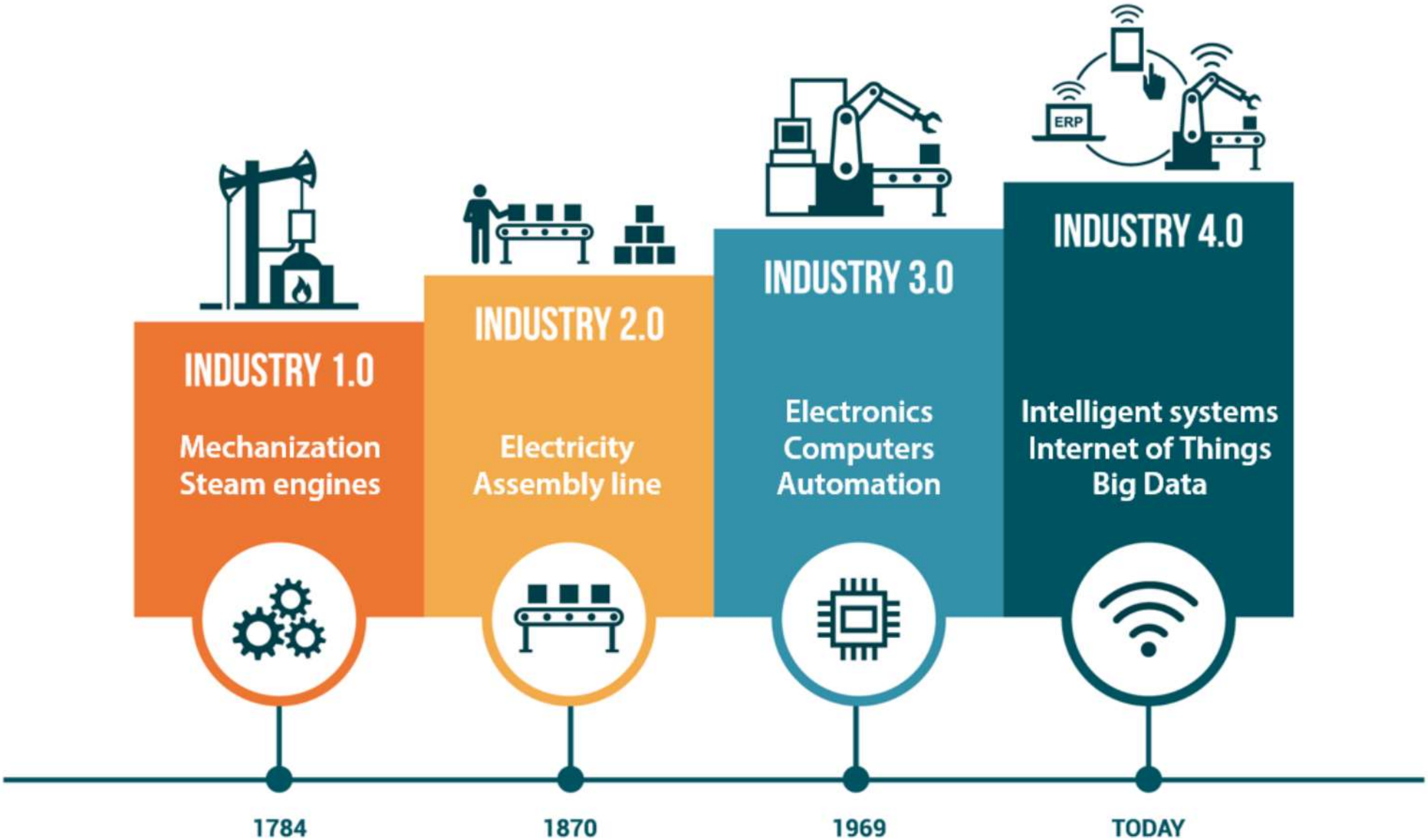
# Data Centre Facility Design : Standard & Guideline

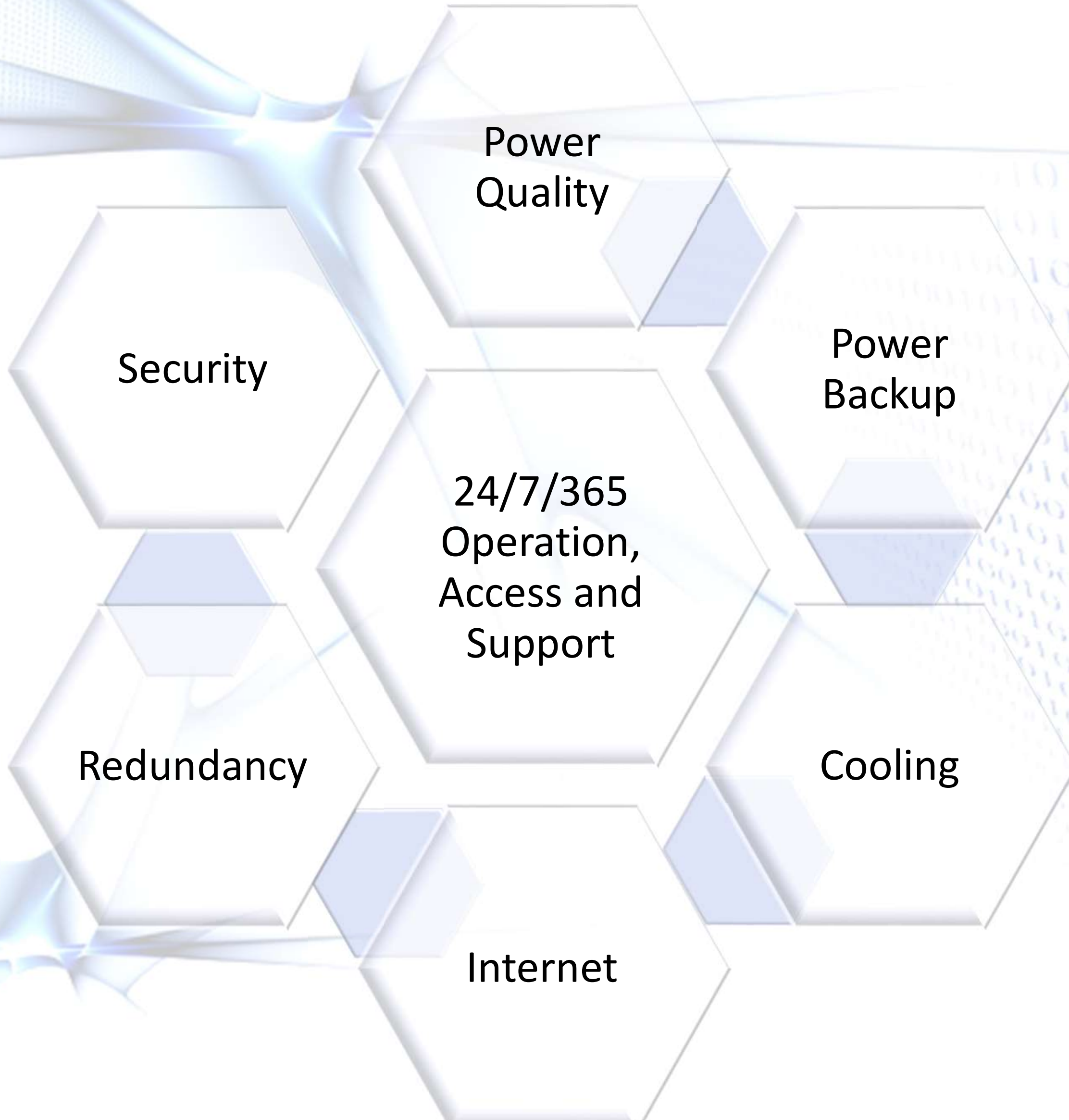
# Session 1

- Importance of Data Centre
- Cause and Cost of Down-Time
- Topology Standards and Certification
- Tier-I / Rated-1 : Basic Component
- Tier-II / Rated-2 : Redundant Components
- Tier-III / Rated-3 : Concurrently Maintainable
- Tier-IV / Rated-4 : Fault Tolerant

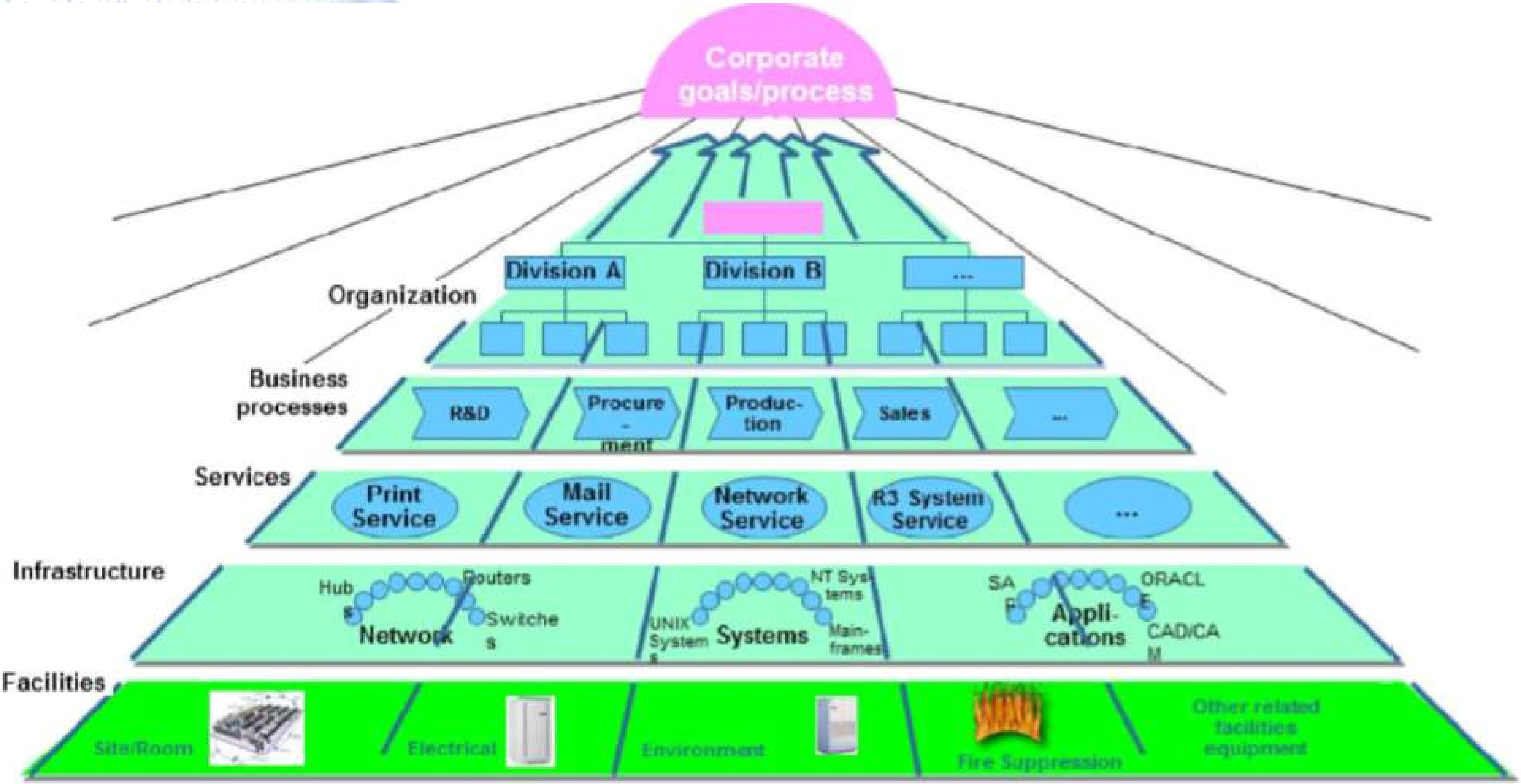
# Revolution Towards Industry 4.0



# Critical Components of Data Centre



# Data Centre in a Business Process




- Having high-performance ICT (Information and Communication Technology) resources on hand is essential for business processes to achieve corporate goals.

# Operations of Data Centre

Data Centre Operations is a broad term that includes all processes and operations performed within a data centre. Typically, data centre operations are distributed across several categories, such as:

Infrastructure Operations

Installing, maintaining, monitoring, patching and updating server, storage & network resources

Security

Processes, tools and technologies that ensure physical and logical security in the data centre premises

Power and Cooling

All processes that ensure enough power is supplied to the data centre facility and the cooling system is operational

Management

Creation, enforcement and monitoring of policies and procedures within data centre processes

# Cost of Down Time and It's Calculation

According to Gartner, average cost of network downtime is around USD 5,600 per minute. Considering average size of ISPs around the world. That is around USD 300,000 per Hour. For any business, USD 300,000 per Hour is a lot on the line.

Beyond the monetary costs, IT downtime can wear on your business's productivity levels. Every time you get interrupted, it takes on average 23 minutes to get refocused on your prior task.

Network failures and power outages aren't the only culprits when it comes to downtime either. Other top factors include:

- Outdated Software and Hardware
- Hurricanes and Floods
- Human Error

So how do you know where you stand when it comes to downtime costs? Here is a simple way to calculate how your business could be affected:

# Cost of Down Time and It's Calculation

**Cost of Downtime (/Hr) = Lost Revenue + Lost Productivity + Recovery Cost + Intangible Cost**

**Lost Revenue** = Revenue/Hour x Downtime (Hour) x Percentage of Impacted Uptime (%)

**Lost Productivity** = [Employee Salary/Hr x Downtime (Hr)] x [#. of Employee x Utilization (%)]

**Recovery Cost**

These are the costs accrued while fixing the issue. They can include but are not limited to:

- Repair services ± Replacement parts
- Lost data recovery ± Other costs due to loss of data

These may not be as tangible at revenue and productivity costs, but they are equally as important when deducing your real downtime costs.

**Intangible Cost**

These are the costs that can sting the most for the long-term. These occur when downtime damages your reputation or your brand. These costs ultimately affect businesses that rely heavily on uptime. Including intangible costs into the Total Downtime Cost Formula gives a better understanding of the long-term consequences that can occur due to downtime.

# Cost of Down Time : Ponemon Institute

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- Average cost of data centre downtime across industries in 2018 was approximately USD 9,000 per Minute for an average of 2,500 $m^2$ of White Space. (It was USD 5,600 in 2010.)
- Average reported incident length was 86 minutes in 2018, resulting in average cost per incident of approximately USD 790,000 (In 2010 it was 97 minutes at USD 505,500)
- For a total data centre outage, which had an average recovery time of 119 minutes in 2018, average costs were USD 1,901,500 (In 2010, it was 134 minutes at USD 680,700)
- For a partial data centre outage, which averaged 56 minutes in length in 2018, average costs were USD 750,400 (In 2010, it was 59 minutes at approximately USD 258,000)
- The majority of survey respondents reported having experienced an unplanned data centre outage in the past 24 months (91%) in 2018. This is a slight decrease from the 95 percent of respondents in the 2010 study who reported unplanned outages.

# Example of Down Time : 2017

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in May 2017, over 75,000 people had their three-day weekend plans stalled when British Airways suffered a massive data centre failure. Along with the chaos of lost luggage, broken trust and frustrations resulting from cancelled and delayed flights, the UK's largest airline also had to deal with a loss over $75 million. The outage was caused by a single engineer who disconnected and reconnected the power supply in a disorganized fashion, triggering a power surge that disrupted the operations of the entire BA infrastructure.

Even the data centre behemoths aren't immune to outages– including Amazon Web Services (AWS) which is considered to be the world's biggest cloud provider, and home to some of the biggest names on the Internet, like Slack, Quora, Netflix, and Airbnb. In 2017, a mistyped command entered by an AWS engineer caused many sites to shut down for several hours, prompting a loss of over $150 million.

A similar incident echoed a year later at one of AWS' biggest rival. On September 2018, a lightning strike caused Microsoft Azure to suffer an outage from voltage surge resulting in damage to hardware, including network devices and storage units.

# Example of Down Time : Google Cloud

In July, 2018 due to a bug in the new security feature added Google Front Ends (GFE) architecture layer. The bug had not been identified earlier despite extensive testing procedures in place, and was triggered only when the configuration changes were introduced in the production environment. The affected services included the Google App Engine, Stackdriver, Diagflow and Global Load Balancers. Customer including Spotify, Discord, Pokemon Go app and Snapchat rely on these cloud networking services to reach a global audience, thereby cascading the impact globally. The outage lasted for around 30 minutes and up to 87 percent of the customers experienced some form of errors on the App Engine, HTTPS Load Balancer or the TCP/SSL Proxy Load Balancer solutions.

The affected customers were provided credits refund as per the Service Level Agreement (SLA) as a common compensation by any cloud vendor. However, the true cost of data centre downtime that averages around $750,000 as of 2015 according to a Ponemon Institute research report far outweighed the offered compensation.

# Example of Down Time : $O_2$

In terms of scale, the largest network outage impacted customers of O2 3G and 4G mobile services in the UK. The outage starting early hours on the December 6, 2018 left 30 million users without the Internet connectivity capabilities. The outage lasted the entire day and was caused due to failure on networking equipment operated by Ericsson and served to several carriers globally. Considering the scale of the issue, Ericsson readily worked to fix the issue and decommission the faulty software later on. Detailed analysis showed that the root cause was tied to expired certificate versions linked to customers including O2. Moreover, the Identical problem occurred for same glitch in October, 2018. Although the issue lasted only 40 minutes.

# Example of Down Time : CenturyLink

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The CenturyLink incident was the highlight network outage of 2018 as it left millions of users without the ability to call 911, ATM withdrawals, access to sensitive patient healthcare records, Verizon mobile data services and even lottery drawings. The incident later led to an FCC investigation considering the “unacceptable” downtime impacting emergency services such as 911 or ATM withdrawals. The outage lasted two days and was caused due to an issue with a single network management card. The device was found transmitting invalid data frame packets across the infrastructure. Despite the multiple layers of redundancy in place, the issue cascaded across its nationwide communication infrastructure. Once the infrastructure systems crashed, CenturyLink had limited visibility into its network to troubleshoot the issue.

# Example of Down Time : 2019

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Outages like these are not anomalies. The rate and severity of these incidents have grown significantly over the last year (2018), according to Uptime Institutes' Global Data Centre Survey. What's surprising is that 80% of the survey respondents believed that their recent outage was preventable.

In March of 2019, the Nordic metals firm, Norsk Hydro, suffered a ransomware attack called LockerGoga that shut down its global operations. This left their 35,000 employees around the world unable to progress with their work. At this point, they are still working to calculate the financial impact of the attack, loss of wages, productivity, and stock price drop.

# UpTime Institute Industry Survey, 2018

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Source: Uptime Institute, 2018

## Job Function

| | |
|---|---|
| IT Management | 35% |
| Critical Facilities Management | 33% |
| Senior Executive (VP or C-Level) | 32% |

n=867

## Location

| | |
|---|---|
| U.S. and Canada | 43% |
| Europe | 19% |
| Latin America | 13% |
| Asia-Pacific (Not China) | 12% |
| Africa and Middle East | 11% |
| Russia | 1% |
| China | 1% |

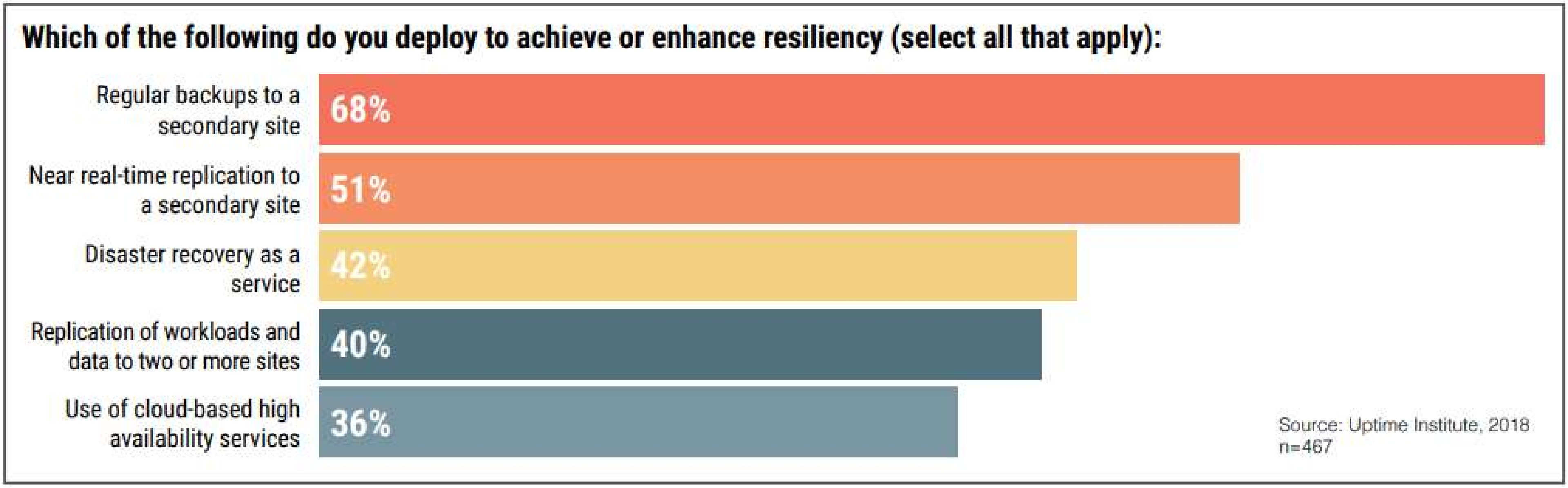
n=714

## Verticals

| | |
|---|---|
| Colocation or Multi-Tenant Data Centers | 20% |
| Financial | 17% |
| Telecommunications | 14% |
| Software and/or Cloud Services | 11% |
| Government | 9% |
| Healthcare/Pharmaceuticals | 5% |
| Manufacturing | 5% |
| Utilities/Energy | 5% |
| Retail/Wholesale/ Distribution | 4% |
| Education | 4% |
| Insurance | 3% |
| Media | 2% |
| Transportation | 2% |

n=713

# UpTime Institute Industry Survey, 2018



# UpTime Institute Industry Survey, 2018

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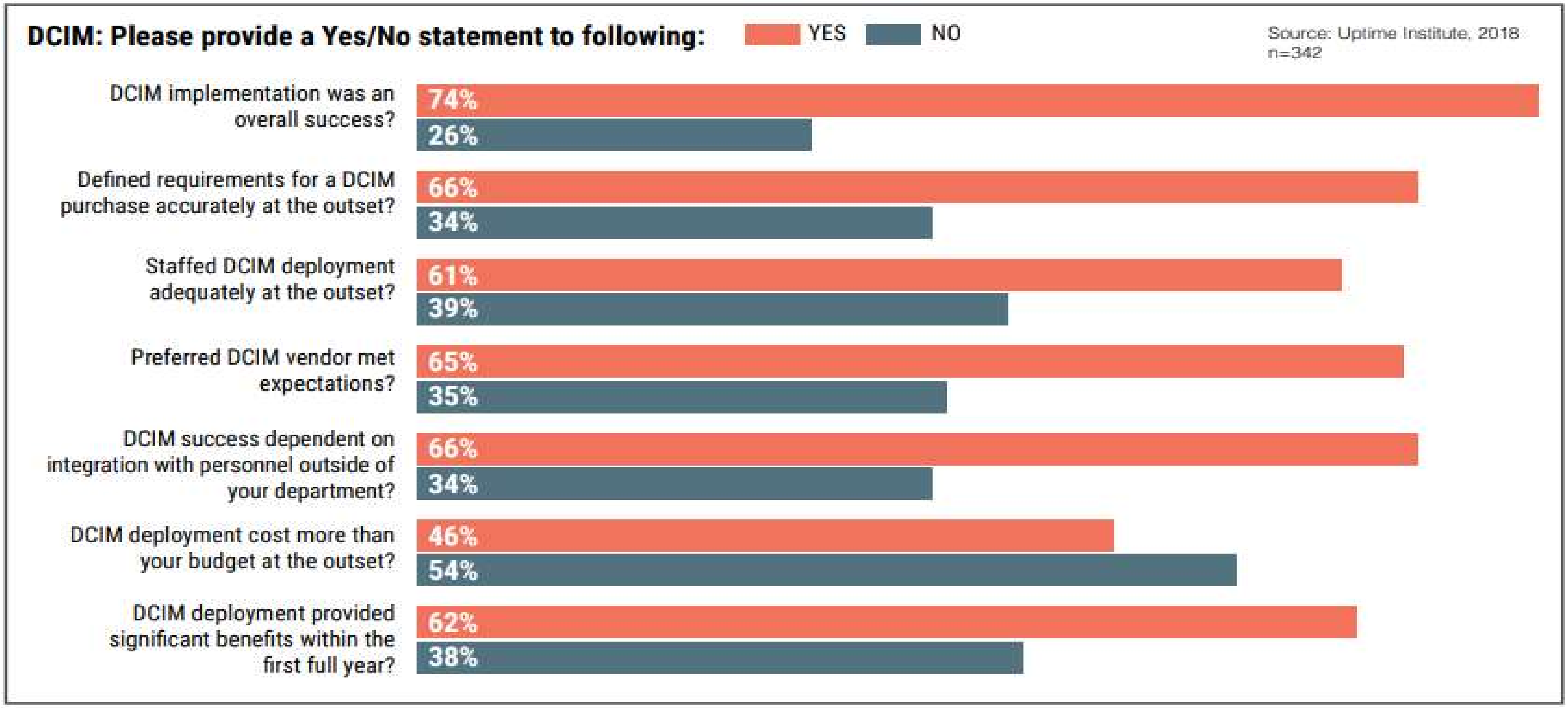

