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Achieving Electrical Flexibility in Offices via Non-Traditional Systems

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ABSTRACT

This study aims to qualitative analysis of non-traditional electrical distribution systems, specifically Systems Furniture, on the flexibility of electrical network design in modern office buildings. With the evolution of work environment concepts such as open-plan offices, hot-desking, and hybrid work, there is a growing need for electrical infrastructures that can respond quickly and efficiently to frequent internal layout changes without requiring costly and disruptive modification works. The article investigates the design principles and technical means that enable these systems to achieve high levels of flexibility, reviews their advantages and challenges, and proposes a framework for engineers and designers to adopt these solutions.

Introduction:

Recent decades have witnessed a radical shift in the design concept of office buildings, from fixed and partitioned spaces to dynamic, open environments that promote collaboration and adaptability. This shift, driven by technological advancement and changing work cultures, has highlighted the shortcomings of traditional electrical installations (fixed in ceilings, walls, and floors) in keeping up with these demands. Any modification to the office layout necessitates disruptive demolition and rehabilitation works for the electrical systems, resulting in high costs, work disruption, and time wastage. Hence, an urgent need has emerged to adopt non-traditional electrical distribution systems that offer high flexibility, with Systems Furniture integrated solutions being one of the most prominent examples.

Systems Furniture refers to integrated, modular office furniture components—such as workstations, partitions, desks, and storage units—designed to be interconnected to create complete work environments. Its defining characteristic is the incorporation of built-in raceways (channels) within its structure to manage and distribute electrical power, data, and telecommunications cabling. Unlike traditional furniture, it is not merely a standalone object but an active part of a building's infrastructure, transforming passive furniture into a flexible utility distribution system.

The modern office is a dynamic environment, constantly evolving to accommodate new technologies, collaborative work styles, and flexible seating arrangements. Traditional electrical installations, fixed within walls and floors, struggle to support this need for frequent reconfiguration. Systems Furniture has emerged as a critical solution to this challenge.

It represents a paradigm shift in interior design and electrical engineering, where the furniture itself becomes the primary vehicle for power and data distribution. By integrating electrical raceways and connectivity points directly into desks, partitions, and overhead bins, it creates a responsive and adaptable "plug-and-play" ecosystem. This approach allows organizations to quickly rearrange office layouts—supporting concepts like hot-desking or team-based zones—without the need for expensive, disruptive, and time-consuming rewiring projects. Essentially, Systems Furniture decouples the dynamic needs of the workspace from the static building infrastructure, delivering unprecedented operational flexibility, cost savings over the long term, and a cleaner, more organized aesthetic.

1. The Problem of Traditional Installations IN Modern Designs

Traditional Electrical Installations refer to the conventional, fixed method of distributing electrical power, lighting, and communication services within a building. IN this approach, the core infrastructure—including conduits, junction boxes, and outlet points—is permanently embedded within the structural fabric of the building during construction, typically within walls, concrete floors, and fixed ceiling systems. This creates a static network where the location of power and data outlets is predetermined and difficult to alter without significant structural intervention.

For decades, Traditional Electrical Installations have been the foundational standard for building electrification. This method is based on a predictive design philosophy, where the future use of every wall and floor space is planned and fixed during the initial construction phase. Conduits are cast into concrete slabs or chased into walls, terminating at permanently located sockets, switches, and light fixtures.

While robust and reliable for static environments, this approach presents a fundamental rigidity. It assumes that the spatial layout and technological needs of occupants will remain largely unchanged over the building's lifespan. Consequently, any subsequent change in office layout—such as moving a wall, adding a workstation, or creating a new collaborative zone—requires invasive construction work: cutting open drywall, breaking concrete slabs, and running new cables. This process is costly, time-consuming, and disruptive to daily operations. IN the context of modern, agile workplaces that demand constant adaptation, the inflexibility of traditional installations has become a significant operational and financial constraint, highlighting the need for more dynamic distribution solutions.

This cycle Fig.1 reveals the fundamental flaw of traditional electrical systems they are built to be permanent in a world that demands change. A simple office reconfiguration triggers a cascade of demolition, rewiring, and repair—a costly, disruptive construction project. Yet the end result is merely a new set of fixed outlets, locking the organization into the same inflexible cycle for the next inevitable change. This process doesn't just waste money and time; it creates organizational inertia, where the fear of disruption stifles innovation and adaptation.

