NEMA devices are designed around standard size ratings: 00, 0, 1, 2 … 9. This gives the device a longer life span, but it also means many NEMA devices are overbuilt for their application. For example, a NEMA Size 0 contactor is rated **5 HP at 460V**, with a full load current of **8A**. The same contactor has a continuous current rating of **18A, more than double the full load current.**

IEC components are application rated rather than defined by standard sizes, with continuous current ratings much closer to their switching capacity. An IEC contactor equivalent to a NEMA Size 0 is also rated **5 HP at 460V** with **8A FLC**, but has a continuous current rating of only **9A**. This tighter tolerance means **IEC controls are typically offered in twice as many sizes as their NEMA-approved counterparts,** allowing for more precise arrangements, less waste, and lower cost.

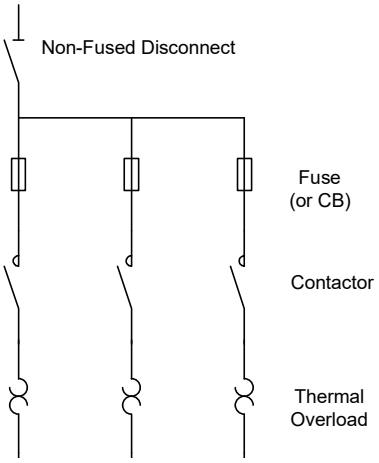
Busbar becomes especially valuable in these multi-device arrangements because it provides a clean, repeatable way to distribute power across several IEC components without duplicating the same block-and-cable wiring for each branch circuit.

IEC manual motor protectors and combination motor controllers also reduce cost by replacing multiple NEMA single-function devices:

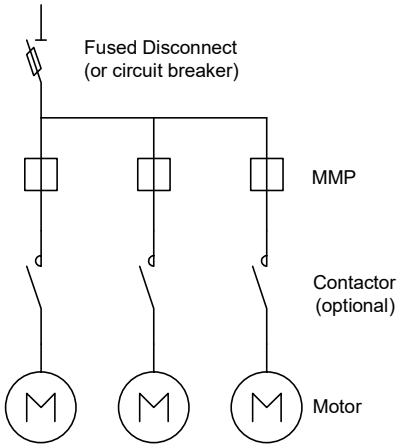
- **Manual motor protectors (MMPs)**, also known as manual motor controllers or motor protection circuit breakers, can provide both motor control and overload protection.
- Several MMPs may be placed on one branch circuit in a group motor installation.
- **Combination motor controllers (CMCs)** also function as branch circuit protection devices, allowing them to be used like group motor installations but without the same restrictions.



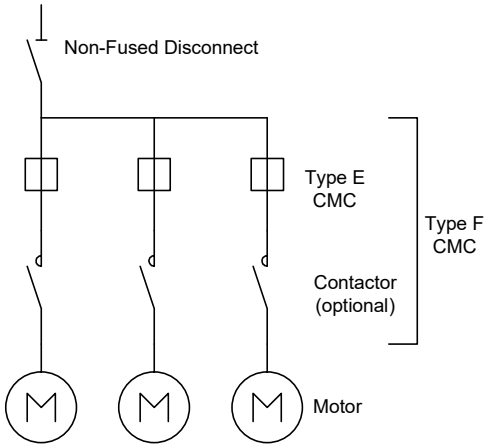
**Traditional Motor Circuit**




**Group Motor Circuit**




**Type E/F Motor Circuit**




Both IEC devices and busbar systems can also reduce labor costs. Virtually all IEC controls up to 100A are designed to mount to a standard 35 mm DIN rail. Instead of drilling and tapping holes for each component, a panel integrator can install an entire row of IEC devices with only a few screws to support the DIN rail.

For busbar systems, acquisition costs are offset by the parts they replace, including line-side wiring, power distribution blocks, and wire duct. Additional savings may come from reducing enclosure size or, in larger systems, eliminating an enclosure altogether. However, **the largest savings come from easier installation and reduced labor.**

In the past, many switchgear installations using busbar required bending, drilling, and tapping copper bus. Newer standardized modular busbar systems eliminate this work. The bus typically only needs to be cut to length, and in some installations even that step may not be necessary. Connections are made through adapters held in place with set screws or tool-less spring clamps.