# UpTime Institute Industry Survey, 2018

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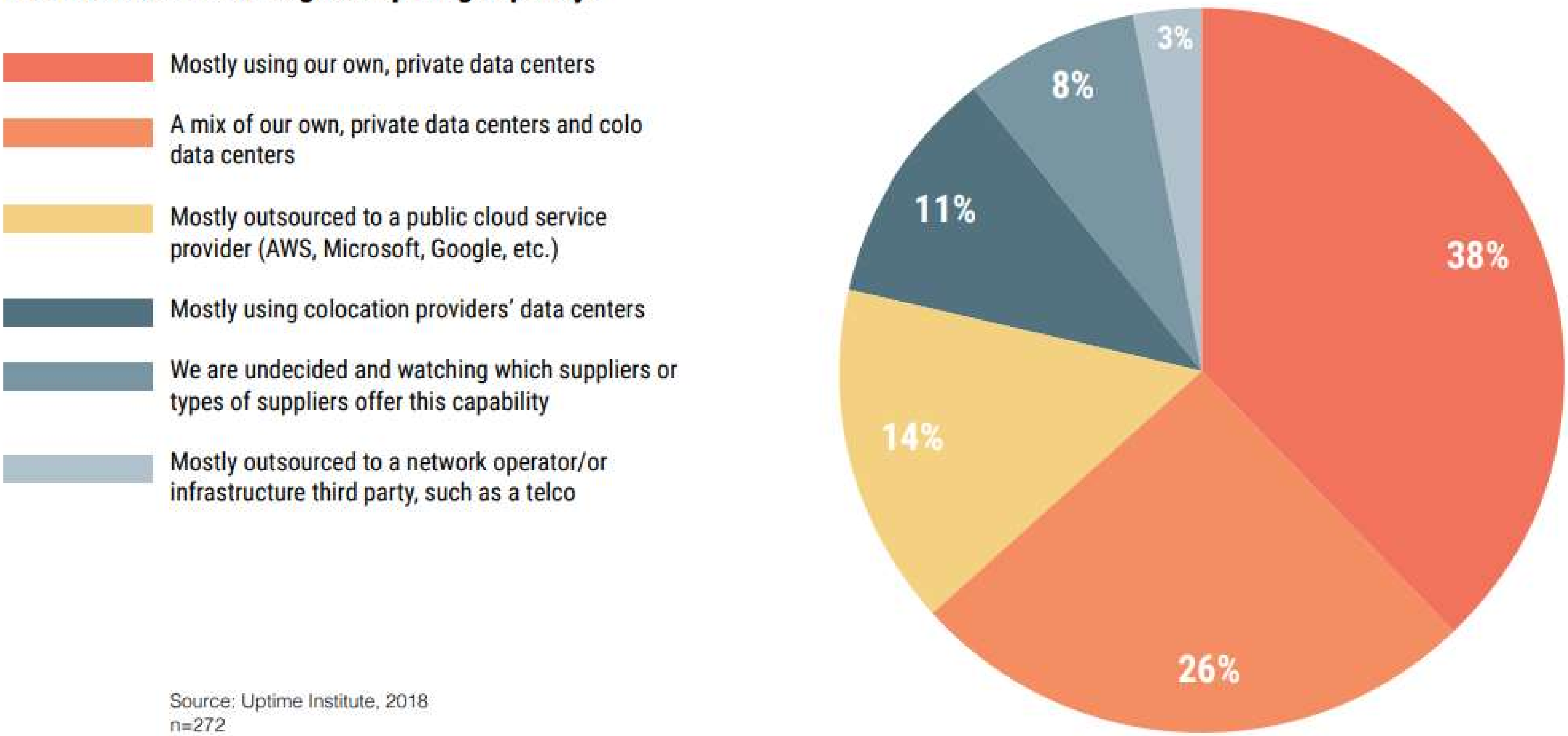
**[For those who do anticipate that their organization will require edge computing capabilities] How will your organization meet its demand for edge computing capacity?**




Source: Uptime Institute, 2018
n=272

# Complexity of DC even without ICT

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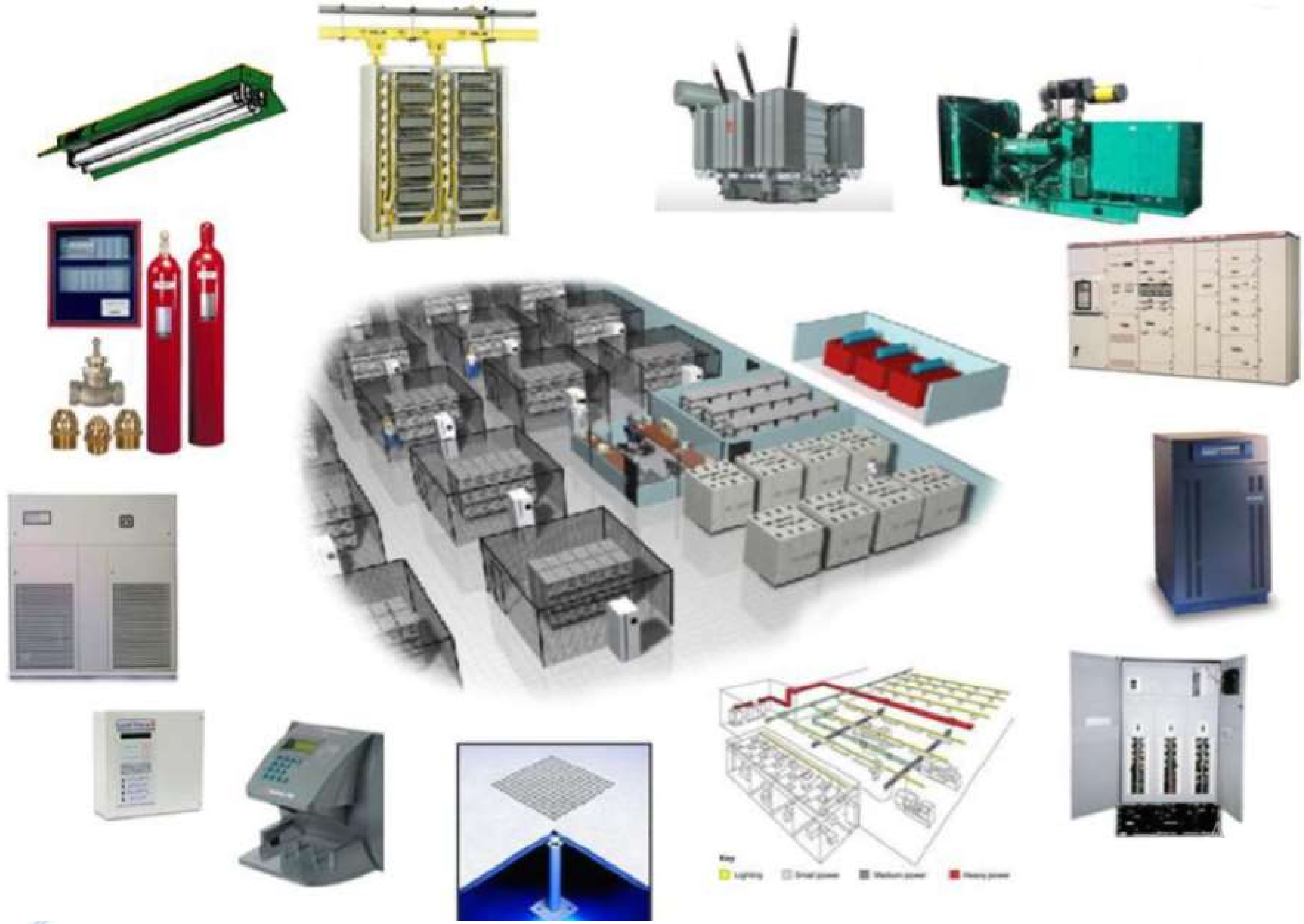
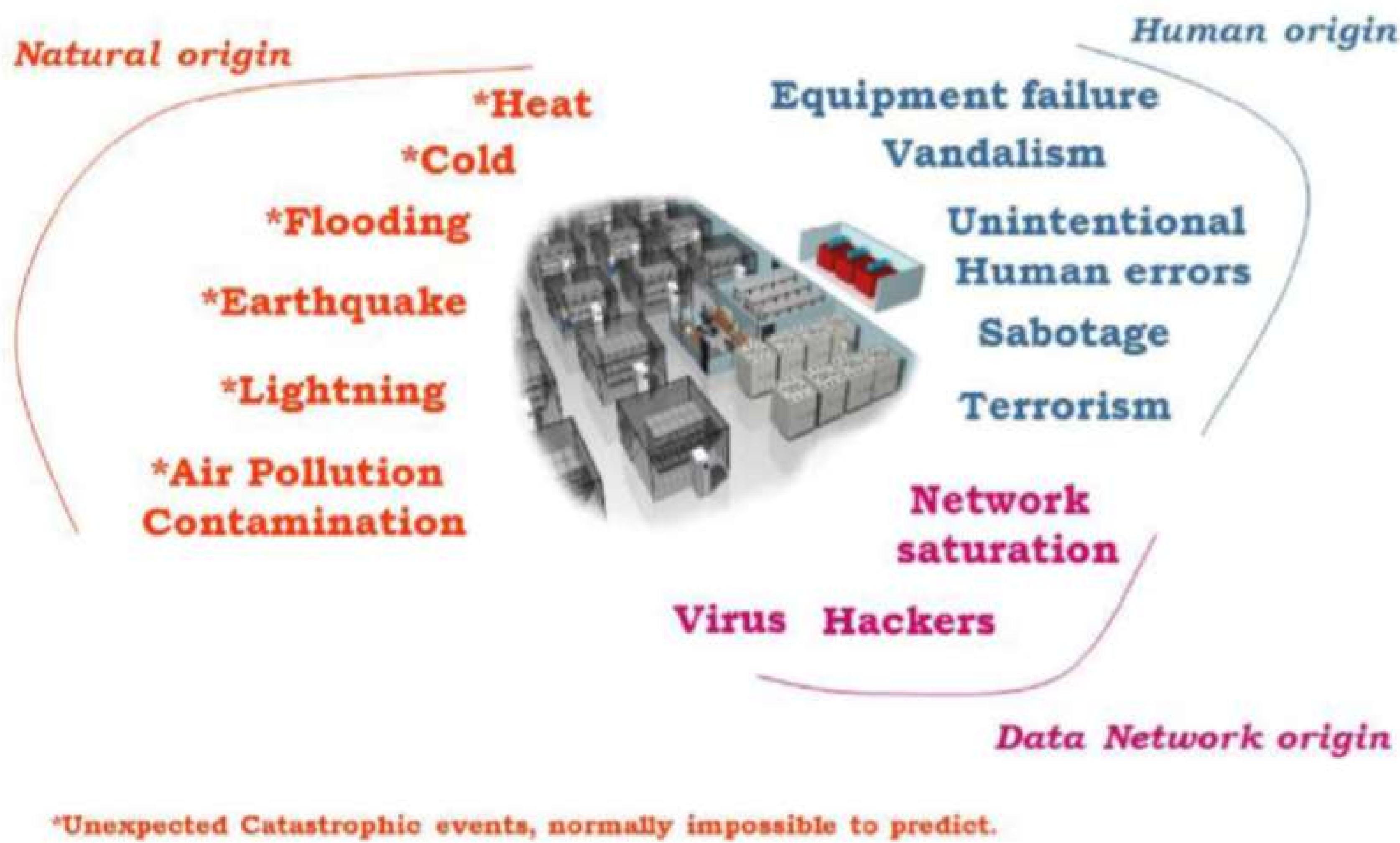


# Risk Factors for Data Centre



# Prominent Cause of Downtime/Failure

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- Human Error
  - No or poorly executed processes and work instructions
  - Unauthorized access
  - Accidents
  - Unnoticed Alarms
- Power Quality issues
  - Poor voltage/current/frequency regulation
  - High level of Common and Normal mode noise
  - High ground resistance
  - Harmonics
- Electro Magnetic Fields (EMF)
  - High radiation levels from power cables / UPS / Transformers / PDU / Lighting etc.
- Environmental Conditions
  - Temperature / Humidity
  - Wrong cooling principles
  - High levels of contamination

# Summary

| Session Review | Moral of the Story |
|---|---|
| | |
| DC is an integral part of Business | DC plays a crucial role in High-Availability |
| | |
| Problems in DC could lead to business incurring substantial loss to the point of total closure | DC has to be part of, and accommodate, the fast pace of Change in Demand |
| | |
| DC is a complex and dynamic space | Fact is that most of the DC today are not ready for Tomorrow’s Demand |
| | |
| Most Down-Time is caused by Power, Cooling, EMF and/or Human Error [only considering Facility Down-Time] | Most, if not all, DC have experienced changes making them potential risk factors for achieving High-Availability |

# Standards and Certification

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| Standard → ↓ Guideline | UpTime [USA] | EPI based on TIA-942 [USA] | BICSI based on TIA-942 [USA] | SS-507 [Singapore] | EN-50600 [Europe] |
|---|---|---|---|---|---|
| Conformity | Tier : I - IV | Rated : 1 - 4 | Class : 0 - 4 | Pass / Fail | Class : 1 - 4 |
| Availability of Standard | Yes | Yes (Paid) | Yes | Yes | Yes |
| Certification | Available | Available | Not Available | Available | Available |
| Scope of Topology | <u>Tier Standard</u><br>Electrical<br>Mechanical<br>Distribution<br><br><u>OS Standard</u><br>Other Element | Electrical<br>Mechanical<br>Distribution<br>Architectural<br>Telecom<br>Site Location<br>Safety-Security<br>Efficiency | Electrical<br>Mechanical<br>Distribution<br>Architectural<br>Telecom<br>Site Location<br>Safety-Security | Electrical<br>Mechanical<br>Distribution<br>Architectural<br>Telecom<br>Site Location<br>Safety-Security | Electrical<br>Mechanical<br>Distribution<br>Architectural<br>Telecom<br>Site Location<br>Safety-Security<br>Efficiency |
| Incorporation | Commercial | Non-Profit | Non-Profit | Non-Profit | Non-Profit |
| Accreditation | No | ANSI | ANSI | Spring | EN-CENELEC |
| Training Event | Yes | Yes | Yes | No | No |
| Auditor | UpTime Only | Multiple ORG | N/A | Multiple ORG | N/A |

# Topology Standard : Definition

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**Rated-1; Basic**
Single path for power and cooling distribution, no redundant components.

**Rated-2; Redundant components**
Single path for power and cooling distribution, redundant components.

**Rated-3; Concurrent Maintainable**
Multiple power and cooling distribution paths, but only one path active, redundant components, concurrently maintainable, compartmentalized.

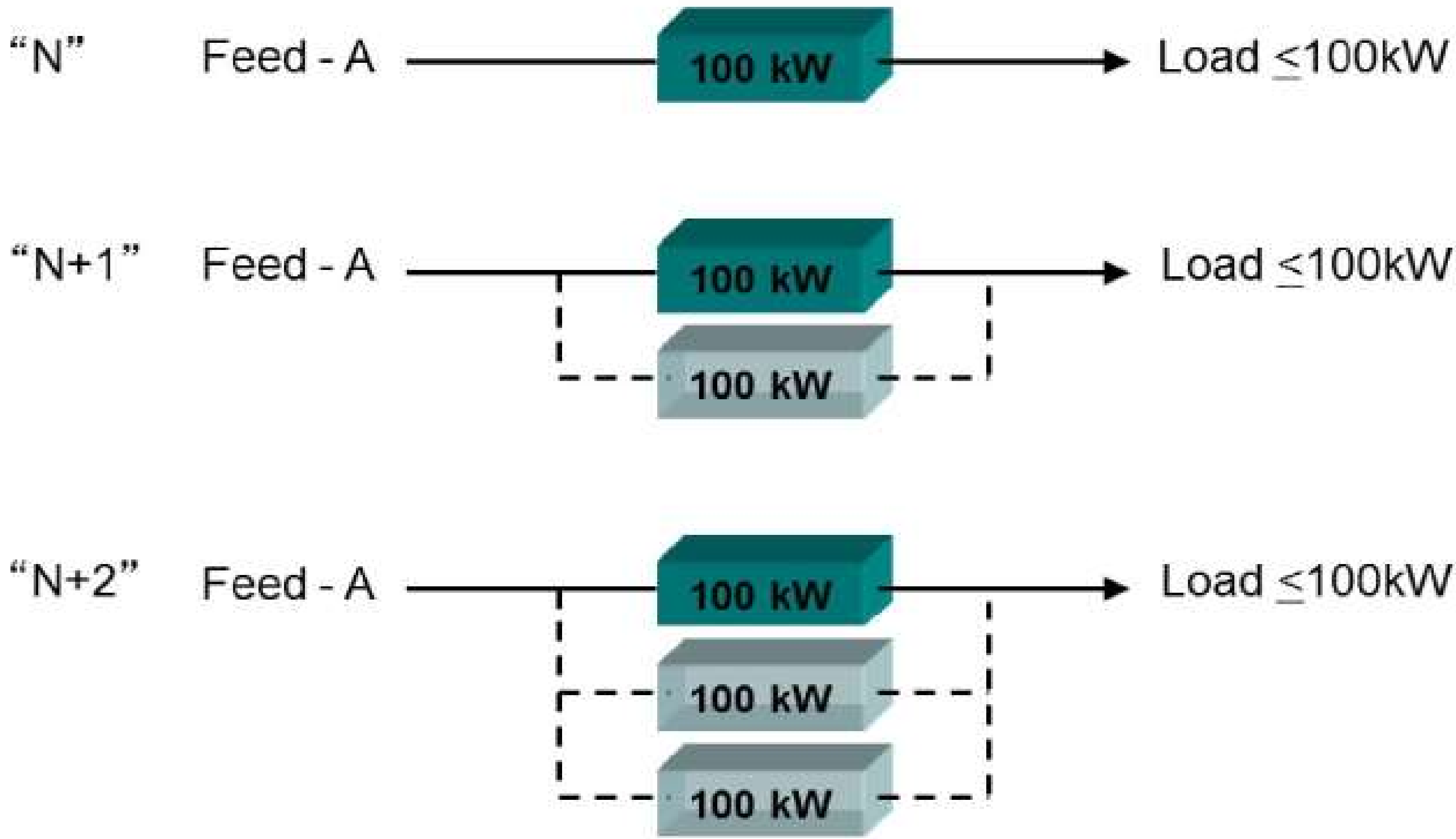
**Rated-4; Fault Tolerant**
Multiple active power and cooling distribution paths, redundant components, fault tolerant, concurrently maintainable, compartmentalized.

# Tier Topology : Basic, RC, CM

| Redundancy | Definition |
|---|---|
| N | System which meets the base requirements (**N**eed) and has no redundancy. |
| N+1 | Redundancy provides one additional unit, module, path, or system in addition to the minimum required to satisfy the base requirement. The failure or maintenance of any single unit, module, or path will not disrupt operations. |
| N+2 | Redundancy provides two additional units, modules paths, or systems in addition to the minimum requirement to satisfy the base requirement. The failure or maintenance of any two single units, modules or paths with not disrupt operations. |

# Topology Standard : N, N+1, N+2

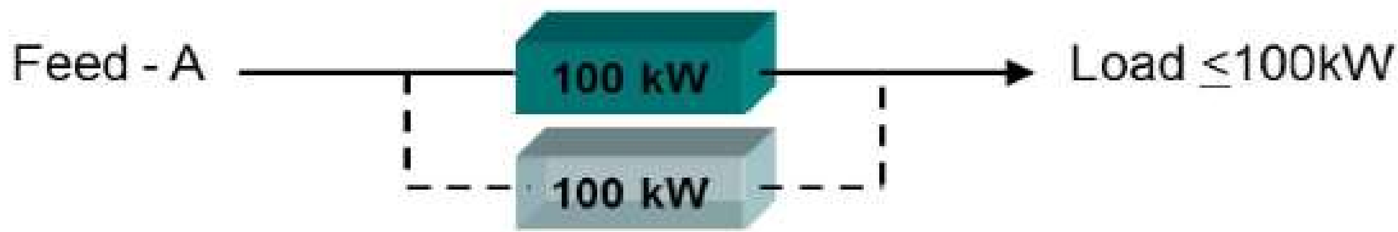
## 'N' Component redundancy levels



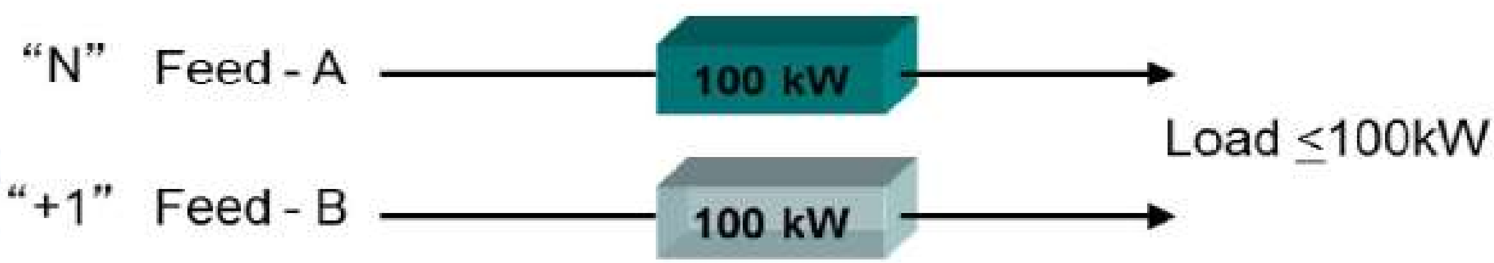
# Topology Implementation : N+1

## N+1 Implementations

- N+1 could mean component redundancy




- N+1 could mean path redundancy



# Redundancy : Component vs Path

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## N+1 Implementations

- N+1 as path implementation leads to higher availability than N+1 at the component level
  - Multiple paths to ICT equipment have less Single Points of Failures (SPoF)
  - Multiple paths allow potential maintenance and faults anywhere in one path without disturbing the other path and therefore the ICT load
  - N+1 at component level still has SPoF at various levels as the distribution path remains single

# Tier Topology : Fault Tolerant

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| Redundancy | Definition |
|---|---|
| 2N | Redundancy provides two complete units, modules, paths, or systems for every one required for a base system. “Failure or maintenance of one entire unit, module, path, or system will not disrupt operations. |
| 2(N+1) | Redundancy provides two complete units, modules, paths, or systems each with “+1” additional capacity. Even in the event of failure or maintenance of one unit, module, path, or system, some redundancy will be provided and operations will not be disrupted. |
| 2(N+2) | Redundancy provides two complete units, modules, paths, or systems each with “+2” additional capacity. Even in the event of failure or maintenance of one unit, module, path, or system, and one of the backup modules then still operations will not be disrupted. |