Characteristics of the Cycle:

- Rigid Starting Point: The infrastructure is locked into the building's structure.
- Disruptive Feedback Loop: Any spatial change triggers a costly and invasive construction process (Demolition → New Wiring → Repair).
- Inherent Waste: The cycle generates physical waste (debris), financial waste (high labor/redesign costs), and operational waste (downtime).
- No Net Flexibility: The process ends exactly where it began: with a new set of fixed, unchangeable points, ready to restart the cycle with the next inevitable change.

IN short, this cycle shows why traditional wiring is unsustainable for modern, agile businesses. It creates a punishing cost for change, which is the one constant in today's workplace.

Cycle created by Traditional Electrical Installations,

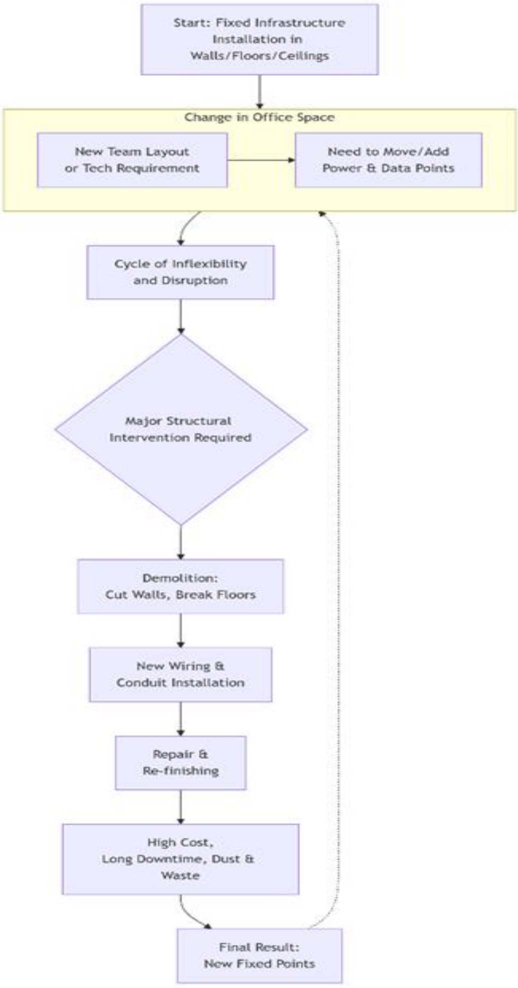

Fig.1 cycle created by Traditional Electrical Installations

Traditional electrical installations rely on a fixed network of power, lighting, and data outlets, installed in predetermined locations during the construction phase. This approach faces significant challenges in contemporary office environments, most notably:

1. Inflexibility any rearrangement of departments or individual workstations requires a physical modification of the installations. Inflexibility is more than just a minor inconvenience. It is a systemic property that makes a building's infrastructure resistant to adaptation, with significant operational and financial consequences. It manifests in three core dimensions: Spatial, Technological, and Operational Inflexibility.

   This is the core value proposition of non-traditional systems like Systems Furniture and Access Floors—they are designed from the outset to make the electrical network adaptable, modular, and responsive to change, breaking the cycle of spatial, technological, and operational inflexibility.

2. Cost and Time modification works require specialized labor and materials, causing prolonged disruption to office activities. The inflexibility of traditional electrical installations creates a direct and punitive link between change, cost, and time.

Cost Escalation a simple request to relocate a desk or add a meeting room triggers major construction costs—specialized labor, materials, demolition, and restoration. This turns a minor operational need into a capital project.

Time as Disruption the process is not just slow; it is actively disruptive. It requires shutting down work areas for days or weeks, generating noise, dust, and downtime that directly destroy productivity and employee focus.

Inflexibility makes adaptation prohibitively expensive and unacceptably slow, forcing businesses to choose between efficiency and their ability to evolve.

3. Rapid Obsolescence With the accelerating pace of technological change, fixed installations become inadequate for accommodating the requirements of new devices (such as high-power workstation chargers, high-definition displays, and Internet of Things (IoT) technologies).
Traditional electrical systems are built for the technology of yesterday, not tomorrow.