Busbar systems also reduce mounting panel modifications. Accurately drilling and tapping many holes by hand can be a major task. Even with CNC equipment, fewer hole locations mean less tooling wear and faster turnaround. In the example above, **8 holes for busbar supports can replace all 26 panel holes** used to mount the OCPD, PDBs, DIN rail, and line-side wire duct.

| Number of Holes to Drill / Tap | | |
|---|---|---|
| | Block & Cable | Busbar |
| OCPD | 4 | 8 |
| PDB | 6 | |
| Wire Duct | 8 | |
| DIN Rail | 8 | |

For applications with very large components, such as OCPDs, VFDs, or SCRs, single pieces of flat flexible busbar can replace multiple round conductors. This saves the labor required to fabricate and terminate cables. Flexible busbar may also eliminate a set of lugs on larger components since it is flat and can mount directly to the copper stab of the device.

Smaller components may also be bench wired onto adapters, allowing kitted assemblies to be completed by less-skilled labor. In these cases, the assembler does not necessarily need to read a wiring schematic. Eliminating wiring steps creates significant savings, since each wire would otherwise need to be measured, cut, stripped, terminated, labeled, and routed through cable duct.

# 7 | Better Performance

Many of the benefits listed thus far support the engineer or panel builder. However, better system performance directly benefits the end user. IEC overload relays provide several enhancements, while busbar systems make it easier to troubleshoot, retrofit, or expand with additional circuits. Together, these advantages mean one thing: **less downtime on the factory floor.**

**An estimated 30% of all motor failures can be attributed to overload conditions**. Most IEC overload relays are Class 10 units, with a 10-second tripping time. Typical NEMA relays are Class 20 units, with a 20-second tripping time, making IEC units twice as fast.

**An estimated 15% of all motor failures can be attributed to single phasing**, which usually occurs when an upstream single-phase load causes an imbalance in a downstream three-phase load. Bi-metallic IEC overload relays are designed with phase-loss sensitivity in mind. In the event of an electrical imbalance, a differential tripping mechanism makes the overload relay more sensitive by lowering the trip point.

Motor temperature is affected by magnetic and current effects, as well as the ambient temperature where the motor operates. Since ambient temperature can vary, the tripping time of the overload relay protecting the motor can vary as well. IEC overload relays use mechanical means to **reduce temperature effects and maintain trip times regardless of conditions.**

In traditional control panels, wire sizes are constrained and there is limited, or possibly no, room for future expansion. Even when expansion is possible, it is often difficult and messy, requiring the mounting panel to be drilled and tapped for larger devices.

By contrast, **a modular busbar system designed for future expansion can accept additional control components without drilling and tapping.** This provides several performance and serviceability advantages:

- Additional control components can be added more easily
- Existing devices can be removed from adapters and replaced with new hardware as needed
- Panels can be retrofitted for different applications with less rework
- In some cases, busbar can even be removed and repurposed in a new enclosure

This level of flexibility is considerably easier than making similar changes in a traditional block-and-cable design.

Maintenance and troubleshooting are also more efficient in a system utilizing busbar:

- Line-side wiring does not need to be traced
- Components can be quickly replaced from their adapters
- Replacement parts can be more easily sourced due to the global availability of busbar components

As with IEC devices, this global availability gives the end user added assurance that replacement parts will be accessible when needed.



# 8 Enhanced Safety

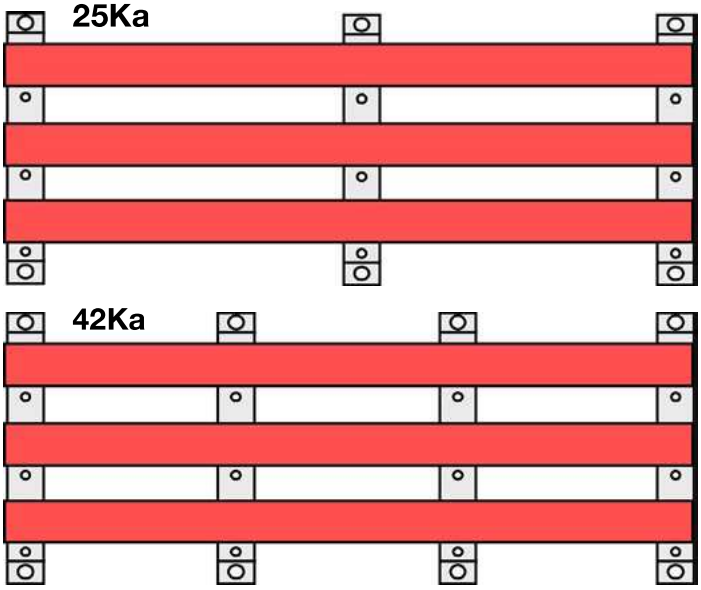
Both IEC devices and busbar systems are equipped with measures to help prevent accidental contact with live parts. Ingress protection (IP) ratings are defined within **IEC 60529** and consist of two numerical digits:

- The first digit defines protection against contact with foreign bodies
- The second digit defines protection against water

IEC devices feature **IP20 bodies, meaning objects 12.5 mm, or 1/2 inch, and greater** are unable to contact the live terminals of the device.