# Topology Deployment : Fault Tolerant

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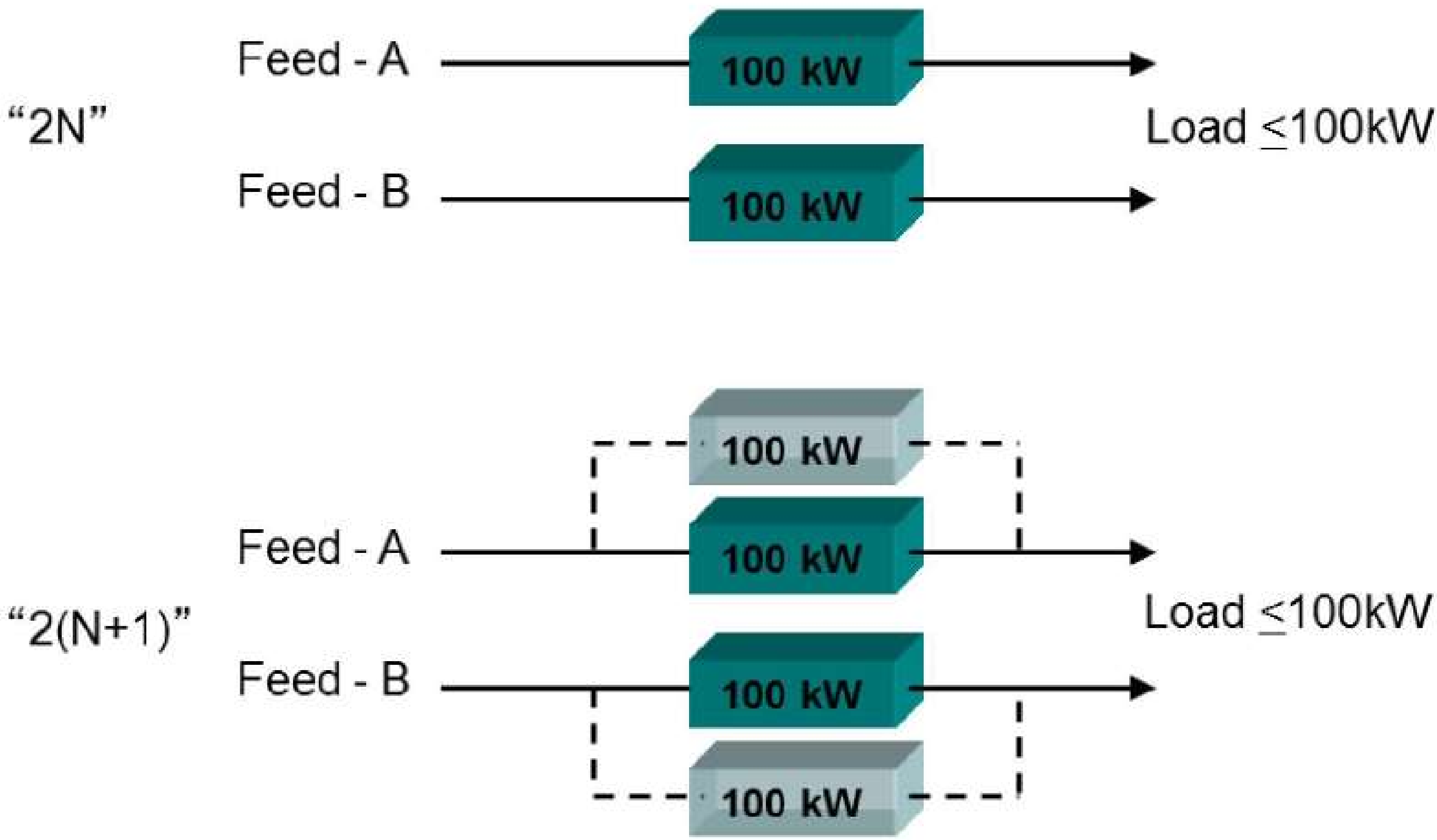

# Topology Standard : UpTime and EPI

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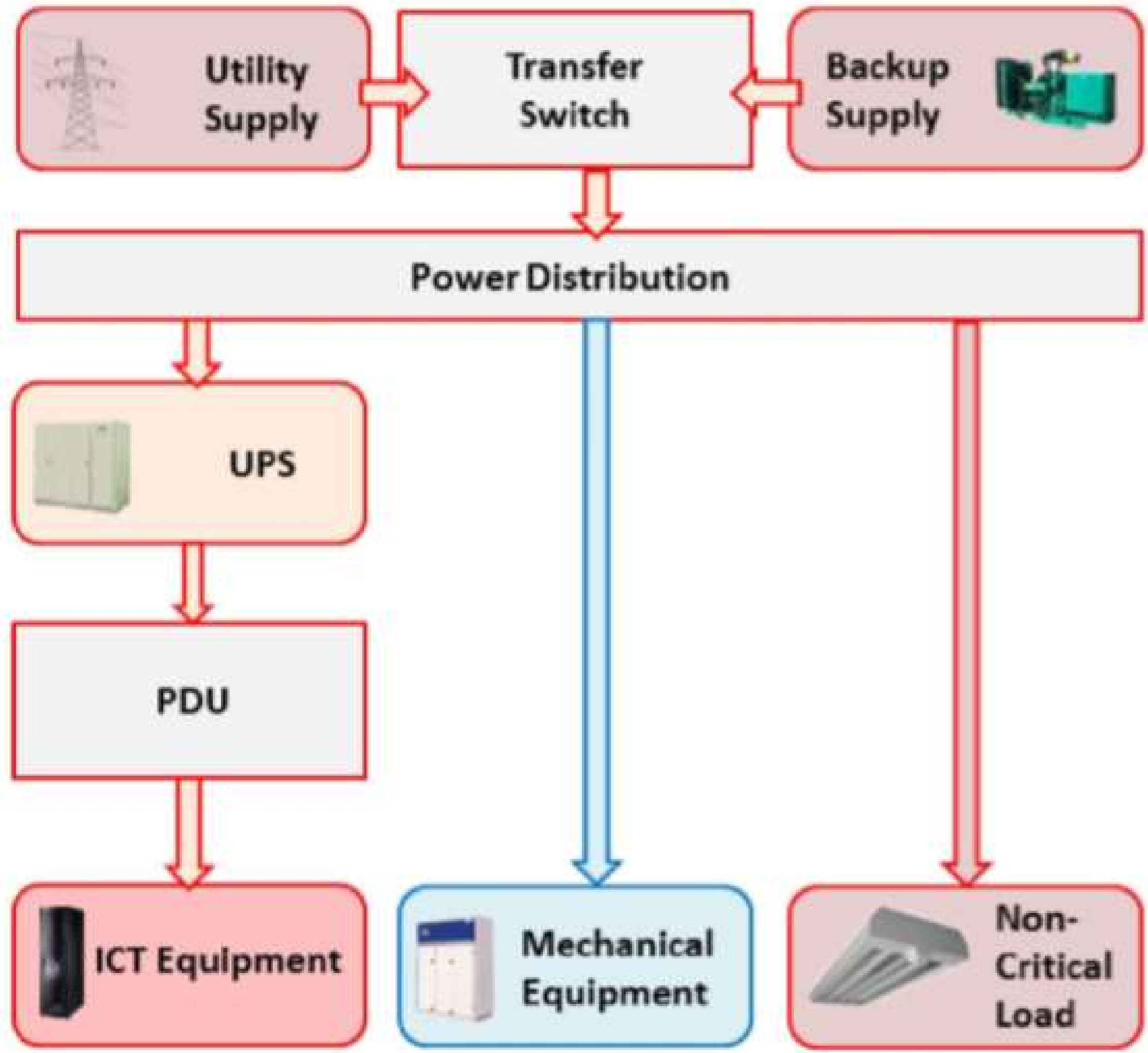
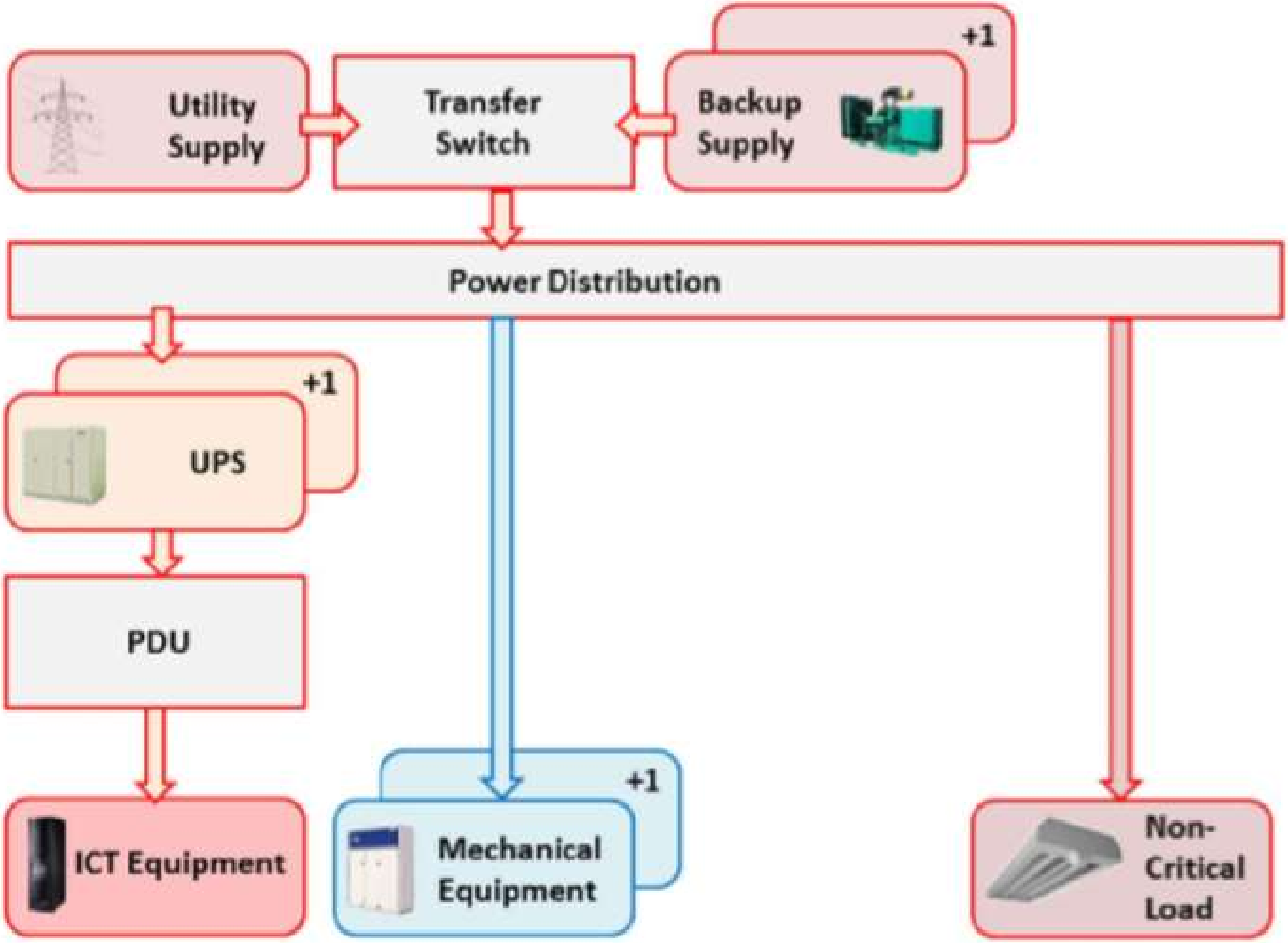
| | Tier I | Tier II | Tier III | Tier IV |
|---|---|---|---|---|
| Active Capacity Components to Support the IT Load | N | N + 1 | N + 1 | N After Any Failure |
| Distribution Paths | 1 | 1 | 1 Active and 1 Alternate | 2 Simultaneously Active |
| Concurrently Maintainable | No | No | Yes | Yes |
| Fault Tolerance | No | No | No | Yes |
| Compartmentalization | No | No | No | Yes |
| Continuous Cooling | No | No | No | Yes |

| | Rated 1 | Rated 2 | Rated 3 | Rated 4 |
|---|---|---|---|---|
| Active Capacity Components to Support the IT Load | N | N + 1 | N + 1 | N + N |
| Distribution Paths | 1 | 1 | 1 Active and 1 Alternate | 2 Simultaneously Active |
| Concurrently Maintainable | No | No | Yes | Yes |
| Fault Tolerance | No | No | No | Yes |
| Compartmentalization | No | No | Yes | Yes |
| Continuous Cooling | No | No | No | No |

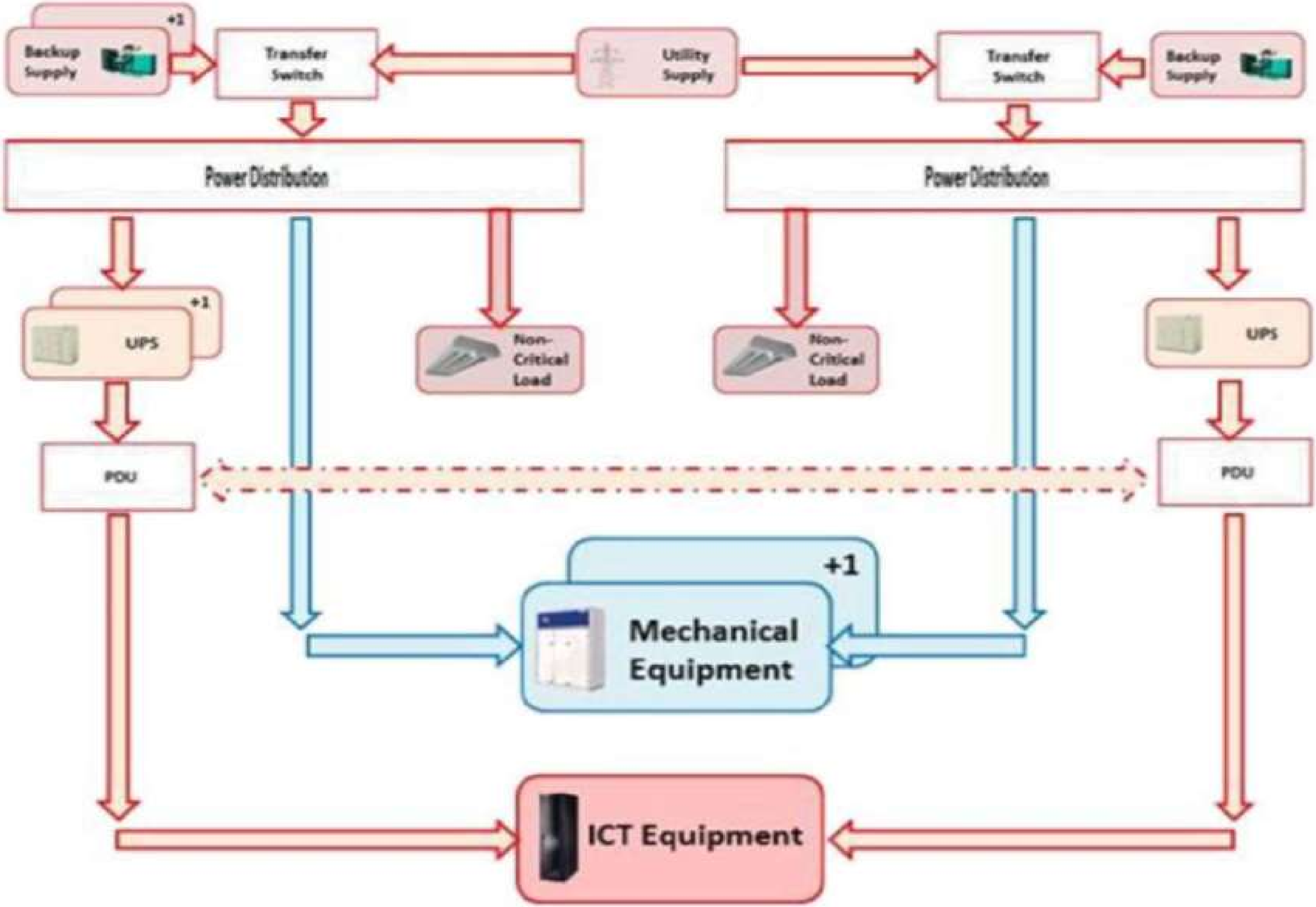
# Simplest SLD : Basic Component



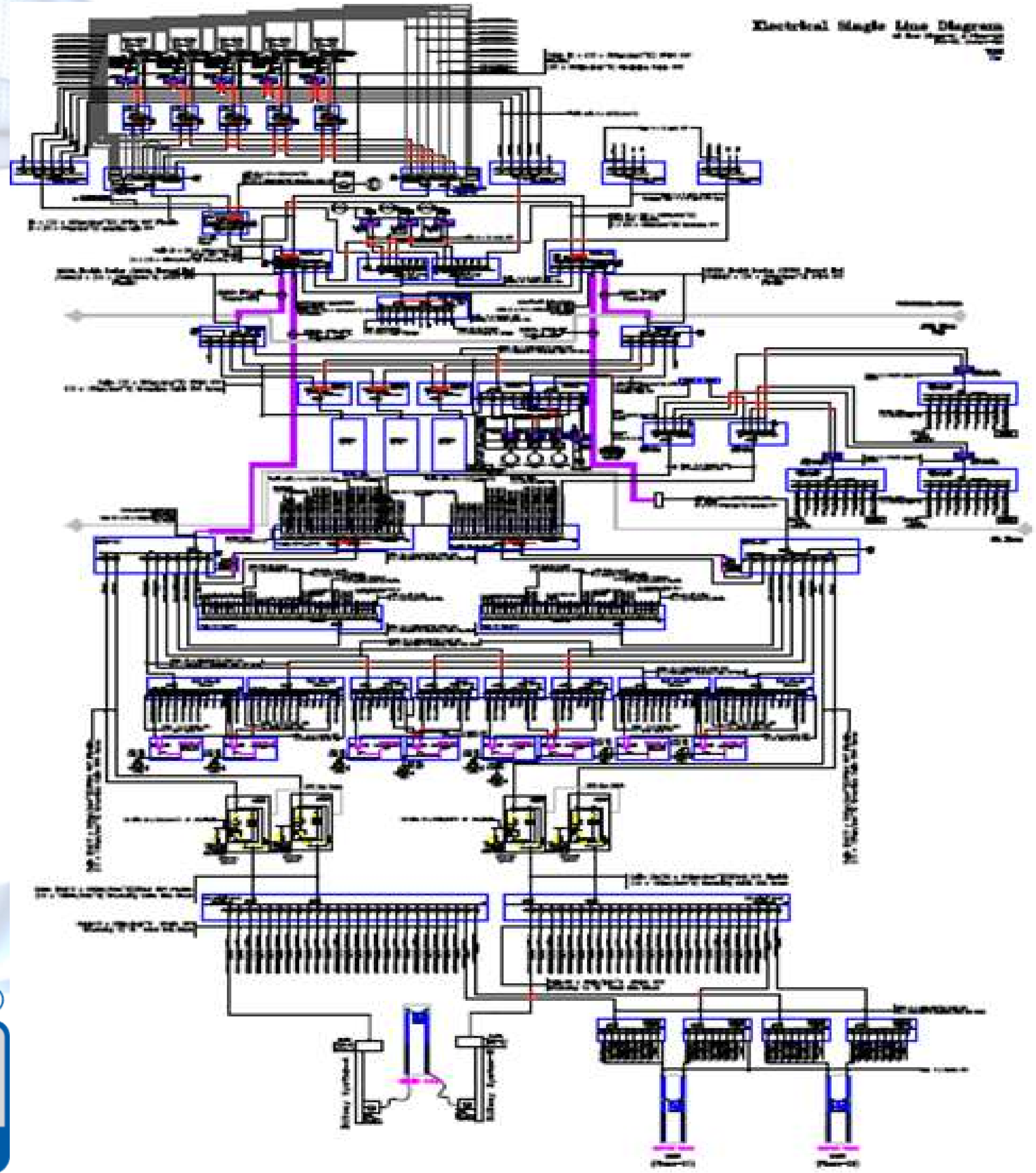
# Simplest SLD : Redundant Component



# Simplest SLD : Concurrently Maintainable



# Real Life SLD : Tier-III Compliant




TIER III

DESIGN

Felicity BigData II Limited

FBD II

Expires 9 January 2021

UPTIME INSTITUTE CERTIFIED

# Simplest SLD : Fault Tolerant

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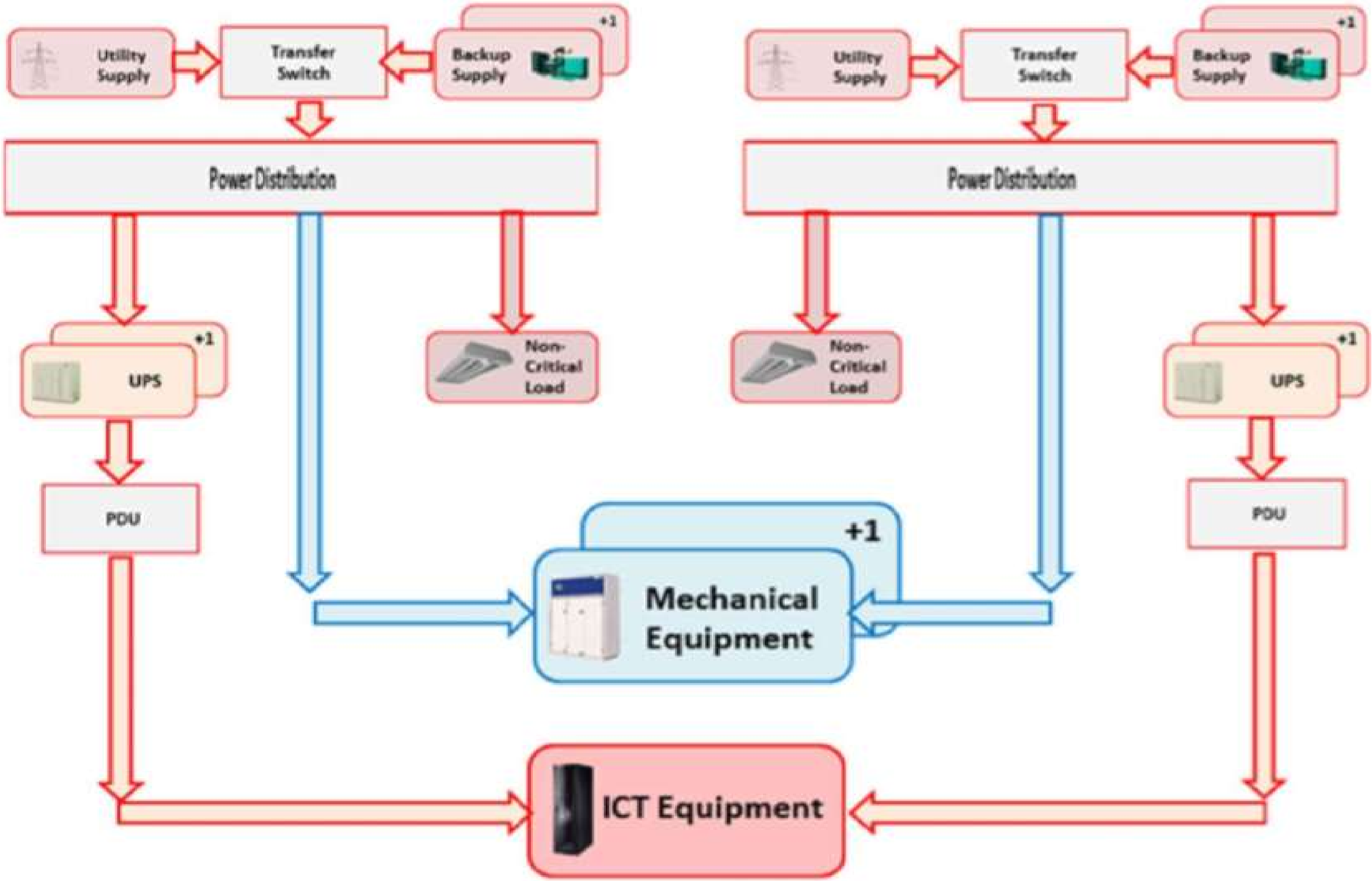

# Session 2

- Environment Class Rating
- Engine Generator Rating
- Hybrid Topology : Best Practice
- Hybrid Topology : Definition
- Hybrid Topology : Design Requirement
- Objective and Summary of Certification
- Cooling Technology for Network Node
- Plenum Cooling Technology