They are designed and installed during construction, locking in assumptions about power needs and data use that can become outdated in just a few years. When new technologies emerge—whether faster data standards, wireless charging, or smart building sensors—the fixed wiring in the walls cannot adapt.

This forces businesses into a cycle of workarounds messy tangles of extension cords, daisy-chained power strips, and data bottlenecks. These makeshift fixes are inefficient, unsafe, and ultimately highlight that the building's own infrastructure is holding the business back.

2. Integrated Vertical and Horizontal Distribution Idea

The core idea is a clean, two-step path for power in a modern office Fig.2:

Down a Single Column Electricity comes from the building's main source (in the ceiling or floor) and travels straight down a single, discreet power pole.

Out Through the Furniture At desk height, it connects to a hidden network of channels inside the desks and office partitions, spreading power sideways to every outlet you need.

The key result All the messy cables are eliminated. Your monitor, laptop, and lamp plug directly into your desk or wall panel. When you need to rearrange the office, you simply unplug the column, move the furniture, and plug it into a new power source elsewhere. It turns electrical wiring from a fixed, tangled problem into a flexible, invisible utility that moves with your workspace.

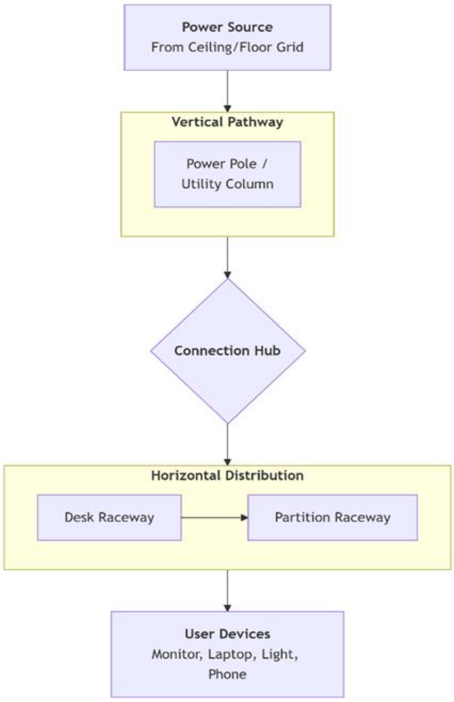

Fig.2 Integrated Vertical and Horizontal Distribution

How It Works:

1. Power Source Energy enters from the building's fixed grid (via ceiling or floor).
2. Vertical Pathway A power pole safely channels it down to desk level.
3. Connection Hub A single plug connects the vertical feed to the furniture.
4. Horizontal Distribution Hidden pathways in desks and partitions spread power sideways.
5. User Devices Everything plugs directly into the furniture. No loose wires.

Power flows down one column, then out through the furniture—all hidden, organized, and easy to move.

3. Non-Traditional Electrical Systems: (The Case of Systems Furniture)

Non-Traditional Electrical Systems refer to dynamic, modular approaches for distributing power and data within a building. Unlike fixed wiring, these systems use movable components—such as power poles, access floors, overhead busways, and raceways integrated into furniture—to create a flexible grid of connectivity. This design allows outlets and services to be easily repositioned, added, or rerouted without structural modifications to the building itself. To meet the demands of agile, modern workplaces, Non-Traditional Electrical Systems have emerged as a transformative alternative to static wiring. Instead of embedding infrastructure permanently within walls and floors, these systems separate services from structure.

Power and data are delivered through a reconfigurable network—like electricity through an overhead busway or a raised access floor—that acts as a "highway" reaching all areas of a floor. Individual workstations or zones then tap into this grid locally, often through Systems Furniture with built-in wiring. This approach treats electricity and data as utilities to be accessed, not fixtures to be built around.

The result is an environment that can evolve as quickly as business needs change, turning office reconfiguration from a weeks-long construction project into a simple, low-disruption task. It is the foundational infrastructure for truly adaptive, future-ready buildings.

Systems Furniture represents a qualitative shift in design philosophy, transforming the electrical infrastructure from a fixed structural element into a movable "furniture" component. These systems operate on two fundamental principles:

1. Integrated Vertical and Horizontal Distribution furniture units (such as office partitions, desks, and cabinets) contain built-in raceways within their structure. These raceways route power and data cables in an organized and safe manner.