Another incorporated safety measure, is more specific short-circuit performance criteria. These criteria, specified by **IEC 60947**, define how devices are allowed to perform after a short-circuit event:

- **Type 1 coordination** devices are allowed to show damage and are not suitable for reuse without repair or replacement of parts
- **Type 2 coordination** devices are not allowed to show damage and are considered suitable for reuse after a short-circuit fault




*More busbar supports increases rigidity and SCCR

In addition to providing **enhanced safety by reducing the possibility of a dangerous arc flash**, a Type 2 device also **saves downtime and increases productivity** because the panel does not require repair or replacement of damaged components.

In the past, busbar was often used in single-use systems fabricated for a specific application. Even today, only a few manufacturers make standardized modular busbar systems suitable for control panel use. **One common misperception is that busbar systems are more dangerous because touch-safe installations are difficult to achieve.**

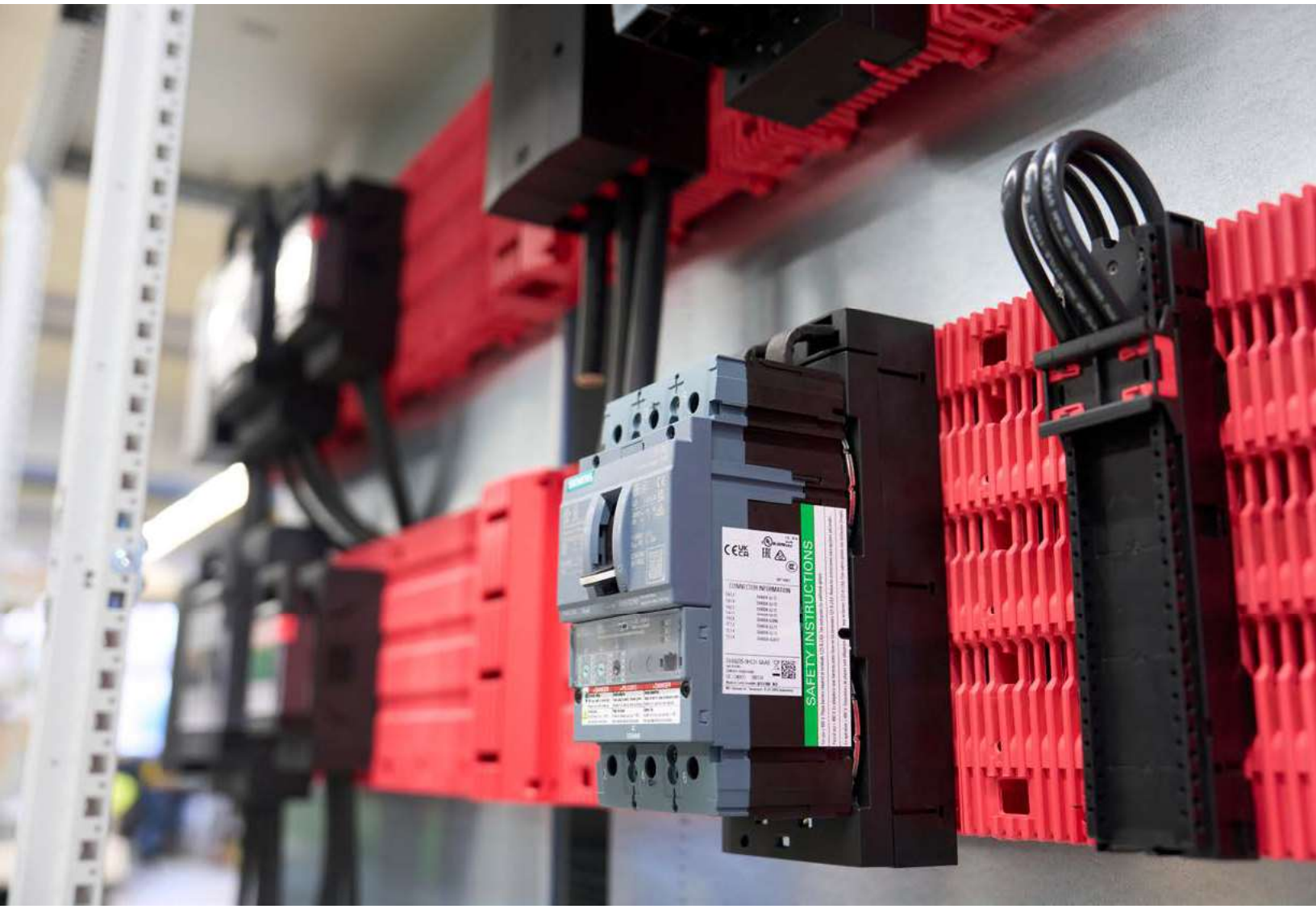
Traditional busbar installations, such as load centers and MCCs, provide touch safety through dead-front panels, where the power connection is only accessible from the rear of the enclosure. Newer modular systems designed for control panels incorporate touch-safe terminals and covers directly into the system. When properly integrated, **busbar systems can be 100% touch safe**, eliminating the risk of stray fasteners, dropped tools, or body parts contacting the bus.