# ASHRAE, 2011 : Environment Class

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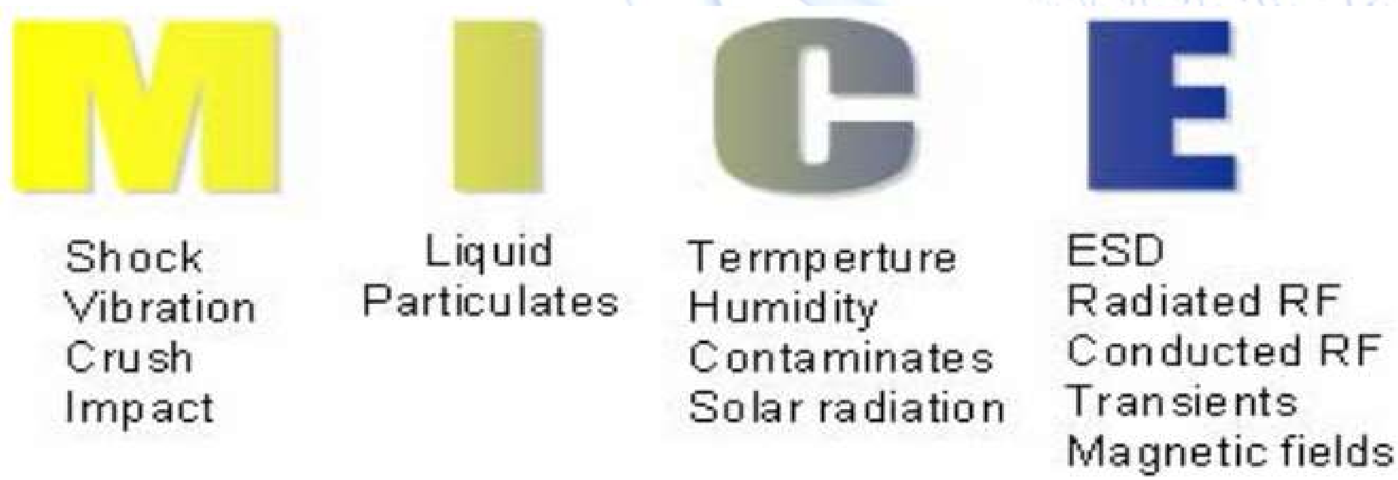
| 2011 | 2008 | Applications | ICT Equipment | Environmental Control |
|---|---|---|---|---|
| A1 | 1 | Data Centre | Enterprise Servers /Storage | Tightly Controlled |
| A2 | 2 | | Volume Servers, Storage products, personal computers, workstations | Some Control |
| A3 | n/a | | Volume Servers, Storage products, personal computers, workstations | Some Control |
| A4 | n/a | | Volume Servers, Storage products, personal computers, workstations | Some Control |
| B | 3 | Office, Home, Transportable environment | Personal Computers, Laptops, printers | Minimal Control |
| C | 4 | Point of Sale, Factory etc. | Point Of Sale Equipment, Ruggedized Controllers, computers, PDA's etc. | No Control |

# ASHRAE, 2011 : Data Centre

| 2011 | Dry Bulb Temperature | Humidity | Dew Point | Max Elevation |
|---|---|---|---|---|
| | Recommended | | | |
| A1-A4 | 18 – 27 °C / 64.4 – 80.6 °F | 5.5 °C DP to 60% RH and 15 °C DP | | |
| | Allowable | | | |
| A1 | 15 – 32 °C / 59 - 89.6 °F | 20 – 80% RH | 17 °C | 3050 |
| A2 | 10 – 35 °C / 10 – 95 °F | 20 – 80% RH | 21 °C | 3050 |
| A3 | 5 – 40 °C / 41 - 104 °F | -12C DP and 8 - 85% RH | 24 °C | 3050 |
| A4 | 5 – 45 °C / 41 - 113 °F | -12C DP and 8 - 90% RH | 24 °C | 3050 |

# Environmental Class Rating


| | | | |
|---|---|---|---|
| Mechanical | $M_1$ | $M_2$ | $M_3$ |
| Ingress | $I_1$ | $I_2$ | $I_3$ |
| Climatic | $C_1$ | $C_2$ | $C_3$ |
| Electromagnetic | $E_1$ | $E_2$ | $E_3$ |
| | Commercial | Light Industrial | Industrial |




**UpTime does not talk about Environmental Class Rating**

# Engine Generator Rating

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| Engine Generator Requirements | Tier I | Tier II | Tier III | Tier IV |
|---|---|---|---|---|
| Rating to Support design load | Any; up to nameplate rating to support design load | Any; up to nameplate rating to support design load | Capable of supporting design load for unlimited hours at site conditions | Capable of supporting design load for unlimited hours at site conditions |
| Continuous | No additional requirement for hours of operation limitations | | Full nameplate capacity | |
| Prime | | | Option 1: 70% of nameplate capacity<br>Option 2: Larger capacity than Option 1 with manufacturer letter | |
| Standby | | | Can be used for Tier III and Tier IV with manufacturer letter; Tier Certification capacity dependent on manufacturer letter | |
| Derating for Site Conditions | Additional derating may be required due to site conditions (ambient temperatures, elevation)—consult manufacturer requirements | | | |

**EPI requires Engine Generator to be Prime with Nameplate Capacity**

# Hybrid Topology : Best Practice

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| | Level 1 | Level 2 | Level 3 | Level 4 |
|---|---|---|---|---|
| Active Capacity Components to Support the IT Load | N | N + 1 | N + 1 | N + N |
| Distribution Paths | 1 | 1 | 2 (Both Active) | 2 (Both Active) |
| Concurrently Maintainable | No | No | Yes | Yes |
| Fault Tolerance | No | No | No | Yes |
| Compartmentalization | No | No | Yes | Yes |
| Continuous Cooling | No | No | No [Average < 5 KW]<br>Yes [Average > 5 KW] | Yes |
| Site Selection | EPI | EPI | EPI | EPI |
| Civil / Structural | EPI | EPI | EPI | EPI |
| Architectural | EPI | EPI | EPI | EPI |
| MMR and Structured Cabling | EPI, IBP | EPI, IBP | EPI, IBP | EPI, IBP |
| Safety, Security, Fire Code | AHJ, EPI | AHJ, EPI | AHJ, EPI | AHJ, EPI |
| Efficiency [PUE, WUE, CUE, DCIE] | TGG | TGG | TGG | TGG |

# Hybrid Topology Definition : Level 3

| Compliance Standard | Validation and Audit |
|---|---|
| Rated-3 and Tier-III Facility | ‘Concurrent Maintainability’ is the philosophy behind the Rated-3 and Tier-III conformity. It requires to ensure that every capacity component as well as their distribution path can be removed / replaced / serviced on a planned basis without disrupting the ICT capabilities to the end-user.<br><br>It applies to all active and passive components of MEP infrastructure. However, Architecture-Civil, Fire Suppression and Safety-Security provisions are out of this scope. Manual fail-over switching of electrical-power is allowed.<br><br>Furthermore, it requires that each distribution path for power, cooling, ICT to be physically separated. Specifically transformer, generator, UPS, battery, chiller plant, carrier room / meet-me room and rack-space should remain 1 (one) hour fire-separated from each other. Additionally, no sharing of PDU, fire suppression and cooling is allowed as well. |

# Hybrid Topology Definition : Level 4

| Compliance Standard | Validation and Audit |
|---|---|
| Rated-4 and Tier-IV Design | ‘Fault Tolerant’ is the philosophy behind the Rated-4 and Tier-IV conformity. It requires to ensure that every capacity component in either of their distribution path can run on the full-load operation of the facility. Hence, capacity component as well as distribution path can tolerate a fault anywhere in the system while the facility is having planned down-time / maintenance without disrupting ICT capabilities to end-user.<br><br>It applies to all active and passive components of MEP infrastructure. However, Architecture-Civil, Fire Suppression and Safety-Security provisions are out of this scope. Software tools for remote operation is required.<br><br>Furthermore, it requires that each distribution path for power, cooling, ICT to be physically separated. Specifically transformer, generator, UPS, battery, chiller plant, carrier room / meet-me room and rack-space should remain 2 (two) hour fire-separated from each other. Additionally, no sharing of PDU, fire suppression and cooling is allowed along with manual fail-over switching of electrical-power. |

# Hybrid Topology : Requirement

| # | Site Selection Requirement |
|---|---|
| 1 | Ground Floor should be high-enough to sustain any flash flood based on 50 (fifty) years of flood history |
| 2 | Distance from Air-Port should be 8 Km / 5 miles |
| 3 | Distance from Rail-Station should be 0.8 Km / 0.5 miles |
| 4 | Within 3,050 m / 10,000 feet from the sea-level |
| 5 | Capability to Handle Seismic Activity based on 'Zone' Requirement |
| 6 | Away from Chemical Plant, Power Generation Plant and Establishment which could be categorized as 'Potential Target of Attack' |

| # | Metallurgical, Structural, Civil and Architectural Requirement |
|---|---|
| 1 | No use of Asbestos, Lead and Poly-Chlorinated Biphenyl |
| 2 | Permanent Shelter with Class-A roof (fully adhered roof) |
| 3 | Separate Parking for Employees and Visitors with Zoning |
| 4 | IBC-2006 (+ updates), NFAP-2001 (+ updates) to be followed along with Code of AHJ |
| 5 | Legal Hierarchy of Compliance : Law / Code of AHJ, DC Standards, International Standards |

# Hybrid Topology : Requirement

| # | Metallurgical, Structural, Civil and Architectural Requirement |
|---|---|
| 6 | Rated-3 requires IIA / IIIA / VA and Rated-4 requires IA / IB level of construction |
| 7 | Vapour Barrier with plastic-sheet or latex-paint |
| 8 | Roof Slope for Rated-3 is 1:48 and for Rated-4 is 1:24 |
| 9 | Floor Loading for Rated-3 and Rated-4 is 12 $KN/m^2$ |
| 10 | Suspended Ceiling is not recommended |
| 11 | All the MEP and ICT equipment should be based on 'Seismic Zone' Requirement |
| 12 | No Exterior Windows in Data Hall / Computer Room |
| 13 | Access Control, Surveillance System and Fire Suppression System shall not be shared in case of the fire-separated zone / room |
| 14 | Monitoring should be continuous (recording should be activity based) along with minimum of 20 fps. Hence, PTZ camera is not acceptable |
| 15 | Dual-Factor authentication based Access Control |
| 16 | Single-Person Double Door Interlock based Man-Trap at the Entrance of Data Centre |
| 17 | Bullet Proof (Level-3 of UL-752) Window at the Reception / Guard Room ($1^{st}$ Entrance) |
| 18 | Doors should swing-away while getting out of any room (if Local Fire Code allows it) |

# Hybrid Topology : Requirement

SANOG

| # | Metallurgical, Structural, Civil and Architectural Requirement |
|---|---|
| 19 | Rated-3 requires 24/7 presence of security guards and Rated-4 requires 24/7 presence of both armed and security guards with walk-in escort and inspection patrol |
| 20 | Emergency Exit Sign, Exit Path Direction, etc. requires minimum 1 Lux light at all time. Unoccupied Rack-Space requires light to keep Surveillance System running smooth. Occupied Rack-Space requires 200 Lux (measured at 1m above the ground and 1m away from the rack) at the sides of the racks and 500 Lux at the front and back of the racks. However, use of night-vision camera and motion sensor will allow to go completely dark rack-space (Emergency Exit Sign, Exit Path Direction shall remain switched on at all time) |
| 21 | Reception / Entry-Lobby, UPS, Battery and Gen-Set rooms should have 2 (two) hour fire-separation for Rated-3 and 4 (four) hour fire-separation in case of Rated-4 facilities. For the rest of the walls, floors and ceilings of the fire separated zone / room it should be respectively 1 (one) and 2 (two) hours |
| 22 | Exclusive ramp / bay for Loading-Unloading and Shipping-Receiving should be followed by Warehouse and Staging area |
| 23 | Two entry-road and loading-bay along with One (sole) reception and exit-road for vehicle and human movement |
| 24 | Access Path and Exit Corridor Philosophy ‘What Come In Should Be Able to Go Out Again’ |

# Hybrid Topology : Requirement

SANOG

| # | Mechanical, Electrical, Plumbing (MEP) Requirement |
|---|---|
| 1 | Rated-4 requires a Remote Operations Centre, Remote Switching of Light and PA system |
| 2 | DCIM (WLDS, EMS, BMS and Automatic Power Fail-Over Switch) or, IDC-IMS (DCIM and NMS) shall be used to mitigate the risk for Rated-4 Facility |
| 3 | EMF should be isolated / filtered and it should be measured from Rack PDU level |
| 4 | UPS and Battery rooms should have maintenance-aisle of minimum 1.2 meter |
| 5 | Rack to Rack distance both in hot and cold aisle should be minimum of 1.2 meter |
| 6 | DRUPS, Generator, Chiller, Cooling Tower, Valve, Fire Pump, Diesel Pump and Chilled Water Pumps should have maintenance-aisle of more than the width of equipment |
| 7 | Battery room need to be separated from UPS room, Switchgear room and Generator Plant. It's also needs to have sufficient natural-air ventilation and Shatter-Proof glass window in the door |
| 8 | Rated-3 allows the Generator / DRUPS to be placed in the Data Hall building with compliance of fire separation. Whereas, Rated-4 requires the Generator / DRUPS to be in separate building / weather proof enclosure with compliance of fire-separation |
| 9 | Diesel Reservoir and Water Reservoir need to carry at least 12 (twelve) hours of full-load operation along with redundancy in storage tank, pump and plumbing. |

# Hybrid Topology : Requirement

| # | Mechanical, Electrical, Plumbing (MEP) Requirement |
|---|---|
| 10 | Generator / DRUPS Rooms and Diesel Reservoirs should be 9 m / 30 feet away from public area in case of Rated-3 and the distance should be 19 m / 60 feet in case of Rated-4 |
| 11 | Data Halls should not have any external window, internals are allowed if they meet the fire-ratings and security |
| 12 | Rated-3 requires everyone to face 3 (three) access control till the Rack and Rated-4 requires 4 (four). However, recommendation is to have 1 (one) extra stage for both cases |
| 13 | Minimum 46 cm / 18 inch vertical clearance under fire suppression nozzles till 1st obstacle |
| 14 | Underground Up-Stream Utility Power Feeder is preferred over Overhead (optional) |
| 15 | Rated-3 requires Single Sub-Station (with Dedicated Distribution Feed for the Facility from Sub-Station) with N+1 Down-Stream Power Feeder. And, Rated-4 requires Dual Sub-Station (with Dual Dedicated Distribution Feed for the Facility from Sub-Station) with 2N Down-Stream Power Feeder |
| 16 | Both up-stream and down-stream power-feeders will remain separated by 20 meter till they are exclusively distributed inside Data Halls |
| 17 | Both up-stream and down-stream optical-fibres will remain separated by 20 meter till they are exclusively distributed inside Data Halls |

# Hybrid Topology : Requirement

SANOG

| # | Mechanical, Electrical, Plumbing (MEP) Requirement |
|---|---|
| 18 | UPS should be backed by Prime Generators (at least) not Standby Generators |
| 19 | Cogeneration Plant instead of 2nd Utility should use Continuous Generator neither Prime nor Standby |
| 20 | HT Switchgear Panel should have Surge Protection Device and Draw-Out Circuit Breakers |
| 21 | Generator with Battery Bank and UPS / DRUPS should be of N+1 configuration (where, N = 1 - 9. Hence, +1 redundant-component for every 9 needed-component) for Rated-3. Whereas, it is 2N configuration (N has no limit) for Rated-4. Furthermore, both Rated-3 and Rated-4 requires Dual-Bus system of Distribution |
| 22 | Chiller, Cooling Tower, AHU, In-Row AHU, Chilled Water Pump, etc. should be of N+1 configuration (where, N = 1 - 5. Hence, +1 redundant-component for every 5 needed-component) for Rated-3. Whereas, it is 2N configuration (N has no limit) for Rated-4. Furthermore, both Rated-3 and Rated-4 requires Dual Piping system of Distribution |
| 23 | Rated-3 and Rated-4 both requires a dedicated feeder in to the Automatic Bypass of the UPS and a dedicated Maintenance Bypass Feeder serving the UPS output PDU |
| 24 | If Static UPS (battery-bank) is used Rated-3 requires minimum 10 (ten) minutes and Rated-4 requires minimum 15 (fifteen) minutes of full-load operation |

# Hybrid Topology : Requirement

| # | Mechanical, Electrical, Plumbing (MEP) Requirement |
|---|---|
| 25 | If DRUPS (fly-wheel) is used Rated-3 requires minimum 6 (six) seconds and Rated-4 requires minimum 9 (nine) seconds of full-load operation |
| 26 | ICT equipment, Safety-Security, Automation Software, Emergency Light and Signs, Chilled Water Pump and AHU should be under the UPS Power Supply. However, ICT and Mechanical Loads are recommended to serve with 2 (two) separate Distribution Network of N+1 configuration for Rated-3 facility. Whereas, Rated-4 requires the same provisioning of 2 (two) separate Distribution Network of 2N configuration |
| 27 | Chiller, Office Equipment, Lighting Load, Diesel and Water Pump, etc. should be under the Gen-Set Power Supply with dedicated Distribution Network of N+1 configuration for Rated-3 facility. Whereas, Rated-4 requires the same provisioning of Distribution Network of 2N configuration |
| 28 | Power Strips / Metered PDU / Tap-Off Box should also carry K-Rated Isolation Transformer or IGBT Harmonics Filter to eliminate the Common Mode Noise |
| 29 | Grounding and Signal Reference Grid as per IEEE Standard |
| 30 | HT and LT Panel along with Generator / DRUPS and each level of electrical distribution is recommended to have Surge Protection Device. Whereas, the requirement is to have Surge Protection in the MDB of Low Voltage Side |

# Hybrid Topology : Requirement

SANOG

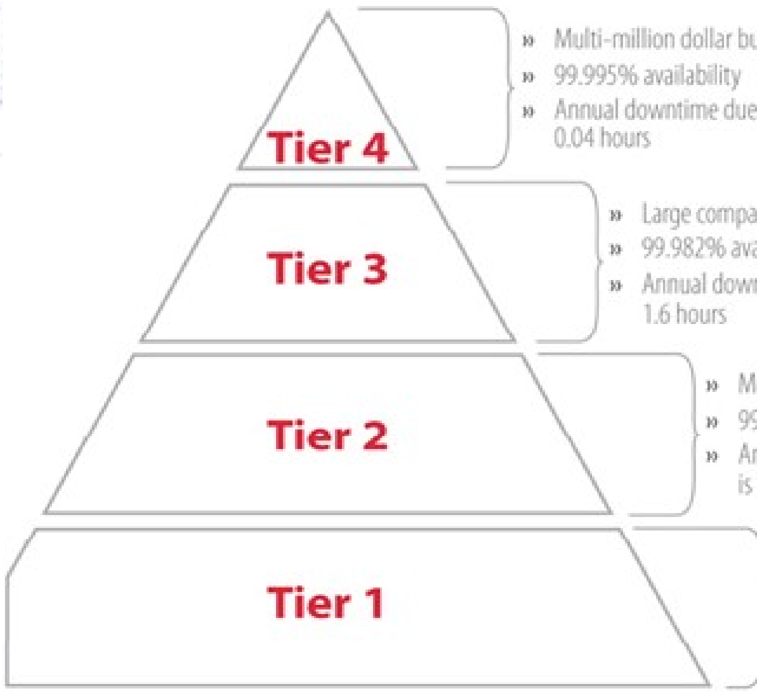
| # | Mechanical, Electrical, Plumbing (MEP) Requirement |
|---|---|
| 31 | Generator-UPS / DRUPS, SPD, HT and LT Switchgear Panel, Motor Control, Chiller Plant, AHU, ATS, STS, Sensors, etc. are recommended to be monitored by CPM system (which needs to have Multiple Level, Multi-Channel Notification) |
| 32 | Rental Provisioning of Load Bank is required (for Testing, Audit and Initial Low-Load Stage) |
| 33 | Current Rating : [Phase 1 = Phase 2 = Phase 3 = Ground = 100%] and [Neutral = 200%] |
| 34 | Isolation Transformer [K-13 or Higher] and/or IGBT (in PDU) to be used for ICT Equipment |
| 35 | Common Mode Noise (CMN) is acceptable up to 1% of Phase to Neutral Voltage. Maximum Acceptable CMN is 3 Volt and Preferred CMN is less than 1 Volt |
| 36 | Form Factor of Panel / Distribution Boards are to be of 2B for Rated-3 and 3B for Rated-4 |
| 37 | Data Hall Design should be designed as MICE-1 ($M_1I_1C_1E_1$) |
| 38 | Environmental Design should be designed as $M_1I_2C_1E_3$ |
| 39 | HVAC System Design should be designed as per ASHRAE, 2011 (including Updates) |
| 40 | Fire Suppression Design should be as per NFPA 2001 (including Updates) and Code of AHJ |
| 41 | Telecom and Network Design as per TIA Standards |
| 42 | Data Halls should have Positive Air Pressure |

# Objective of Certification

SANOG

| Criticality | Business characteristics | Effect on system design |
|---|---|---|
| 1 (Lowest) | • Typically small businesses<br>• Mostly cash-based<br>• Limited online presence<br>• Low dependence on IT<br>• Perceive downtime as a tolerable inconvenience | • Numerous single points of failure in all aspects of design<br>• No generator if UPS has 8 minutes of backup time<br>• Extremely vulnerable to inclement weather conditions<br>• Generally unable to sustain more than a 10 minute power outage |
| 2 | • Some amount of online revenue generation<br>• Multiple servers<br>• Phone system vital to business<br>• Dependent on email<br>• Some tolerance to scheduled downtime | • Some redundancy in power and cooling systems<br>• Generator backup<br>• Able to sustain 24 hour power outage<br>• Minimal thought to site selection<br>• Vapor barrier<br>• Formal data room separate from other areas |
| 3 | • World-wide presence<br>• Majority of revenue from online business<br>• VoIP phone system<br>• High dependence on IT<br>• High cost of downtime<br>• Highly recognized brand | • Two utility paths (active and passive)<br>• Redundant power and cooling systems<br>• Redundant service providers<br>• Able to sustain 72-hour power outage<br>• Careful site selection planning<br>• One-hour fire rating<br>• Allows for concurrent maintenance |
| 4 (Highest) | • Multi-million dollar business<br>• Majority of revenues from electronic transactions<br>• Business model entirely dependent on IT<br>• Extremely high cost of downtime | • Two independent utility paths<br>• 2N power and cooling systems<br>• Able to sustain 96 hour power outage<br>• Stringent site selection criteria<br>• Minimum two-hour fire rating<br>• High level of physical security<br>• 24/7 onsite maintenance staff |

# Summary of Tier Certification




**Tier 4**

- Multi-million dollar business
- 99.995% availability
- Annual downtime due to site is 0.04 hours
- Two independent utility paths
- Fully redundant (2N+1)
- Able to sustain 96-hour power outage

**Tier 3**

- Large company
- 99.982% availability
- Annual downtime due to site is 1.6 hours
- Multiple power and cooling paths
- Fault tolerant (N+1)
- Able to sustain 72-hour power outage

**Tier 2**

- Medium-size business
- 99.749% availability
- Annual downtime due to site is 22.0 hours
- Single path of power and cooling
- Some redundancy in power and cooling systems

**Tier 1**

- Typically small business
- 99.671% availability
- Annual downtime due to site is 28.8 hours
- Single path of power and cooling
- No redundant components