   What is Integrated Vertical and Horizontal Distribution?

   It is a comprehensive cabling management strategy where power and data pathways are built directly into the structural components of office furniture (partitions, desks, screens), creating a continuous, organized, and hidden network both vertically (up/down) and horizontally (across) the workspace.

   It solves the core problem of traditional "surface cabling" (wires running along floors or tacked to walls) by embedding the infrastructure within the furniture itself.

   How It Works: A Two-Axis System

   Imagine a grid within your office furniture:

   1. Horizontal Distribution (The "Across" Network)

– Pathway dedicated raceways (channels) run horizontally through the components that make up a workstation. This includes:
  - Desk Raceways channels running along the underside or back edge of a desk.
  - Partition Raceways channels running through the core of workstation panels or screens.
– Function: These horizontal pathways carry cables from one point in a workstation to another—for example, from the point where power enters a desk to multiple outlet locations for monitors, laptops, and phones.

   2. Vertical Distribution (The "Up/Down" Network)

– Pathway dedicated vertical raceways are integrated into taller elements, primarily:
  - Power Poles / Utility Columns freestanding or partition-mounted columns.
  - Tall Partition Raceways channels within full-height or overhead storage units.
– Function: These vertical pathways serve as the critical link between the building's fixed infrastructure (power from the floor or ceiling) and the furniture's horizontal network. They safely bring cables down from an overhead busway or up from an access floor box and feed them into the desk or partition system.

Visualizing the Integration, the true power is in the seamless connection of these two axes at designated interconnection points. These are often specialized ports or junction boxes where a vertical column plugs into a horizontal desk raceway.

This creates a unified, "plug-and-play" electrical skeleton within the furniture ensemble.

Benefits of This Integration:

- Eliminates Cable Chaos all cables are concealed and organized within protected pathways, ensuring a clean, professional, and safe aesthetic.
- Enables True Modularity workstations can be unplugged from the vertical feed, reconfigured (desks and panels swapped), and reconnected without handling individual device cables. The wiring moves with the furniture.
- Enhances Safety & Compliance protects cables from damage, reduces trip hazards, and simplifies compliance with electrical codes regarding cable bending radius and containment.
- Facilitates Easy Maintenance & Upgrades technicians can access the entire cable run through removable covers, making it easier to replace or upgrade cables without disrupting the entire workspace.

IN essence, Integrated Vertical and Horizontal Distribution transforms furniture from passive objects into an active, intelligent utility grid, providing power and data exactly where and when it's needed.

Here is a visual summary of the efficient and flexible cycle enabled by Integrated Vertical and Horizontal Distribution in Systems Furniture.

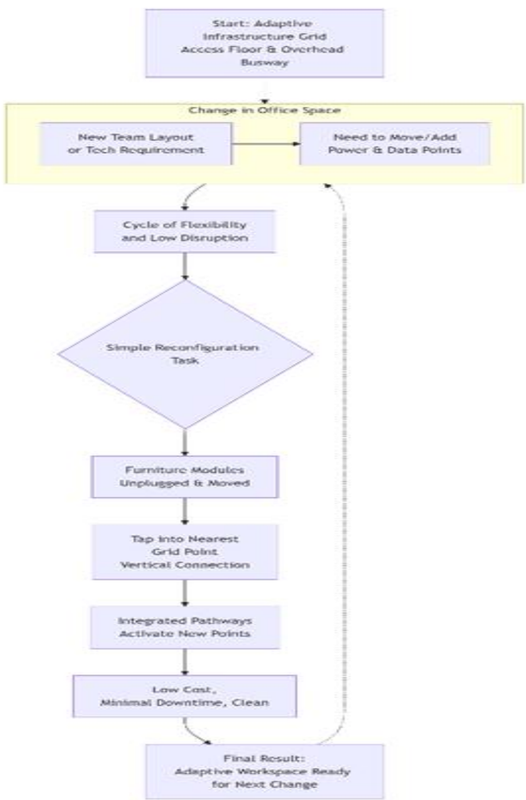

Fig.3 Integrated Vertical and Horizontal Distribution in Systems Furniture

The cycle enabled by integrated distribution is fundamentally different. It turns change from a crisis into a simple, routine task.