Power distribution blocks can present a safety concern because many are not touch-safe, increasing the potential for a dangerous arc flash. Busbar systems are designed to eliminate power distribution blocks altogether, making them safer than many typical block-and-cable installations.

Busbar systems can also provide **a higher default short-circuit current rating, or SCCR, than power distribution blocks**. PDBs often require a current-limiting device to achieve an acceptable rating, while busbar systems provide additional design flexibility by allowing a higher SCCR simply by adding supports.

# 9 | Global Market Acceptance

Like IEC motor controls, busbar systems for use in control panels are readily available throughout the world and typically carry **both a CE Mark** for the European market and a **UL Mark** for the North American market. This combination is a powerful one-two punch for global manufacturers such as those in the automotive industry. It not only provides a common platform for machinery, helping to ensure that parts can be easily sourced anywhere in the world, but also **ensures all installations will conform to electrical codes** set by local jurisdictions.



# 10| Conclusions

Modular busbar systems are the next logical step in control panel optimization, offering many of the same advantages that helped IEC devices gain acceptance in North America:

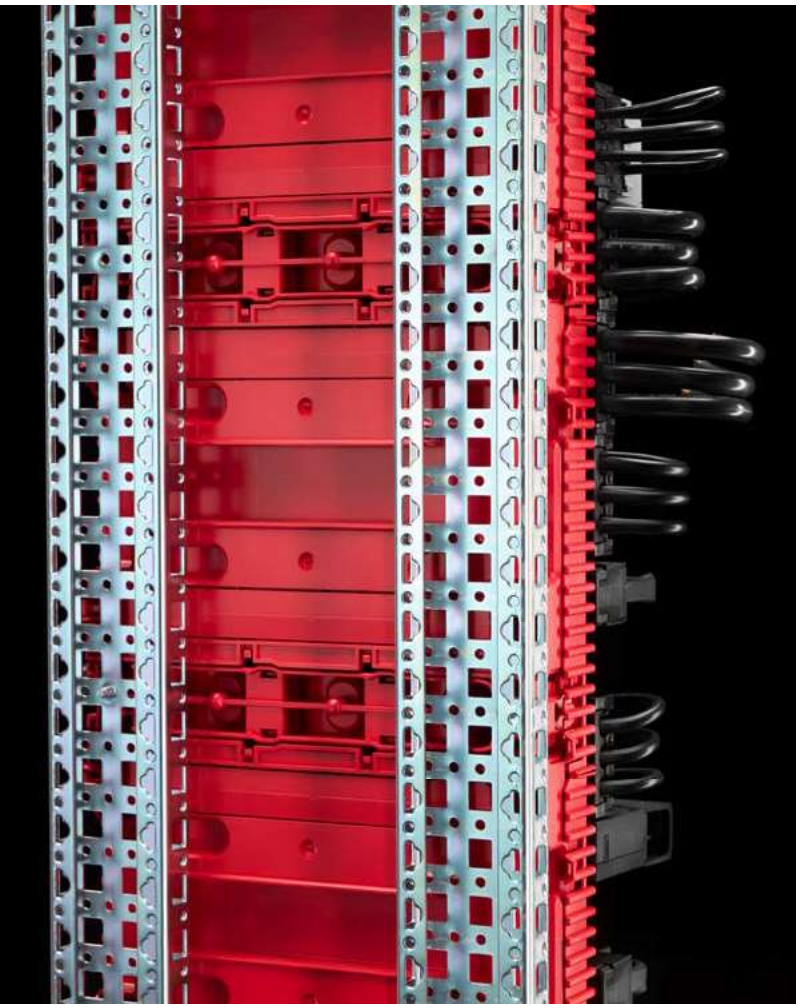
**1. A Standardized Platform for Design**
IEC devices use standardized metric sizing, and modular busbar systems were designed primarily to work with IEC components. Together, they give control panel engineers a more consistent platform for selecting and arranging components.