# Types of Heat

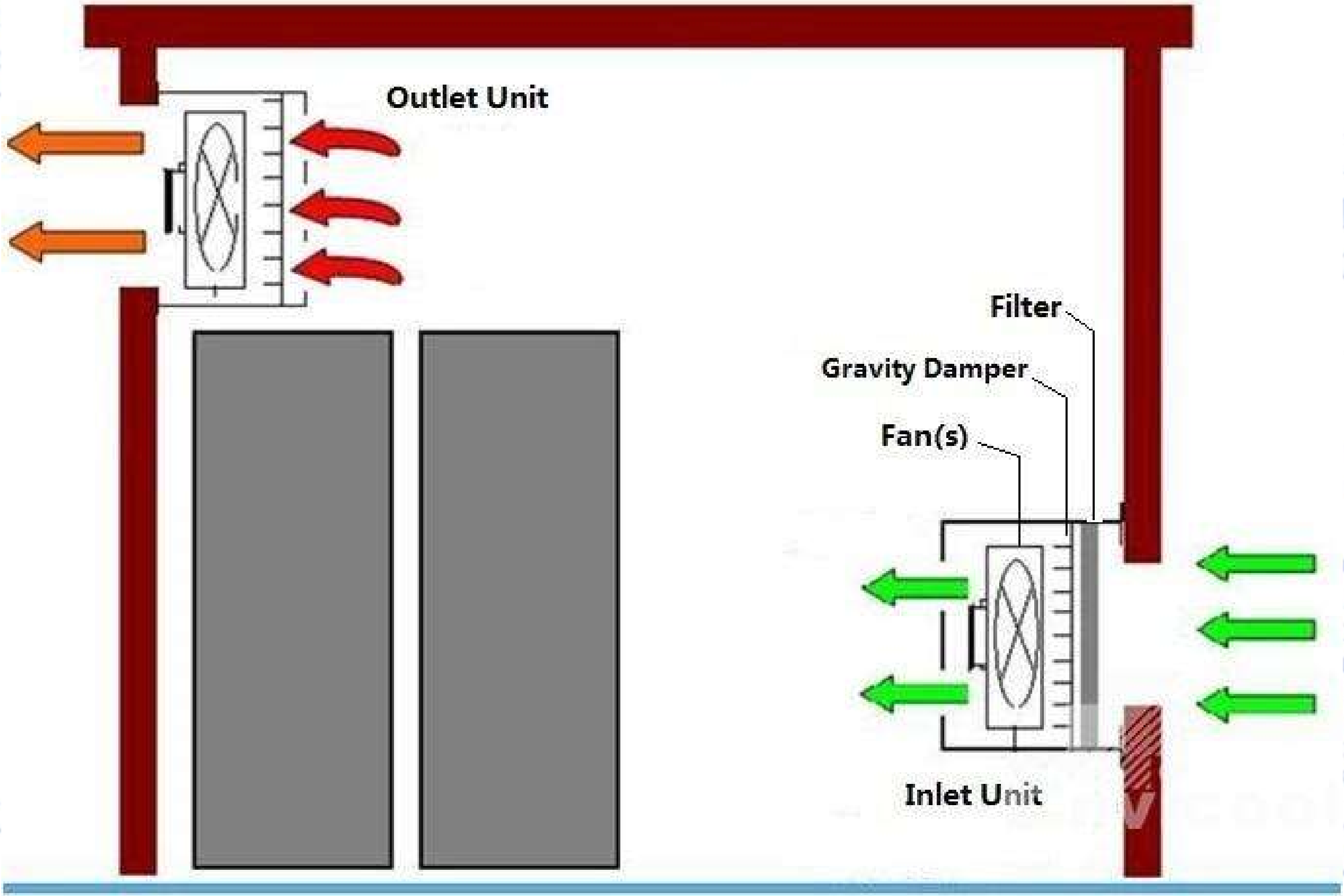
- Sensible Heat
  - Heat that causes a change in temperature in an object
  - ICT equipment generate sensible heat as it produces heat but no moisture
  - Sensible capacity is the capacity required to lower the temperature
- Latent Heat
  - Heat that causes a state change of a substance
  - Humans create latent heat as we produce heat and moisture
  - Latent capacity is the capacity to remove the moisture from the air
- ICT Equipment is purely Sensible Heat

# Cooling Technology for Network Node

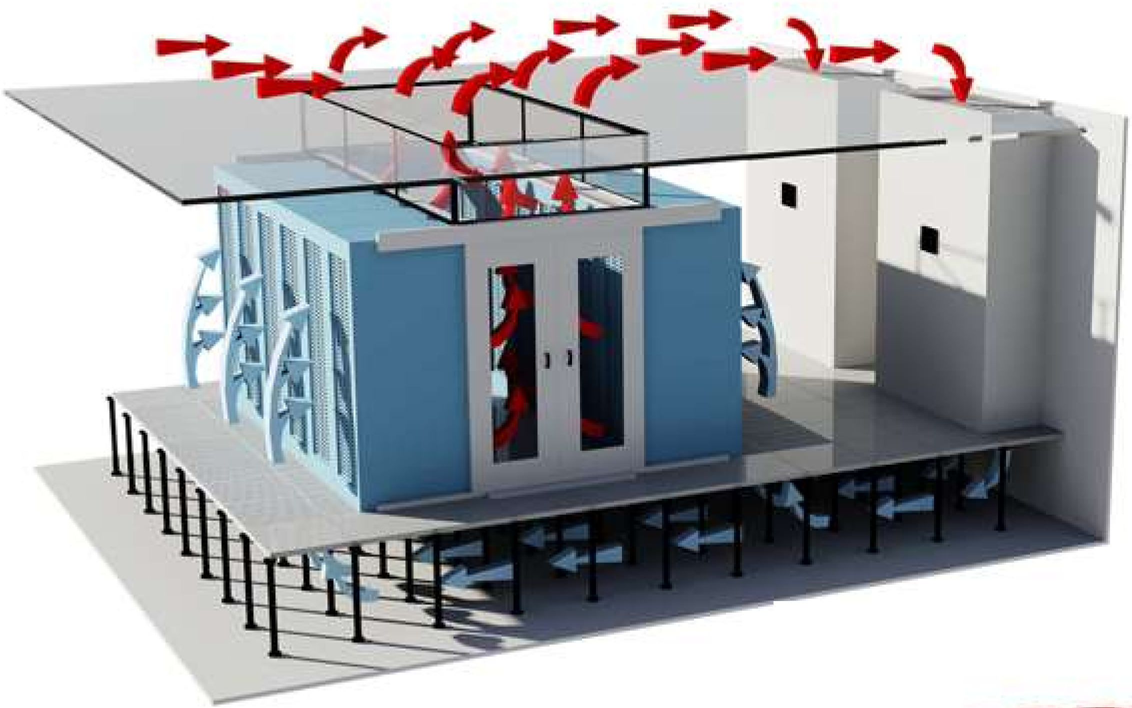
SANOG

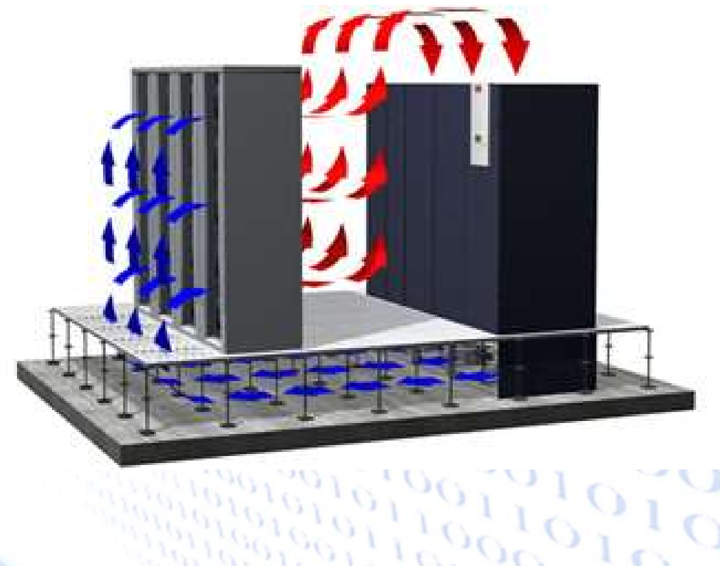
| Free Cooling Technology | Chemical Coolant (DX) Technology | Water Coolant Technology |
|---|---|---|
| Natural Free Cooling | Comfort AC<br>VRF<br>Precision AC | Air Cooled Water (+DX) Chiller |
| Kyoto Wheel<br>Strainer Cycle | Air Cooled DX (+Water) Chiller | Water Cooled Water Chiller |
| Not Applicable<br>[Weather Dependency] | Applicable<br>[Small & Medium] | Applicable<br>[Medium & Large] |

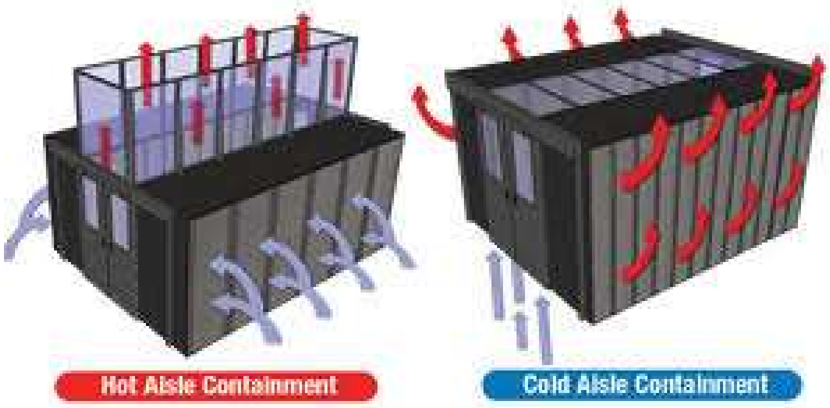
# Free Cooling Technology

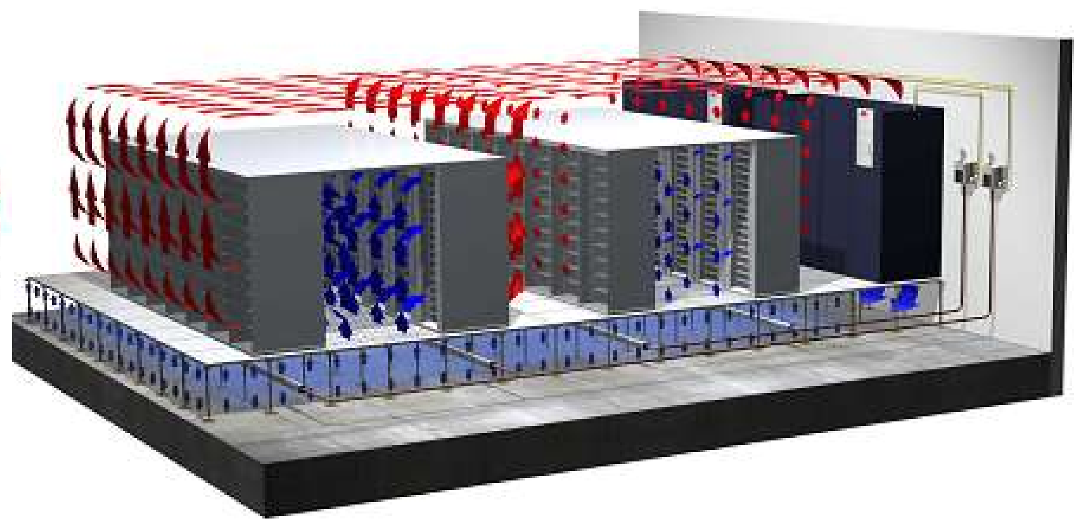


# Chemical Coolant Technology : Plenum

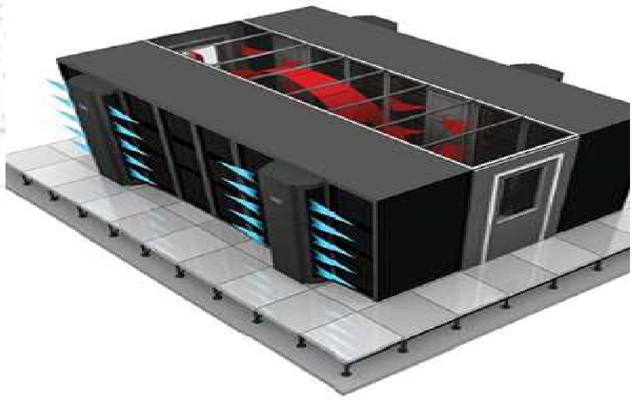


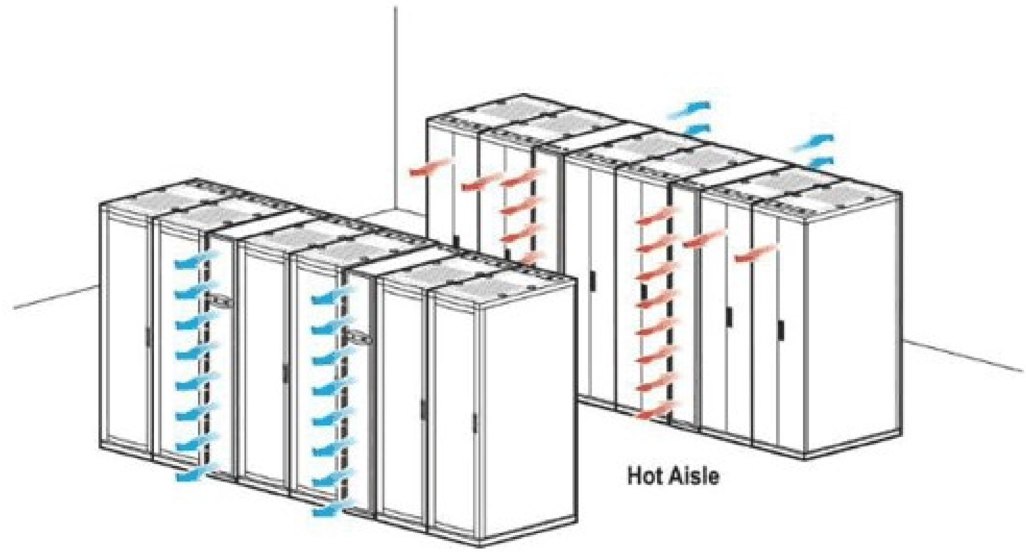


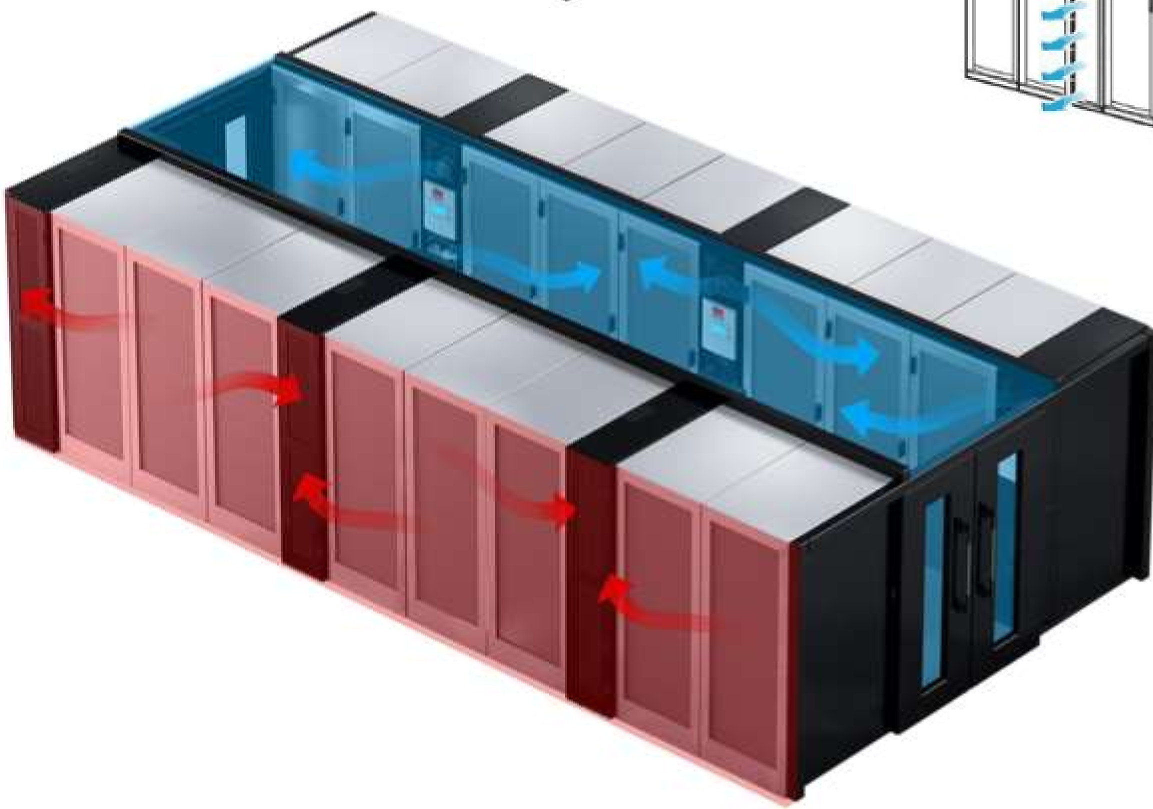


# Chemical Coolant Technology : In Row

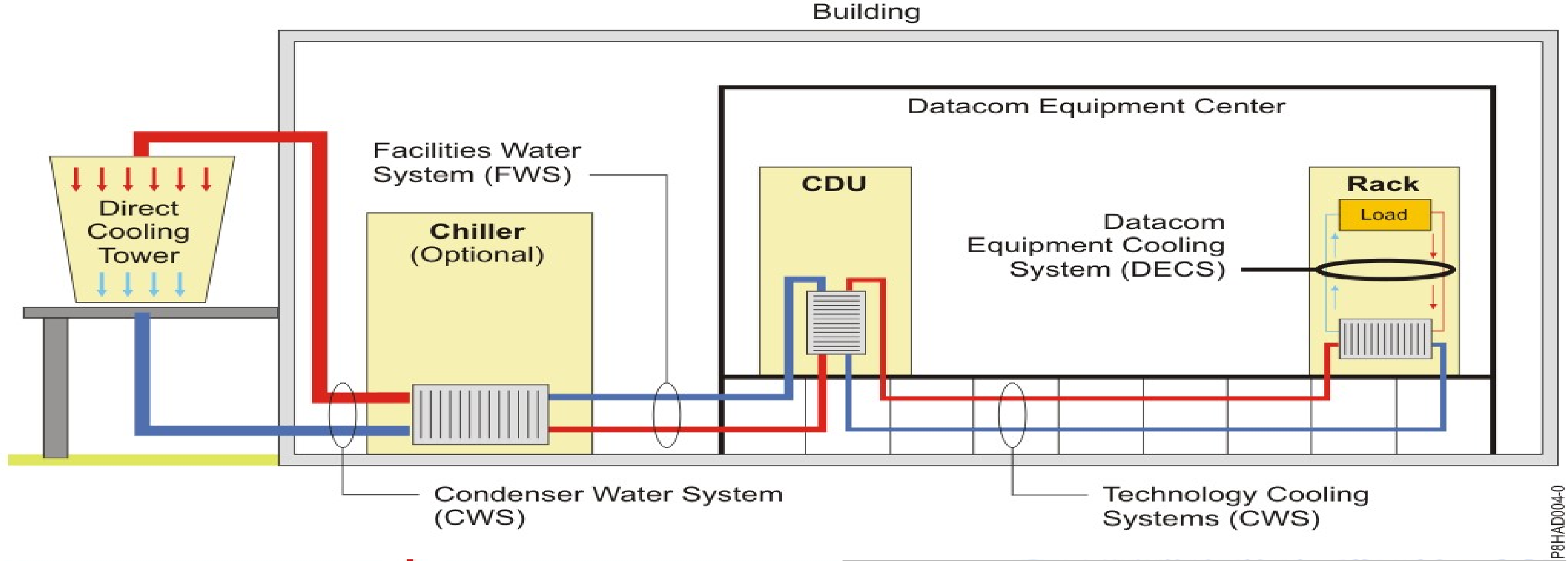




# Water Coolant Technology

SANOG




**Air-Cooled**

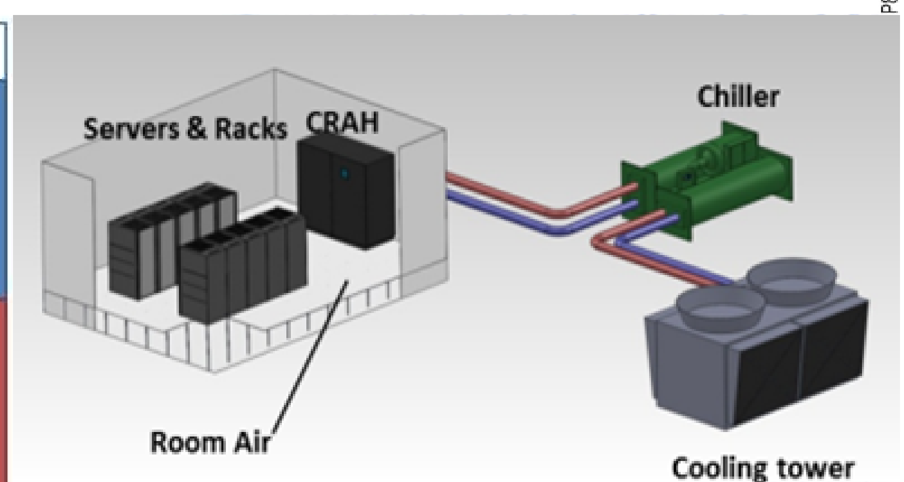
- Lower installation cost
- Less maintenance (depending on application)
- Cooling tower not needed
- Condenser pump not required
- Require less space

- Generally less efficient
- Life span is not as long
- Noisy
- No LEED points

**Water-Cooled**

- Usually have a longer life
- Higher efficiency
- Indoor placement
- Larger tonnage capabilities
- Refrigeration containment
- LEED points

- Additional maintenance costs
- Water treatment cost
- Mechanical room needed
- Large consumption of water
- Require larger space
- 3 storey CUC in lieu of 2



# Trend in ICT : Power and Cooling

SANOG

**Statistics of Yearly World Average Per Rack Power Density [* IBM]**

- Year 1995 1.1 KW
- Year 2000 2.2 KW
- Year 2005 3.5 KW
- Year 2010 4.4 KW
- Year 2015 5.5 KW
- Year 2020 7.0 KW
- Present Maximum Power Density / Rack 30 KW

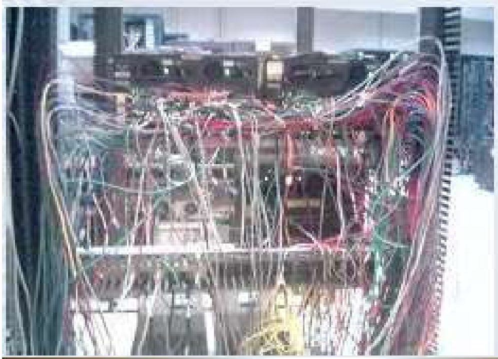
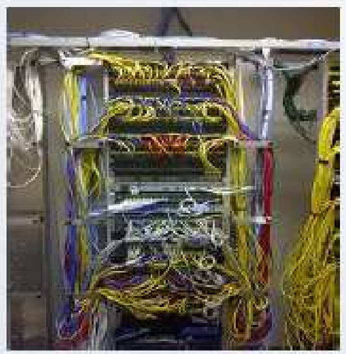
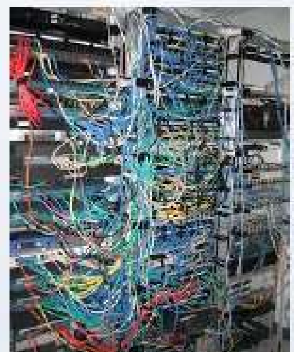
**Statistics of Yearly Bangladesh Average Per Rack Power Density**

- Year 1995 No Data
- Year 2000 1.1 KW
- Year 2005 1.6 KW
- Year 2010 2.2 KW
- Year 2015 2.8 KW
- Year 2020 3.5 KW
- Present Maximum Power Density / Rack 7.0 KW