Here, the infrastructure itself is designed to adapt. When a new team needs space or technology requires an upgrade, the process is clean and logical:

1. Unplug furniture modules from the building's power/data grid
2. Move and reconfigure them
3. Reconnect to the nearest access point in the ceiling or floor
   Instead of construction crews and weeks of disruption, this requires minimal downtime—often just hours. The system doesn't fight against change; it is built for change.

   This creates a sustainable, efficient workspace where layout can evolve as quickly as business needs do, with almost no waste and significantly lower long-term costs.

Characteristics of This Cycle:

- Adaptive Starting Point the infrastructure is a live grid (Access Floors / Busways) feeding a modular furniture network.
- Simple Feedback Loop spatial change triggers a logical reconfiguration process (Unplug → Move → Reconnect).
- Operational Efficiency the cycle minimizes waste—virtually no physical debris, low labor cost, and near-zero operational downtime.
- Sustainable Flexibility the process ends with a workspace that is more adaptable than before, ready to effortlessly enter the cycle again, turning change from a threat into a routine operation.

2. Modular Connectivity these raceways are interconnected using quick and easy-to-assemble connectors, creating an integrated network across the furniture ensemble.
   Modular Connectivity is a design principle where electrical and data components are standardized into discrete, interchangeable units that can be quickly connected and disconnected without specialized tools or rewiring. It replaces hardwired, permanent connections with a "plug-and-play" system of compatible ports, connectors, and pre-terminated cables, enabling non-destructive reconfiguration of the entire network.

At the heart of any flexible electrical system lies the principle of Modular Connectivity. If Integrated Distribution provides the pathways for cables, Modular Connectivity provides the intelligent joints that make those pathways reconfigurable. Think of it as the electrical equivalent of LEGO blocks—standardized components designed to snap together and apart effortlessly.

This approach moves away from the traditional model of splicing and soldering wires inside junction boxes. Instead, it uses pre-engineered connectors that ensure proper polarization, grounding, and data integrity with each connection. IN practice, this means a power column can be disconnected from a desk raceway, moved five meters, and reconnected to another access point—all in minutes, by facilities staff, without cutting a single wire or calling an electrician.

By decoupling the furniture layout from the fixed building infrastructure, Modular Connectivity is what truly enables the agile, adaptable, and future-proof workspace, turning theoretical flexibility into practical, on-the-ground reality.

4. Mechanisms for Achieving Design Flexibility

These systems achieve flexibility through several design and technical mechanisms:

1. Grid Infrastructure and the Relationship with Access Floors:
   Grid Infrastructure and Access Floors the Foundation of Flexibility, Modern flexible office design relies on a foundational layer known as Grid Infrastructure. This is a planned, regular matrix of potential power and data connection points installed across an entire floor plate. Unlike traditional point-to-point wiring, this grid is ubiquitous and neutral, designed not for a specific layout but to service any future layout.
   Access Floors (raised floors) are the most effective physical manifestation of this grid concept. The cavity created between the structural floor and the raised floor panels forms a continuous, accessible service plenum. Within this plenum, a network of power cables and data conduits can be routed freely to designated "tap-off" points at any grid location.

The Relationship is Synergistic:
The Grid defines the where—the array of possible connection locations. The Access Floor provides the how—the hidden, flexible pathway to reach any of those points without demolition. When a furniture cluster needs to move, it simply reconnects to the nearest grid point via a floor box, with all cabling neatly managed in the plenum below. This combination transforms a static floor into a live, adaptable service field, making the entire space inherently reconfigurable and separating building structure from service delivery.

- Power Source the main power supply from distribution boards is distributed across the building floor using "Access Floors" or through suspended ceilings using raceway systems (like Poke-Through devices or Power Poles). These floors and ceilings provide a grid of regularly spaced power feed points (grid points).
- Connection Points the integrated furniture units connect to the nearest feed point on this grid infrastructure via flexible cables. Once this connection is made, the entire network integrated within the furniture becomes active and operational.

2. Modularity:
   The system is designed as standardized modules (work pods, desks, lighting units) that can be easily assembled, disassembled, and reassembled. This nature allows for the complete reconfiguration of the space without interfering with the fixed infrastructure.
   Modularity is the design philosophy of creating a system from standardized, interchangeable units that can be independently replaced, removed, or

reconfigured.