**2. Easier Integration for Panel Builders**
The IEC-busbar combination helps integrators complete control panel systems more efficiently by reducing wiring complexity, simplifying installation, and supporting easier builds across many applications.

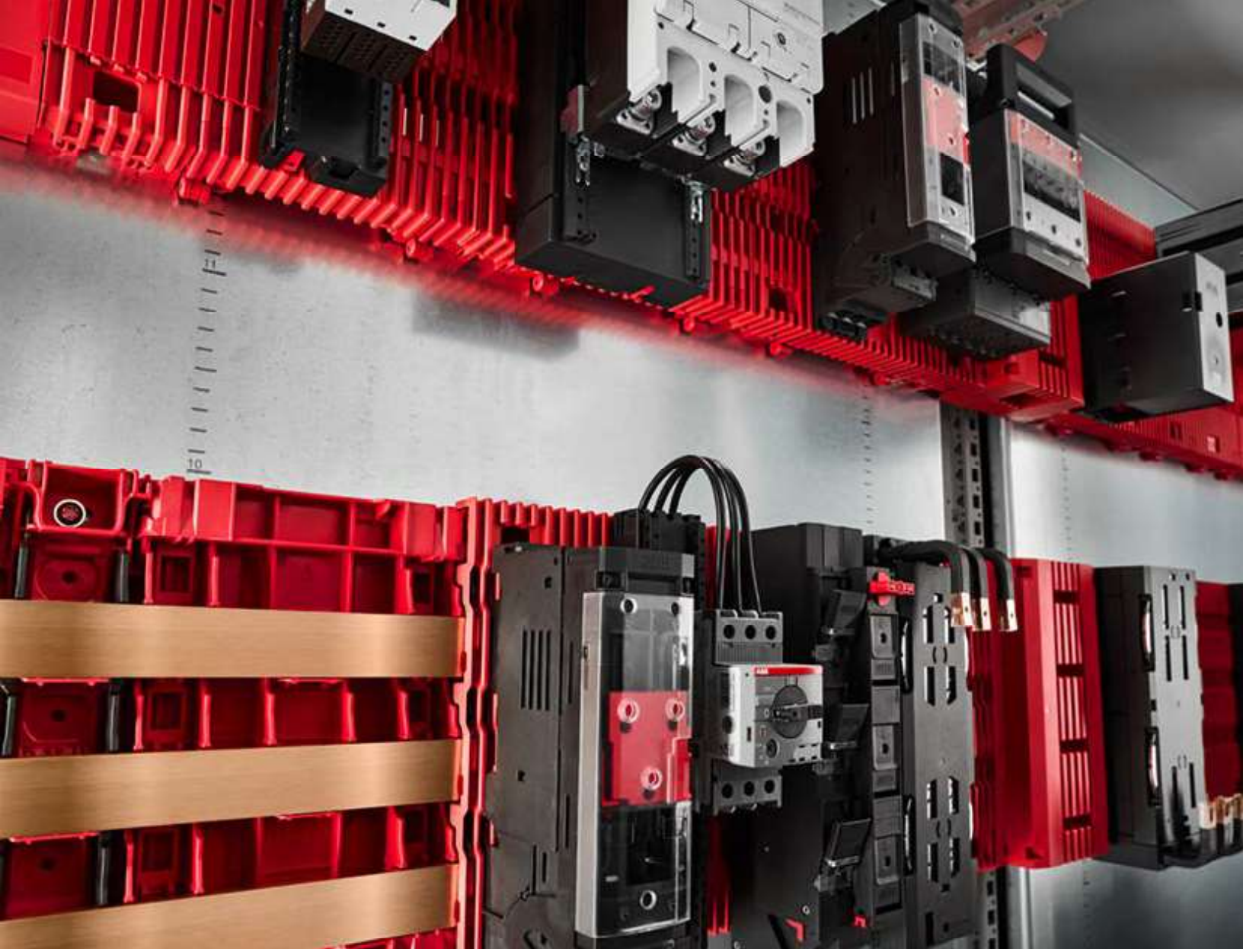
**3. Lower Labor and Installation Costs**
Common parts can be kitted in advance, helping streamline production and improve productivity. These assemblies may also be completed with a less-skilled labor force, since workers do not always need to be proficient with electrical equipment to complete certain installation steps.

**4. Global Acceptance and Flexibility for End Users**
End users benefit from the worldwide acceptance of IEC components, while modular busbar systems carry many of the critical certifications needed for global installations.

**5. A More Competitive Control Panel Solution**
Reduced acquisition costs, panel space savings, lower labor requirements, easier integration, and enhanced safety make the IEC-busbar combination an ideal choice for modern control panel systems across a wide range of markets.



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