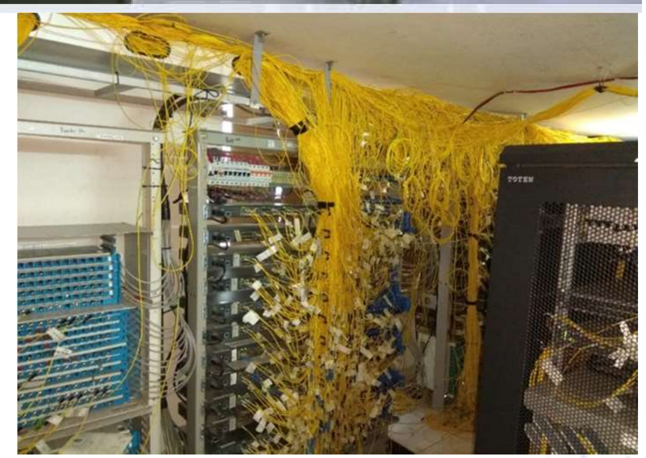
# Importance of Structured Cabling

SANOG







# Relation : Power, Cooling and Heat

SANOG

Power | Heat

1 KW of Power Consumption = 1 KW of Heat Generation

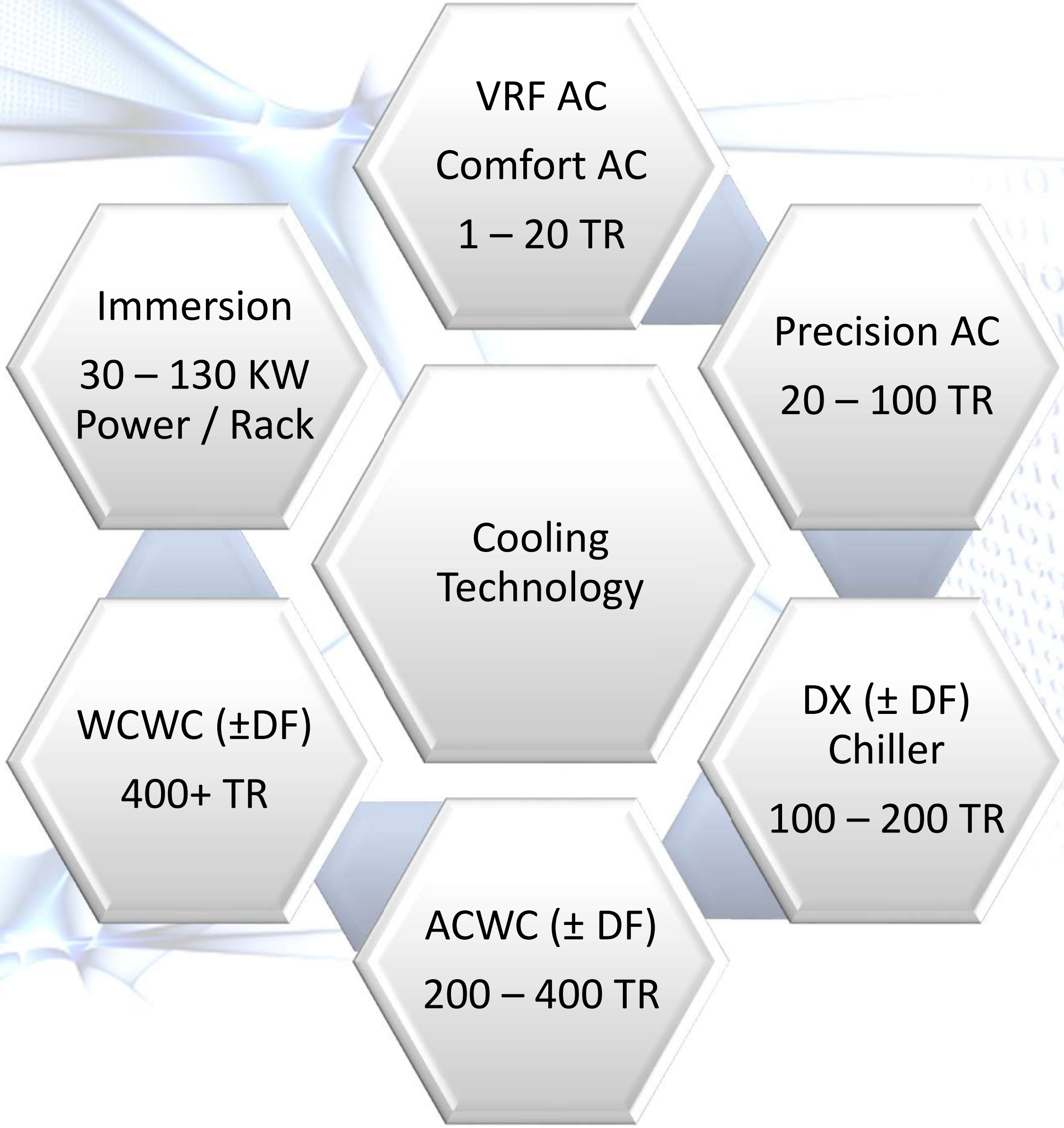
Heat | Cooling

1 KW of Heat Generation = 1 KW of Cooling Requirement

Cooling | Power

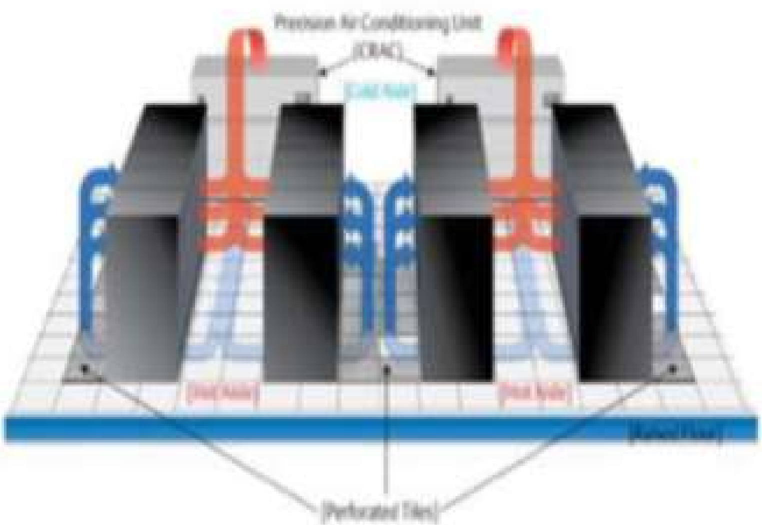
1 KW of Cooling Requirement ≠ 1 KW of Power Consumption

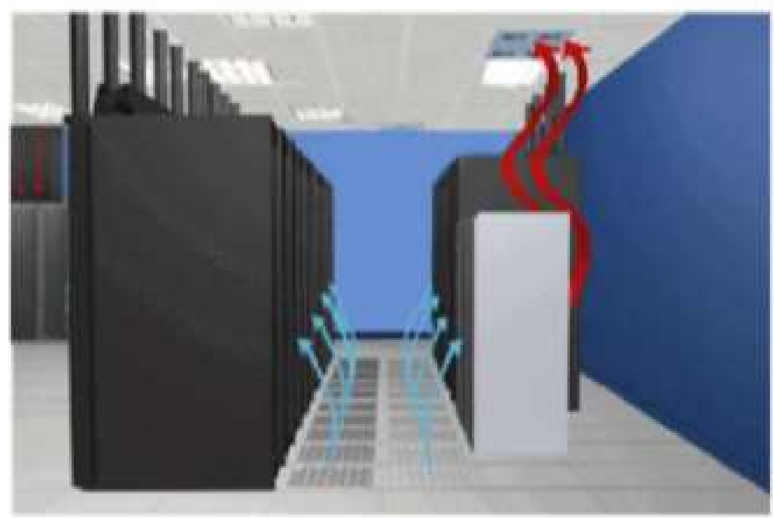
# Cooling Technology Selection



# Plenum Cooling Technology

Raised floor design is based on the principle of an under-floor cold air distribution path, whereby the hot air is flowing back to the air-conditioner unit either via the room or via a dedicated duct or suspended ceiling void.



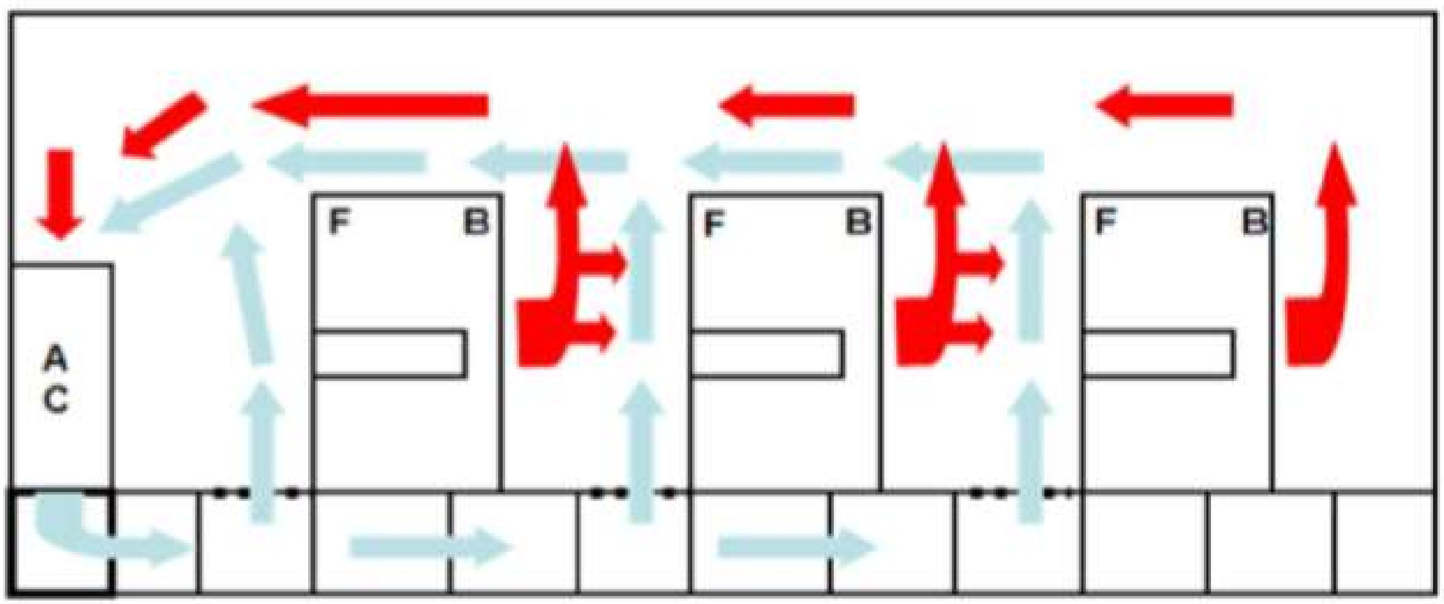


# Plenum Cooling Technology

SANOG

**'Class Room' setup**

- Traditional way of computer room setup
- Leads to in-efficiencies due to mixing of hot- and cold-air
- Not recommended

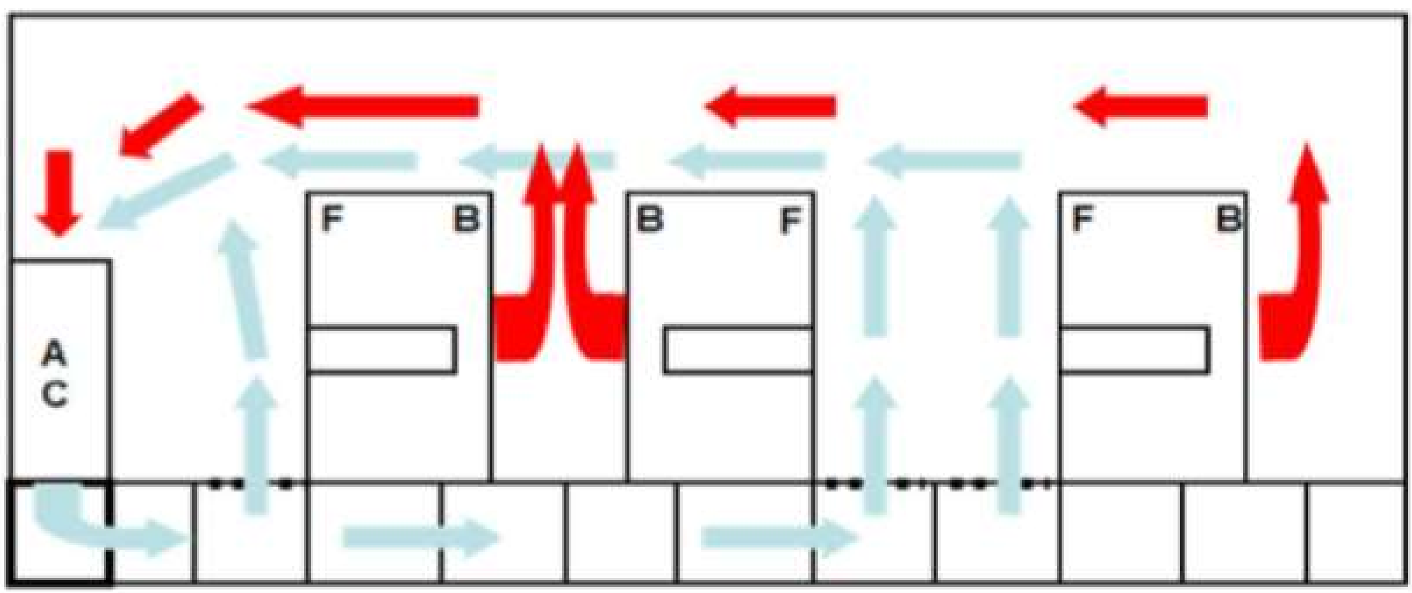


# Plenum Cooling Technology

SANOG

## Hot- and Cold-Aisle Setup

- Racks are placed Front-to-Front and Back-to-Back
- Cold- and Hot-Air areas are separated
- Some hot air will still flow into the cold air areas

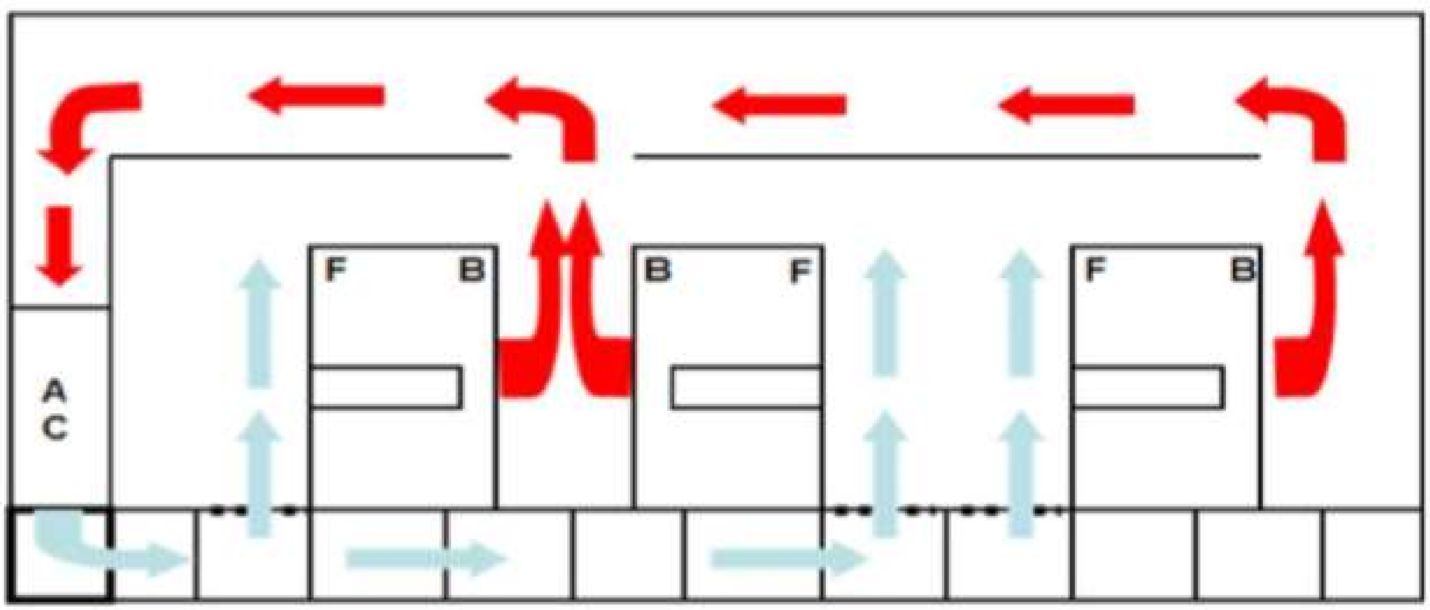


# Plenum Cooling Technology

SANOG

## Hot- and Cold-Aisle Setup with Suspended Ceiling

- A suspended ceiling can aid in guiding the hot-air back to the air-conditioner without mixing with the cold-air areas
- Increased efficiency

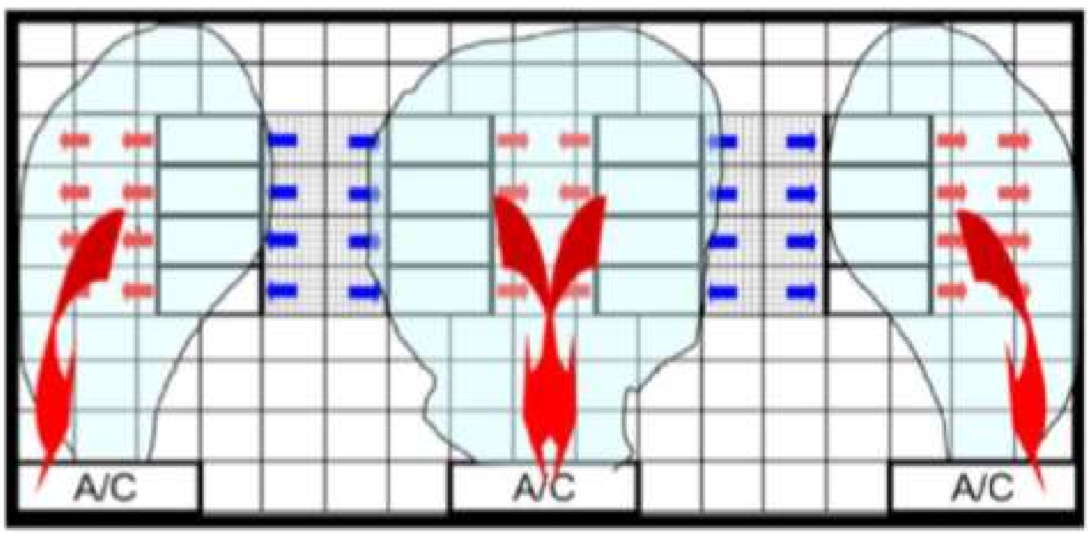


# Plenum Cooling Technology

SANOG

## Air Conditioning Positioning

- Air conditioners should be placed perpendicular to the hot aisle
  - Allow fast hot air return
  - Allow more evenly equalised air pressure under the raised floor

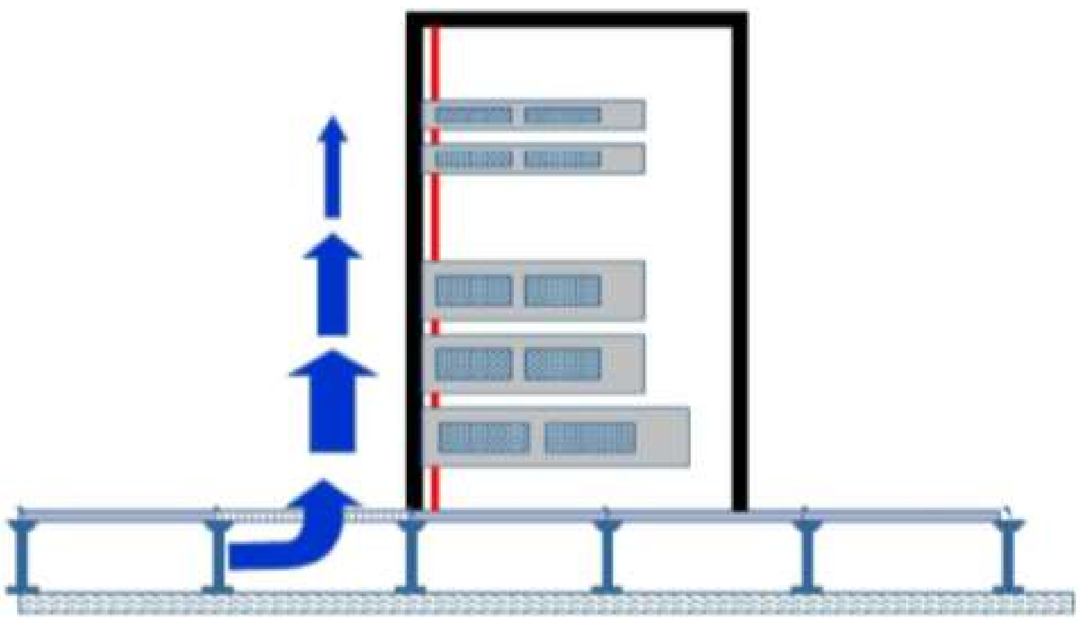


# Plenum Cooling Technology

SANOG

**Placement of equipment in rack**

- With traditional down flow cooling, the bottom of the rack will be colder than the top
  - Put high heat load approx. 30cm/1ft above raised floor and not above half the rack height
  - Higher possible if you have enough CFM

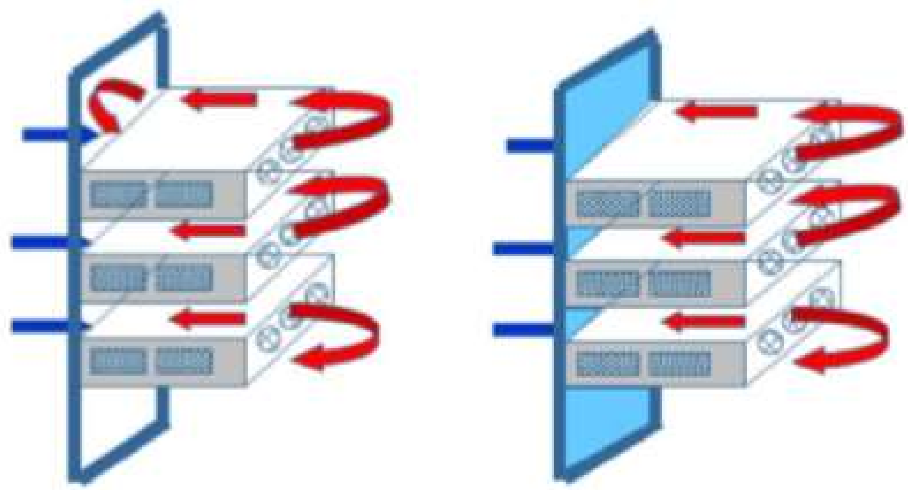


# Plenum Cooling Technology

## Avoid Leakage and Short Circuit Air

- Air leakage from the floor
  - Use grommets

- Air leakage within the racks (back-wash) leads to in-efficiencies
  - Use blanking panels



# Session 3

- Static UPS Technology
- Battery Technology
- Rotary UPS Technology
- Comparison Between UPS Technology
- Power System Configuration (Gen-Set, UPS)

# Static UPS System : Type and Mode

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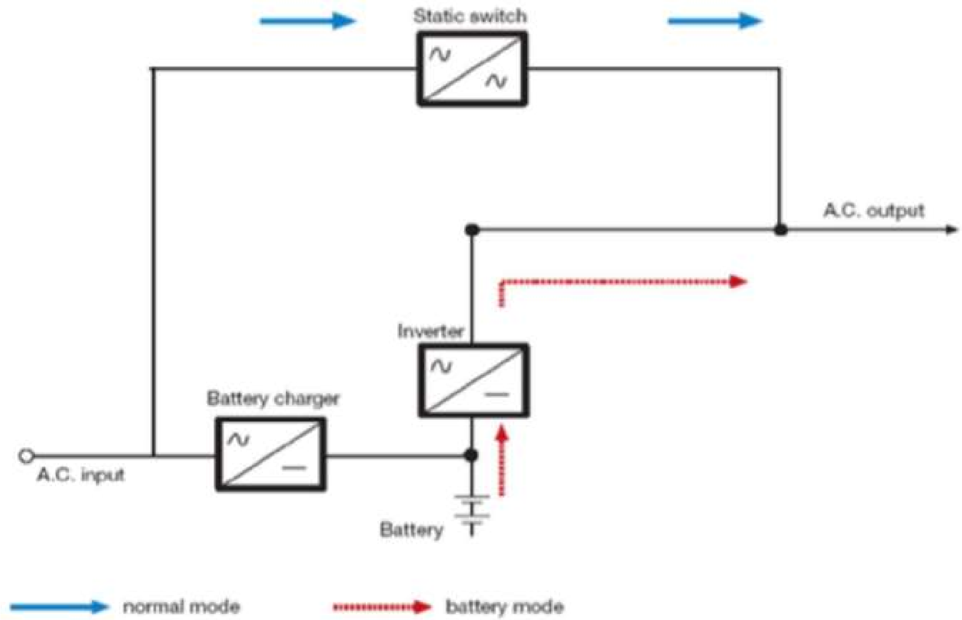
- Offline
- Line Interactive
- True Online Double Conversion
- Others (i.e. Delta Conversion, Hybrids, High frequency transformerless, Eco/Smart mode UPS, Compressed Air etc.)
- European Norm for classification of UPS systems: EN50091-3 / IEC62040-3
  - VFD-Class (Voltage and Frequency Dependent)
  - VI-Class (Voltage Independent)
  - VFI-Class ( Voltage & Frequency Independent)
- ONLY VFI-Class UPS systems are a good fit for mission critical data centres