IN the context of office electrical systems and furniture, it means that components like workstations, power columns, partition panels, and lighting are self-contained units with predefined connection points. They are designed to "snap together" to form a complete workspace and, more importantly, to be taken apart and rearranged without affecting the integrity of the whole system

The core idea is to break complexity into simple, reusable parts. Instead of a custom-built, monolithic environment, you create a flexible kit of parts. This allows for:

- Easy Reconfiguration spaces can be reshaped quickly by non-specialists.
- Scalability systems can be easily expanded or reduced.
- Simplified Maintenance & Upgrades individual faulty or outdated modules can be swapped out without disrupting the entire area.

  Ultimately, modularity shifts the design goal from creating a single, fixed solution to creating a versatile and adaptable platform for change.

3. Integration with Smart Building Systems: These systems can be easily integrated with Building Management Systems (BMS) and automation systems. Sensors (for motion, occupancy, lighting) and controls for lighting and blinds can be distributed via the same integrated network, enhancing energy efficiency and comfort.

Flexible electrical systems enable true smart building integration. The same modular pathways for power become conduits for sensors and data, feeding a centralized (BMS). This allows for automated, demand-based control of lighting, HVAC, and energy use based on real-time occupancy, while providing valuable data on space utilization. The result is a self-optimizing workspace that is not only adaptable in layout but also intelligent in operation.

5. Analysis of Advantages and Challenges

The benefits of Non-Traditional Electrical Systems are overwhelmingly worth it for modern, dynamic organizations. The initial higher investment is a strategic one that pays for itself and generates value over time.

- Advantages:
  1. Exceptional Flexibility reconfiguring spaces takes hours instead of days.
  2. Reduced Long-Term Costs significant reduction in maintenance and modification costs.
  3. Enhanced Efficiency providing power and data points exactly where the user needs them, reducing the use of unsafe, long extension cords.
  4. Aesthetics completely hiding cables maintains a clean and aesthetic appearance for the space.
- Challenges and Considerations:

1. Integration and Interoperability Challenges

Beyond basic compatibility, systems often face protocol mismatches between different manufacturers' components. A power management module from one vendor may not communicate effectively with a sensor array from another, creating data silos and reducing system intelligence. This can lead to partial system functionality, where only basic power distribution works while smart features fail.

2. Lifecycle and Obsolescence Management

The rapid evolution of technology presents a unique paradox systems designed for flexibility can themselves become obsolete. The connectors, data protocols, and even voltage standards embedded in today's furniture may not support future needs. Organizations face the risk of their "future-proof" system requiring complete replacement in 7-10 years rather than gradual upgrade.

3. Performance Verification and Certification

Unlike traditional wiring with well-established inspection protocols, integrated systems present verification challenges. How does an inspector verify that every connection in a reconfigurable system meets code after multiple rearrangements? The chain of responsibility becomes blurred between furniture installers, electricians, and integrators.

4. Cost Modeling and ROI Justification

The financial case extends beyond initial hardware costs to include:

- Hidden training costs for facilities staff
- Specialized maintenance contracts
- Higher insurance premiums during the technology's "proving" period
- Depreciation accounting challenges for integrated furniture-infrastructure assets

Case Studies: Implementation Obstacles in Practice

Case Study 1: Major Technology Corporation

Project: Implementation of fully integrated Systems Furniture across 4 floors (60,000 sq ft).

Obstacles Encountered:

1. Coordination Failure Electrical contractors and furniture installers worked on different schedules with minimal communication, resulting in connector mismatches at 30% of interconnection points.
2. Performance Gap The promised "plug-and-play" reconfiguration took 3-4 hours per workstation instead of the estimated 45 minutes, as staff lacked proper training.
3. Unexpected Cost The need for signal repeaters in longer furniture runs was not anticipated, adding 15% to the project's low-voltage budget.

Outcome: The project finished 60 days behind schedule with 22% budget overrun. While eventually successful, the initial 6 months saw significantly reduced productivity and multiple workarounds with traditional power strips.

Case Study 2: Regional Bank Headquarters

Project: Hybrid system combining access floors with modular furniture in a renovation.