# Static UPS : Offline / Standby (VFD)

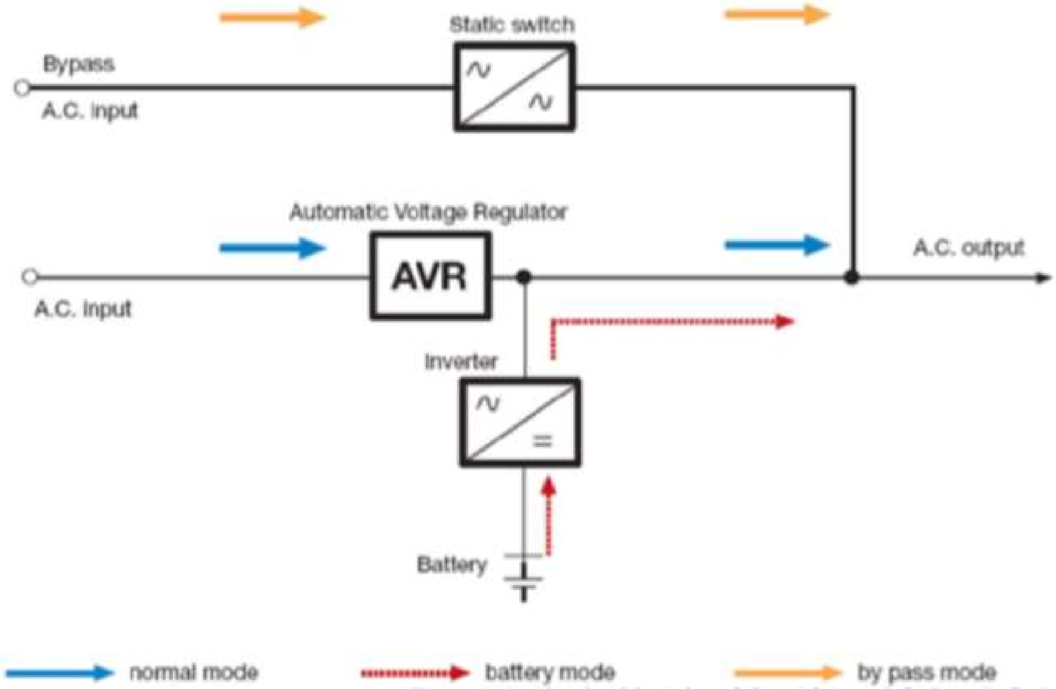
SANOG




- Pro's
  - Very cheap
- Con's
  - Load not isolated from the utility
  - Large transfer time (up to 12-14mS)
  - Large ripple voltage on battery
  - Modified Sine-Wave / True Sine Wave exceptional
  - No Frequency regulation
  - No true battery test capability
  - No bypass
  - Only able to run for short time (risk of overheating)
  - Generally smaller kVA Output (less than 2 kVA)

# Static UPS : Line Interactive (VI)

- Pro's
  - Cheap
- Con's
  - 2-4 ms Transfer Time
  - Load not isolated from the utility
  - Ripple voltage on battery
  - Some level of surge protection
  - Some level of voltage regulation
  - No frequency regulation
  - 'Modified Sine Wave' (PWM) or True Sine Wave
  - Generally smaller kVA output (less than 5 kVA)



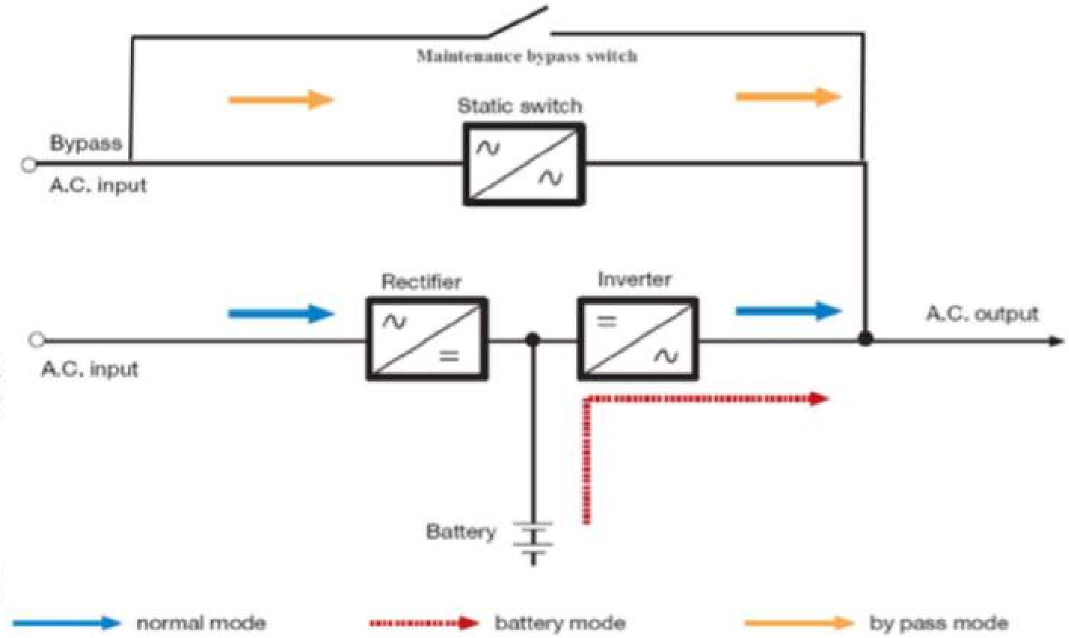
# Static UPS : Online / Double Conversion (VFI)

Con's

- More expensive

Pro's

- Isolates the load from the input AC
- Rectifies the input AC
- Generates a true sine wave output
- Designed to always have full load on inverter
- Designed to run for long run times
- Supplies regulated & isolated voltage& frequency to the load
- Synchronizes to the input phase when online
- Bypass functionality (static & maintenance)



# Static UPS System : Pros and Cons

- Relatively complex power and control electronics
- Requires a controlled environment
- Requires batteries
  - Need to be replaced typically every 3-4 years for 5-year design life and every 7-8 years for 10-year design life
  - Chemical waste
  - Unknown cost factor (SLA battery price can fluctuate heavily depending on lead pricing)
- One of the oldest UPS technologies used for data centre environments
- Available in 500VA – 1,6MVA in single systems

# Static UPS System : Summary

| Grid Problem | Off-line UPS | Line Interactive UPS | On-line UPS |
| --- | --- | --- | --- |
| Surge | Indefensibility | Limited defense | Full defense |
| High voltage pulse | Indefensibility | Limited defense | Full defense |
| Transient Over voltage | Indefensibility | Limited defense | Full defense |
| Voltage falls | Limited defense | Limited defense | Full defense |
| Noise | Limited defense | Limited defense | Full defense |
| Deviation of frequency | Indefensibility | Indefensibility | Full defense |
| Continuous low voltage | Full defense | Full defense | Full defense |
| Interruption of the utility | Full defense | Full defense | Full defense |

# Battery Technology : Flooded Cell

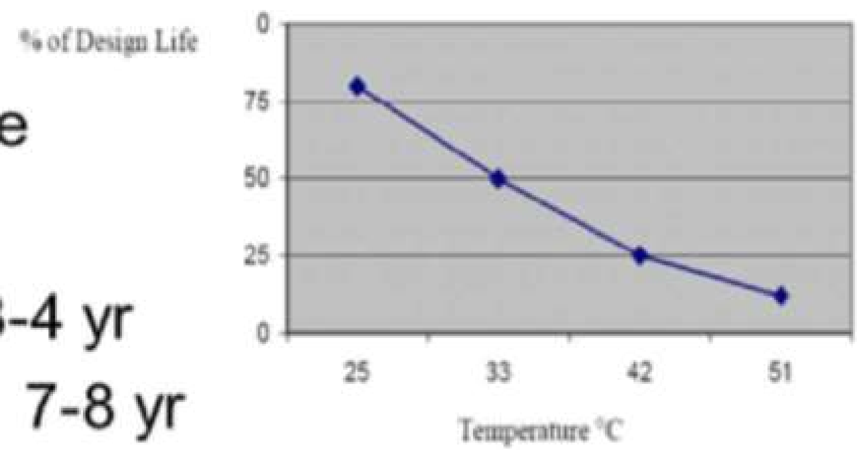
SANOG

- Also called: Wet or Vented cells
- Mainly used in UPS of 500kVA
- and above
- Pro's
  - Long life span (typically 15 – 20 years)
  - Able to operate at high currents
- Con's
  - Must be stored in special, vented rooms
  - Requires maintenance (water replenishment)
  - Electrolyte requires special handling (burns)
  - Can only be used in one position

# Battery Technology : SLA / VRLA

- SLA (Sealed Lead Acid)
- VRLA (Valve Regulated Lead Acid)
  - 5 Year Design Life
  - 10/12 Year Design Life

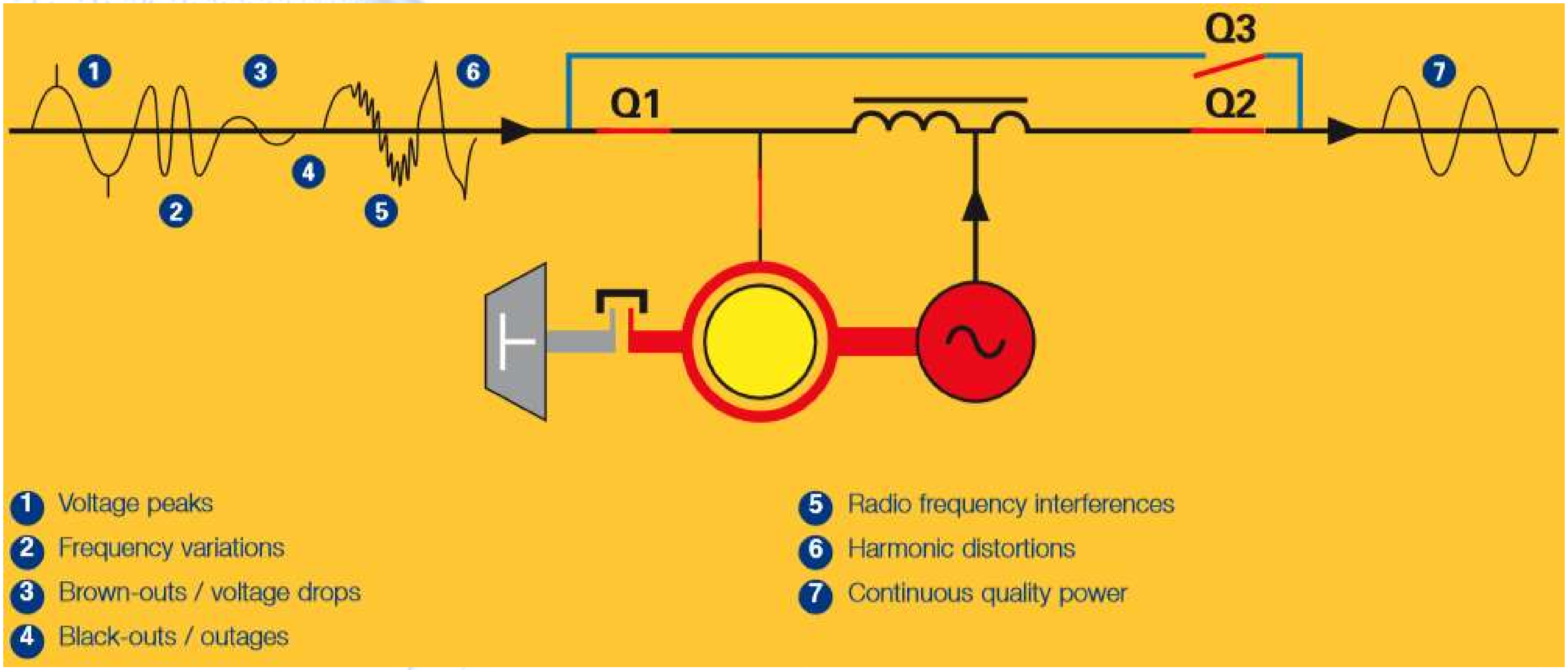
- Design life does not equal Service Life
  - Number of discharges and level of discharge
  - Ripple factor of UPS
  - Ambient Temperature
- Average Service life
  - 5 Yr design approx 3-4 yr
  - 10 Yr design approx. 7-8 yr



# Battery Technology : Ni-Cd / Lithium Ion

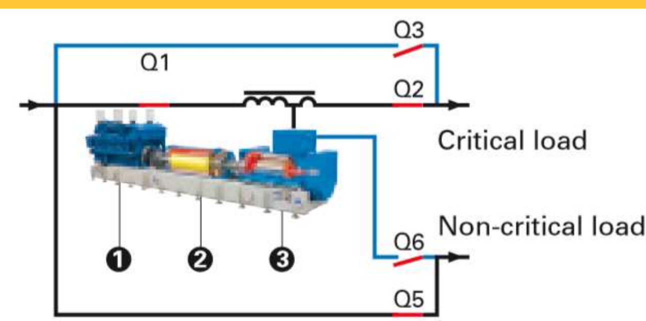
- Ni-Cd batteries
- Pro's
  - Long life time (20 years)
  - Able to work in high ambient temperature
  - Reliable/Predictable life
  - Allows for fast charging
- Con's
  - Need special charger in UPS
  - Memory effect
  - Very expensive (4 – 6 times more than SLA)
  - Expensive to dispose (high chemical content)

# Rotary UPS System : Type and Mode



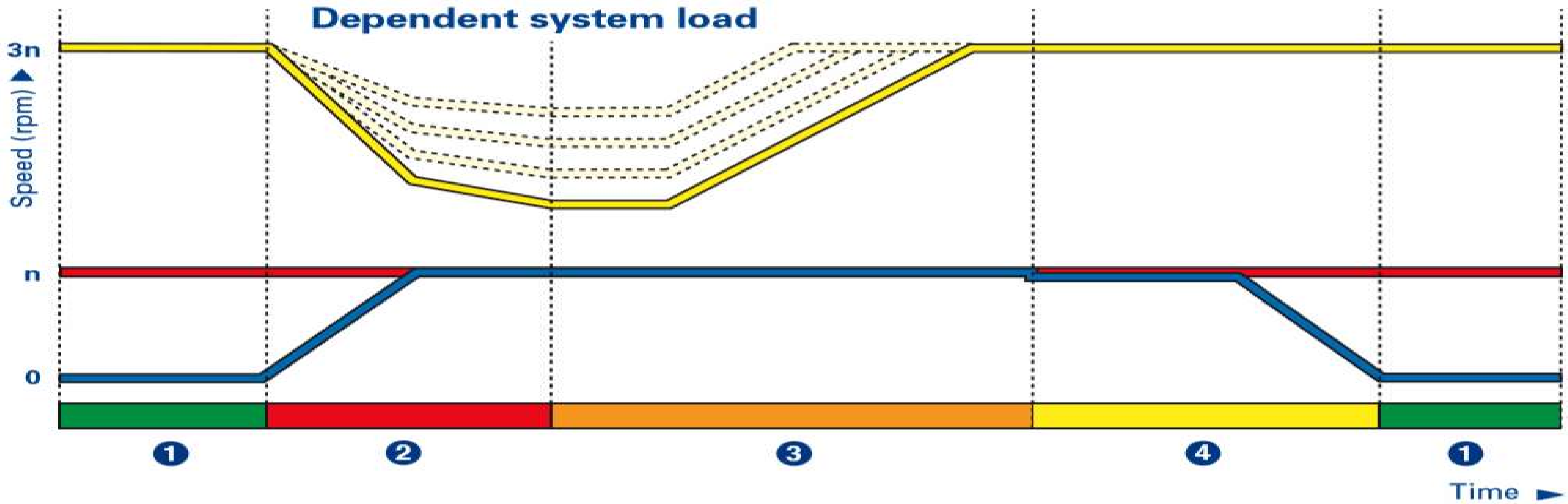

## Rotary UPS Operational Mode

1. Utility Mode
2. Change Over to Diesel Mode
3. Diesel Mode
4. Back To Utility Mode



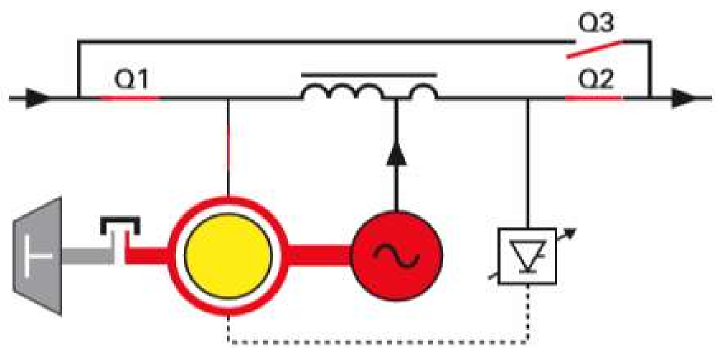

A dual output system optimally capitalizes UPS/CPS' capacity
❶Total power rating ❷Critical load rating ❸Total power rating

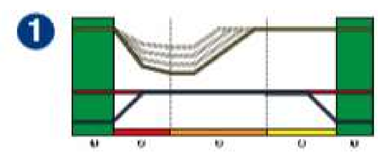
# Rotary UPS System : Operational Basic




## ❶ Utility mode

In utility mode, the reactor and the generator function as an active filter that prevents any disturbance from the utility reaching the critical load. The generator runs as a motor and drives the outer rotor of the induction coupling at a speed of 1500/1800 rpm. Through excitation of the two pole three-phase winding in the outer rotor, the inner rotor reaches a speed of 3000/3600 rpm relative to the outer rotor. As a result, kinetic energy is stored in the inner rotor. The outer rotor of the induction coupling is isolated from the standby diesel engine by the free-wheel clutch.



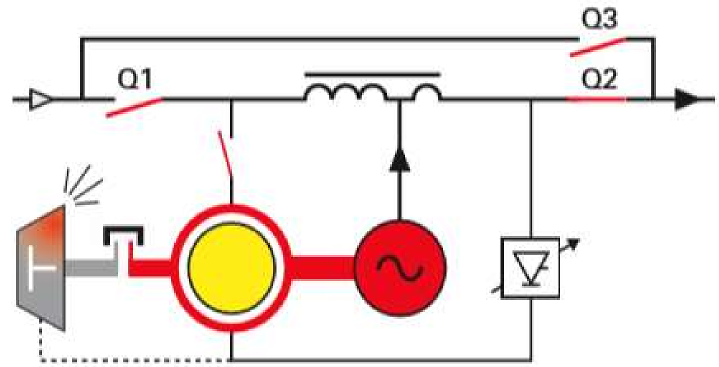



# Rotary UPS System : Operational Basic

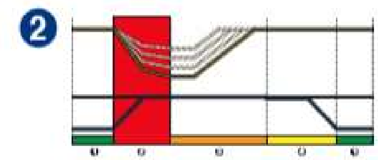
SANOG

## ❷ Change-over to diesel mode

In case of a power interruption or an unacceptable deviation in the supply of utility power, the circuit breaker Q1 opens. The induction coupling's DC windings are then excited, thus allowing a transfer of stored kinetic energy from the inner rotor to the outer rotor. The speed of the generator remains constant at 1500/1800 rpm.



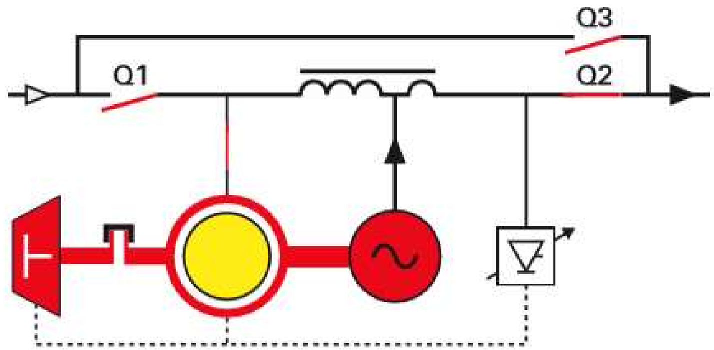

Simultaneously, the diesel engine starts and ramps up to 1500/1800 rpm in less than 2 seconds, after which the free-wheel clutch engages automatically. For the next few seconds the diesel engine together with the induction coupling drive the generator to ensure a proper supply of power to the critical load. Within 5..10 seconds the diesel engine is the sole provider of power to the load.

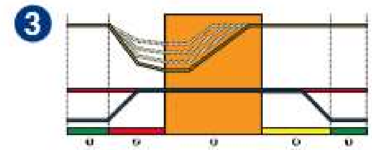


# Rotary UPS System : Operational Basic

## ❸ Diesel mode

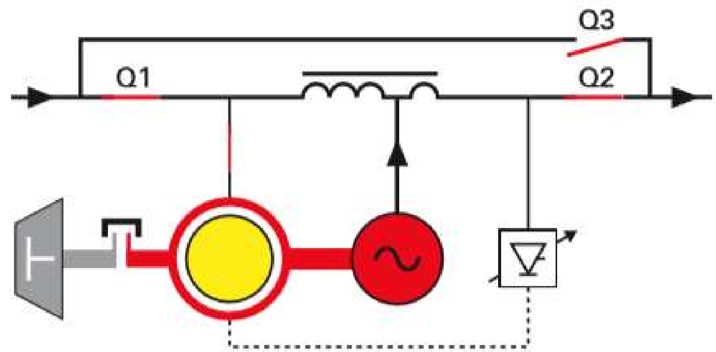
When in diesel mode, the three-phase winding of the outer rotor is re-energized causing the inner rotor to ramp up to 3000/3600 rpm again. The speed of the diesel engine is monitored and digitally controlled to ensure a constant output frequency. While in diesel mode, the output frequency remains within narrow tolerances, even if the system encounters high load steps, since the induction coupling will be utilized to support the diesel engine.

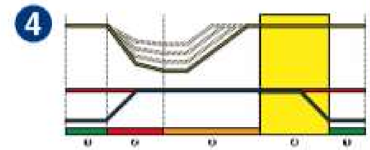



## ❹ Back to utility mode

After utility power has stabilized, the UPS/CPS synchronizes with utility power and closes Q1. The diesel engine then ramps down to 1450/1750 rpm, and as a result the free-wheel clutch disengages. Simultaneously, the generator returns to its motor operation and maintains the speed of the outer rotor of the induction coupling at 1500/1800 rpm. The diesel engine will continue to run for a short time in a no-load condition to cool down. After the diesel has completed its cool-down run it will shut down and return to standby mode.