Obstacles Encountered:

1. Structural Limitations Existing floor loading capacity could not support both access floor systems and desired workstation density, forcing a compromised design with fewer power access points.
2. Change Management Resistance Senior management rejected the "temporary look" of power poles, demanding more integrated solutions that exceeded budget.
3. Code Interpretation Conflict Local inspectors required separate emergency circuit pathways that couldn't be integrated into the furniture system, creating a parallel traditional wiring requirement.

Outcome: The final implementation used a hybrid approach that achieved only 60% of the planned flexibility. The return on investment timeline extended from 3 to 5 years.

Comparative between Traditional and Non-Traditional Electrical Systems.

Feature	Traditional Electrical Systems	Non-Traditional Electrical Systems
Core Philosophy	Fixed, permanent infrastructure.	Flexible, modular, and adaptive infrastructure.
Installation Base	Embedded within walls, floors, and ceilings during construction.	Uses movable components: access floors, power poles, overhead busways, and furniture-integrated raceways.
Flexibility & Reconfiguration	Low. Any change requires demolition, rewiring, and restoration.	High. "Plug-and-play" modularity allows quick, tool-free reconfiguration.
Response to Change	Slow, disruptive, and expensive (a construction project).	Fast, clean, and low-cost (a facilities task).
Cost Structure	Lower initial cost, but very high cost of change over time.	Higher initial investment, but very low cost of change over the lifespan.
Technology Adaptation	Poor. Struggles with new tech; leads to unsafe workarounds (power strips, extension cords).	Excellent. Designed to easily integrate new power/data standards and IoT devices.
Cable Management	Exposed or hidden in fixed conduits; messy temporary solutions often needed.	Fully integrated and hidden within system components; maintains a clean, professional appearance.
Ideal For	Static environments with fixed, long-term layouts (e.g., some industrial settings, legacy buildings).	Dynamic, modern environments (e.g., offices, tech hubs, flexible learning spaces, healthcare wings).
Impact on Business Agility	Hinders agility. Fear of disruption discourages necessary layout changes.	Enables agility. Supports rapid adaptation to new work models (hybrid, hot-desking, collaboration).
Long-Term Value	Becomes a liability that resists change and innovation.	Becomes a strategic asset that enables growth, efficiency, and future-proofing.

Table 1 comparative between Traditional and Non-Traditional Electrical Systems

The Table1 clearly illustrates that the choice between these two systems is a choice between two different business philosophies.

On one side, Traditional Systems prioritize low initial cost and permanence. They are a gamble that future needs will match today's layout, a bet that most modern organizations lose.

On the other side, Non-Traditional Systems prioritize long-term operational agility and adaptability. The higher initial investment buys freedom from future disruption and cost.

Ultimately, the table shows that the "cost" of traditional systems is merely deferred and amplified, paid later through expensive, reactive renovations. The non-traditional approach pays upfront for a permanent capability to change, making it the definitive choice for any dynamic, forward-thinking business.

Conclusion:

Achieving genuine electrical flexibility in the modern office necessitates a fundamental departure from conventional wiring methodologies, embracing instead the paradigm of non-traditional systems. This transition represents more than a technical upgrade; it is a strategic reimagining of the workplace infrastructure as a dynamic, adaptive platform. By decoupling critical services from the fixed building structure through innovations like access floors, overhead busways, and furniture-integrated raceways, power and data are transformed from static fixtures into ubiquitous, on-demand utilities. This foundational shift is operationalized through the core principles of modular connectivity and integrated distribution, which reconfigure office components into a re-combinable kit of parts, enabling rapid, tool-free reconfiguration without disruptive construction. Furthermore, this flexible physical layer seamlessly converges with smart building ecosystems, embedding sensors and data pathways to enable intelligent, responsive control over energy use, space utilization, and environmental comfort. Consequently, the historically punitive economics of workplace change are inverted: where traditional systems impose exorbitant costs and prolonged downtime for every modification, non-traditional systems render adaptation a routine, low-cost, and efficient operational task. Therefore, investing in these systems is not merely an expenditure on advanced electrical components, but a strategic commitment to organizational agility, resilience, and future-proofing, ultimately ensuring that the physical workspace evolves as fluidly as the business it supports.

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