# Rotary UPS System : Pros and Cons

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- Only available in higher kVA ratings 200kVA – 3,000kVA
- Heavy (e.g. 600kVA could weigh approx. 8 Ton)
- More noisy
- Relative simple design setup
- No need for batteries for energy storage
  - A few batteries only to provide starting energy for generator section)
- No need for controlled environment
- Long life span
- Good efficiency

# Comparison : SUPS versus DRUPS

SANOG

DRUPS Diesel Rotary UPS + LT-Panel

SUPS Static UPS + Battery Bank + Battery Room PAC + PFI + Many Distribution Panel + AVR + Generator + UPS and Gen-Set Synchronizers + Phase Plotter

| Description | DRUPS [1.5 MW] | SUPS [1.5 MW] |
|---|---|---|
| Capital Expenditure [CapEx] | 1.0 Million USD | 0.75 Million USD |
| Battery Backup | Not Required | Required (5 min) |
| Space Consumption | 100% | 182% |
| Life Time | 25 Years | 10 Years |
| Operational Expenditure [OpEx] | 1.84 Million USD | 5.46 Million USD |
| Pay Back [CapEx Difference] | 9 Months | 0 Months |
| Power Efficiency [AVR to BBT] | 97% | 92% |
| Continuous Cooling | Possible | Not Possible |
| Power Level | 415 Volt \| 11 KV \| 33 KV | 415 Volt |
| Signature Users | NTT, KDDI, Fujitsu, AWS, Global Switch, GE, Tele House, Google | Equinix, TM, CT, MS, AWS, Tata, Digital Realty, Facebook, Google |
| Market Share [as Clean & QPS] | 18% | 82% |
| Thumb Rule of Usage | Total Power > 3 MW<br>OpEx is 1$^{st}$ Priority<br>Continuous Cooling | Total Power < 3 MW<br>CapEx is 1$^{st}$ Priority<br>Backup Time > 30 s |

# Power System Configuration

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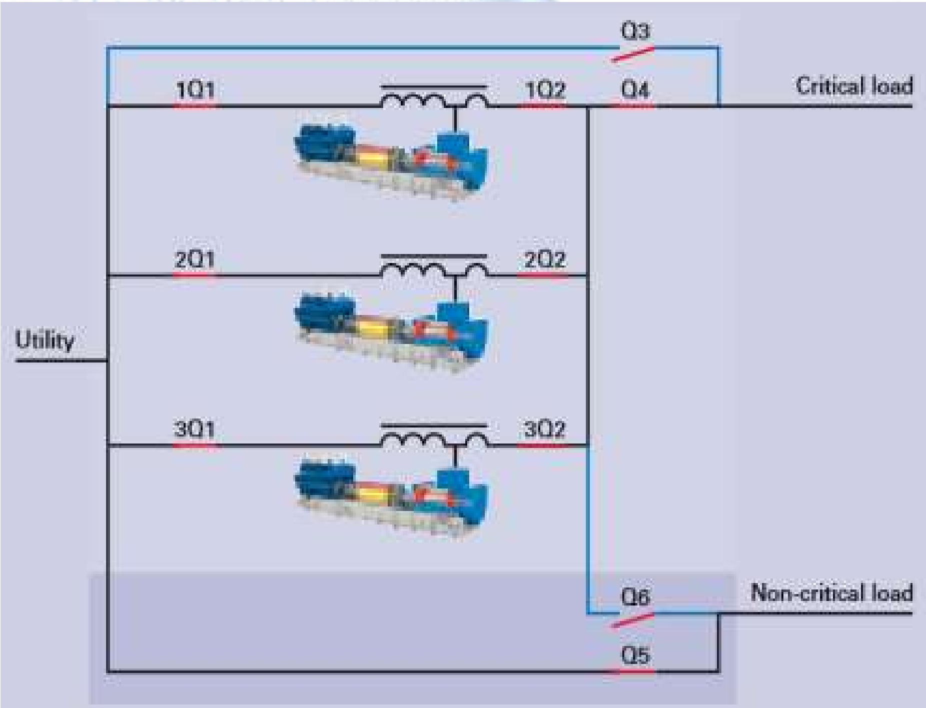
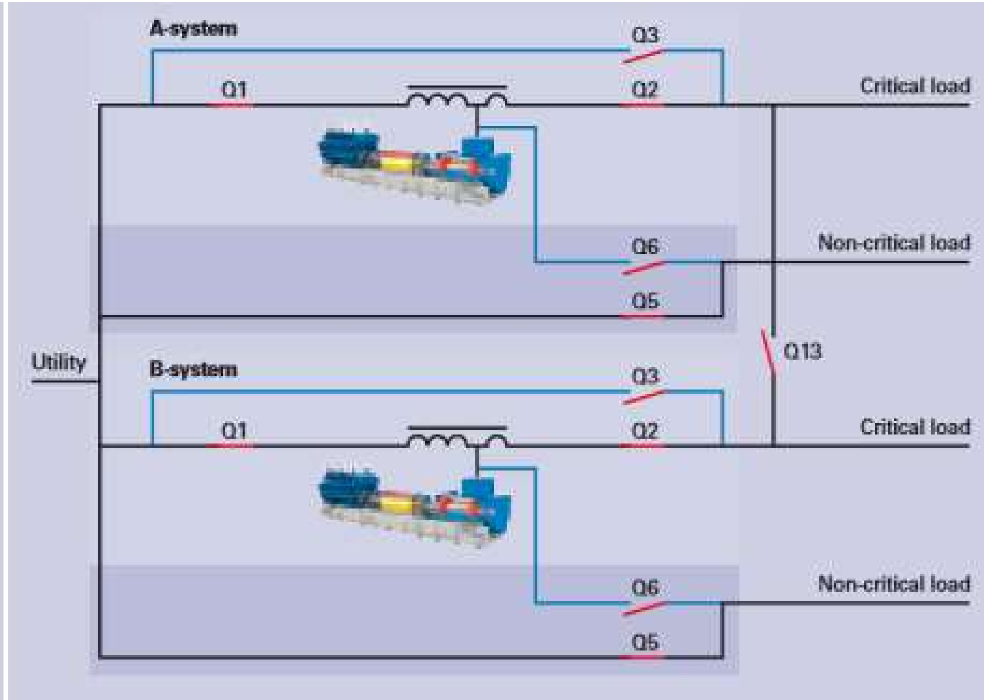
| System configuration | Characteristics |
|---|---|
| Parallel Redundant (PR) | Simplest and most compact means of achieving redundancy between UPS units and of supporting very large or multiple loads. |
| Master - Slave (MS) | Eliminates a common UPS output bus-bar. |
| Cross - Link (CL) | Virtually eliminates the common output bus-bar. On multi-UPS unit systems, far less UPS units required to achieve required redundancy than in an MS system. |
| Isolated - Parallel (IP) | No common output bus-bar due to additional tie breakers and isolating chokes.<br>Efficient and flexible use of the system redundant capacity. |
| Isolated - Redundant (IR) | No common output bus-bar due to separation of loads and UPS unit outputs.<br>Fewer breakers and chokes required than in an IP system. |
| Distributed Redundant (DR) | No common output bus-bar due to separation of loads and UPS unit outputs.<br>Fewer breakers and chokes required than in an IP system.<br>Efficient and flexible use of the system redundant capacity. |

# Power System Configuration

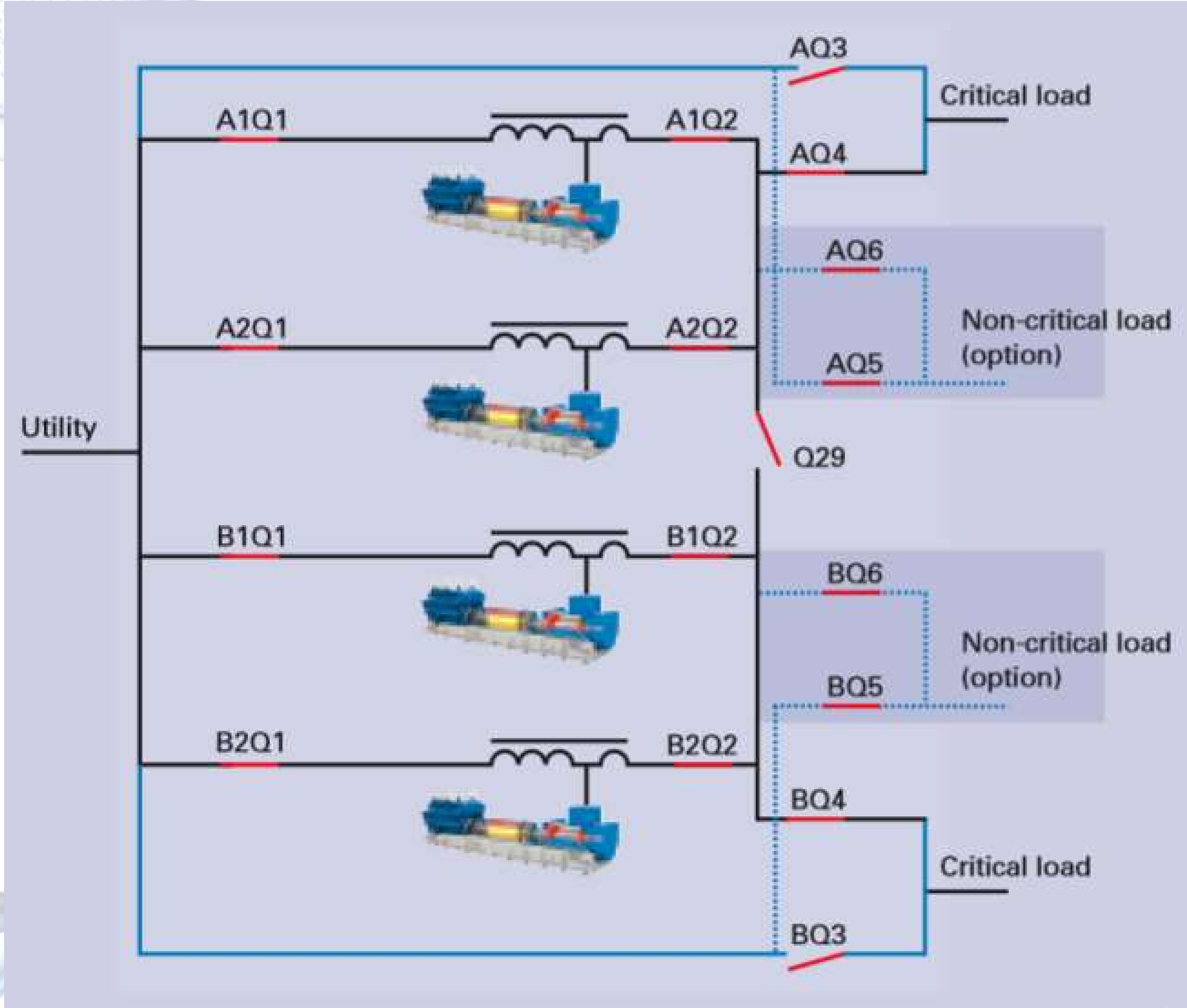



Parallel Configuration



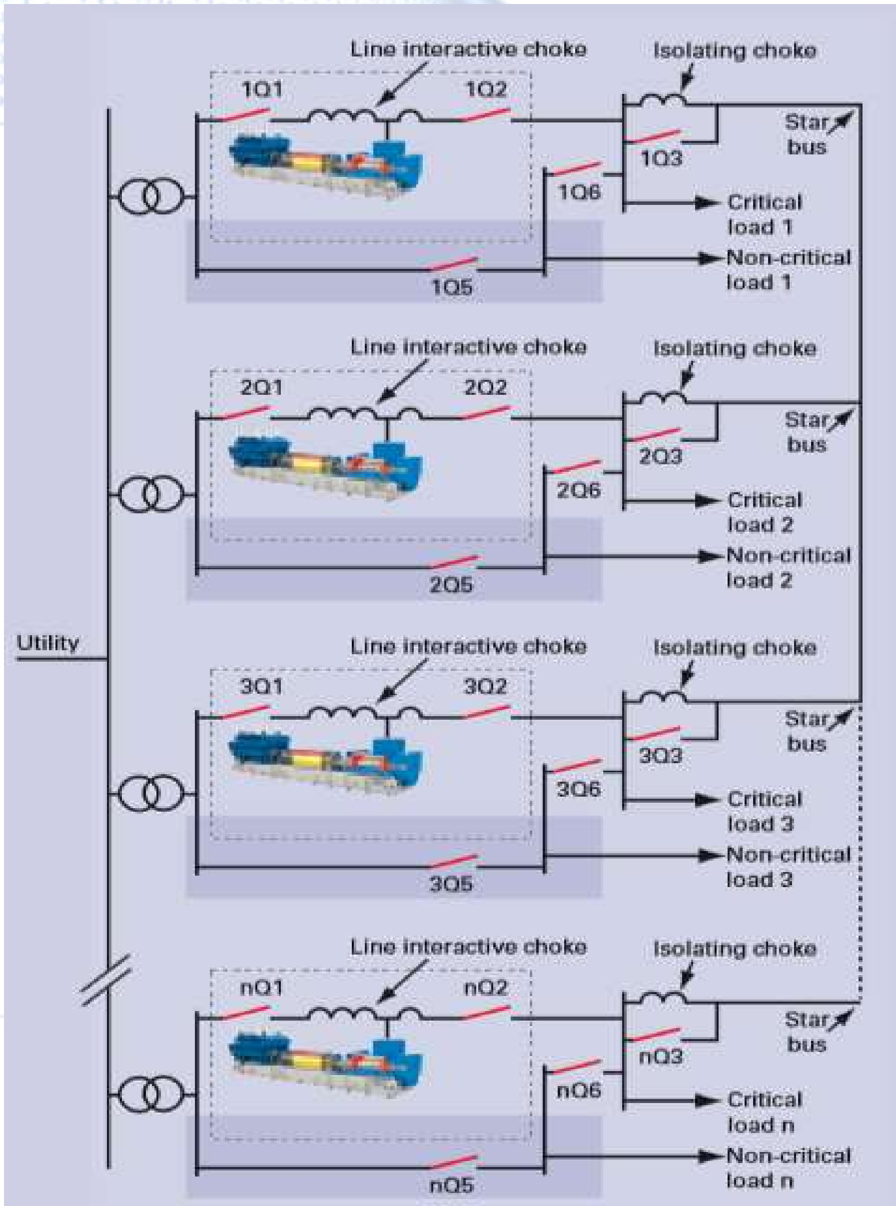

Master-Slave Configuration

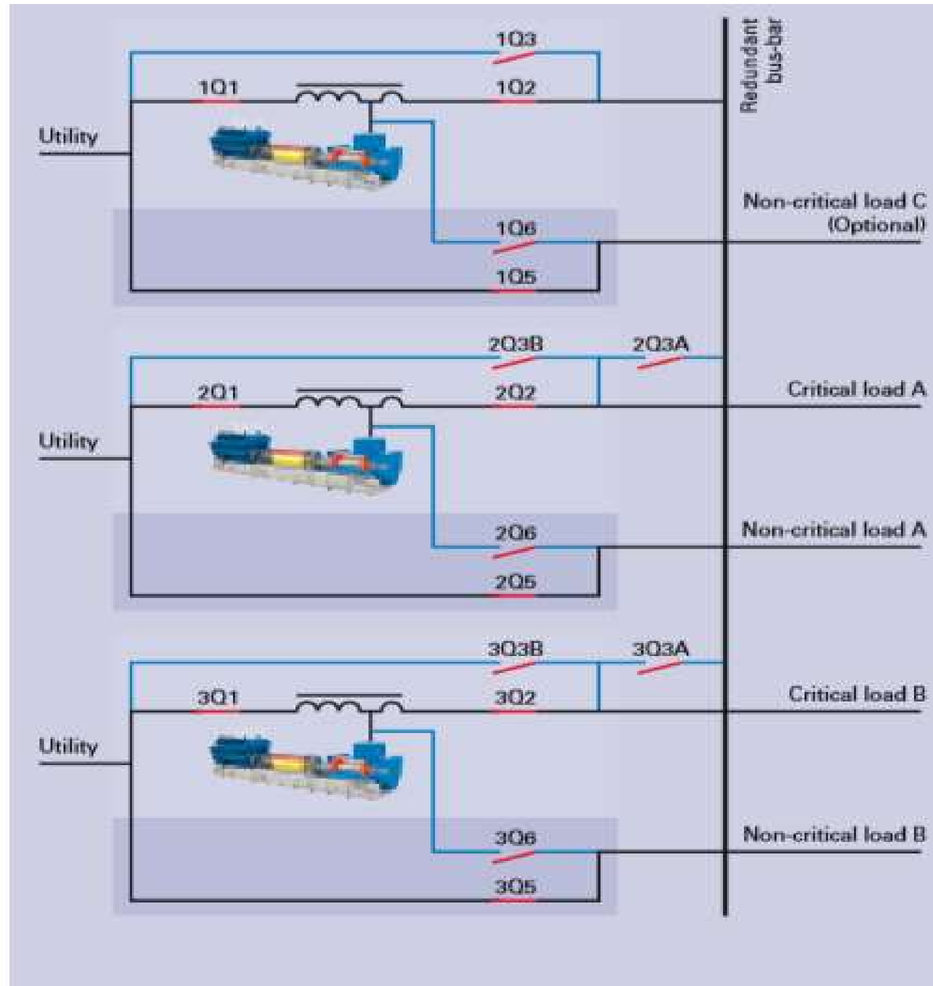
# Power System Configuration




Cross-Link Configuration

# Power System Configuration

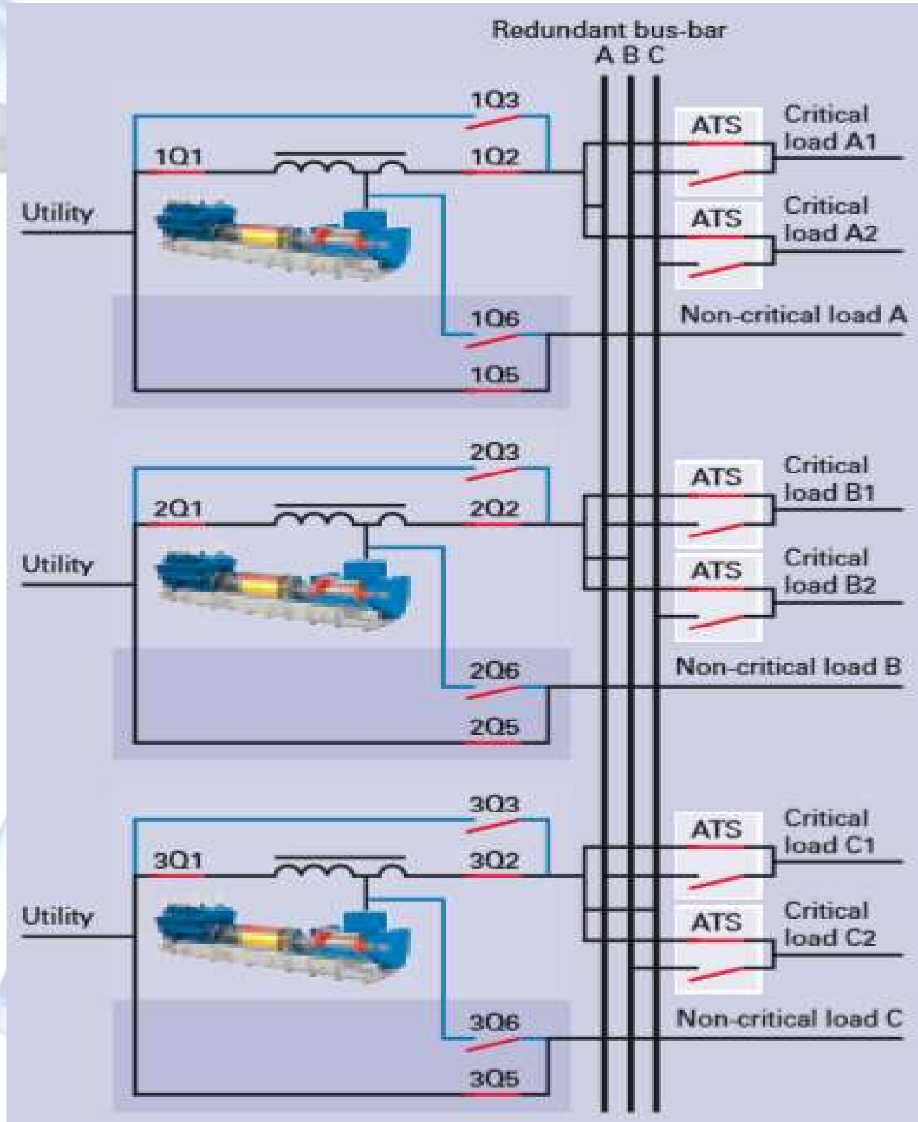



Isolated Redundant Configuration

Isolated Parallel Configuration (IP Bus)

# Power System Configuration




Distributed Redundant Configuration

# Power System Configuration

| Configurations | Scale of availability | Tier class |
|---|---|---|
| Capacity (N) | 1 = Lowest | Tier I |
| Isolated redundant | 2 | Tier II |
| Parallel redundant (N+1) | 3 | |
| Distributed redundant | 4 | Tier III |
| System plus system (2N, 2N+1) | 5 = Highest | Tier IV |

**Power System Configuration Selection** [N+1 Setup for Level-3 Certification]

1. Static UPS — Distributed Redundant Configuration
2. Rotary UPS (LV) — All Configuration remains Applicable
3. Rotary UPS (MV) — All Configuration, But, Isolated Parallel Configuration (IP Bus)

**Tier-IV Certification with N+1 Setup** [Assuring 'N' after any Failure]

1. Static UPS — Not Applicable
2. Rotary UPS (Only LV) — Only Applicable with Isolated Parallel Configuration (IP Bus)

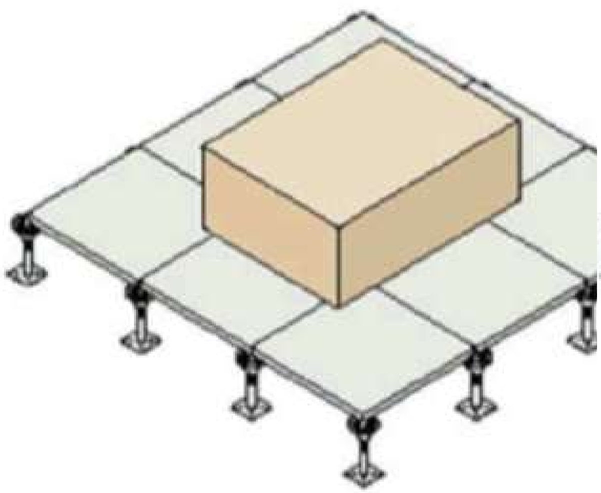
# Session 4

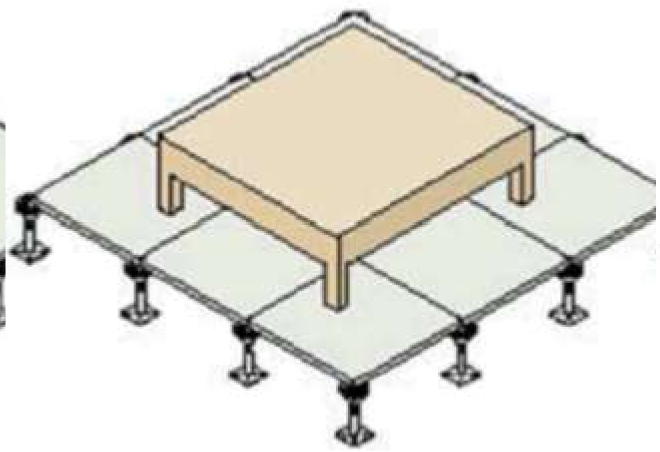
- Raised Floor, Floor Loading and SRG
- TIA-942 Cabling Standard
- Cable and Pipe Distribution
- Seismic Isolation for Rack and Facility
- Data Centre Efficiency : The Green Grid
- Safety, Security, Monitoring in Data Centre
- Fire Suppression System
- Technology Selection : Option & Thumb Rule
- Quiz : Topology and Design Misconception
- Question, Answer, Feedback, Advice

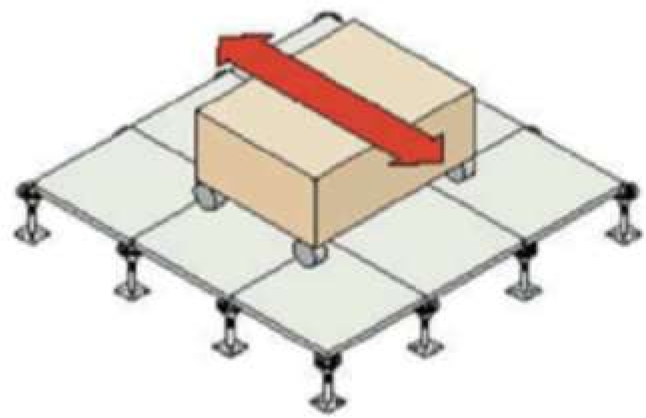
# Raised Floor and Type of Loading

**Raised Floor Selection**

1. Die Formed Welded Steel Construction [Level-1 and Level-2]
2. Die Formed Welded Steel Shell with Cement-Filled Core [Level-3 and Level-4]
3. Galvanized Floor [Beware of Zinc Whiskers | Not Recommended]
4. Wood Filled Core [Beware of Rolling Load, Life | Not Recommended]
5. High Pressure Laminate [Recommended for Rack-Space]
6. Rubber Laminate [Recommended for Ramp, Access Floor, NOC, etc.]







# Load Bearing Capacity : Slab and Tiles

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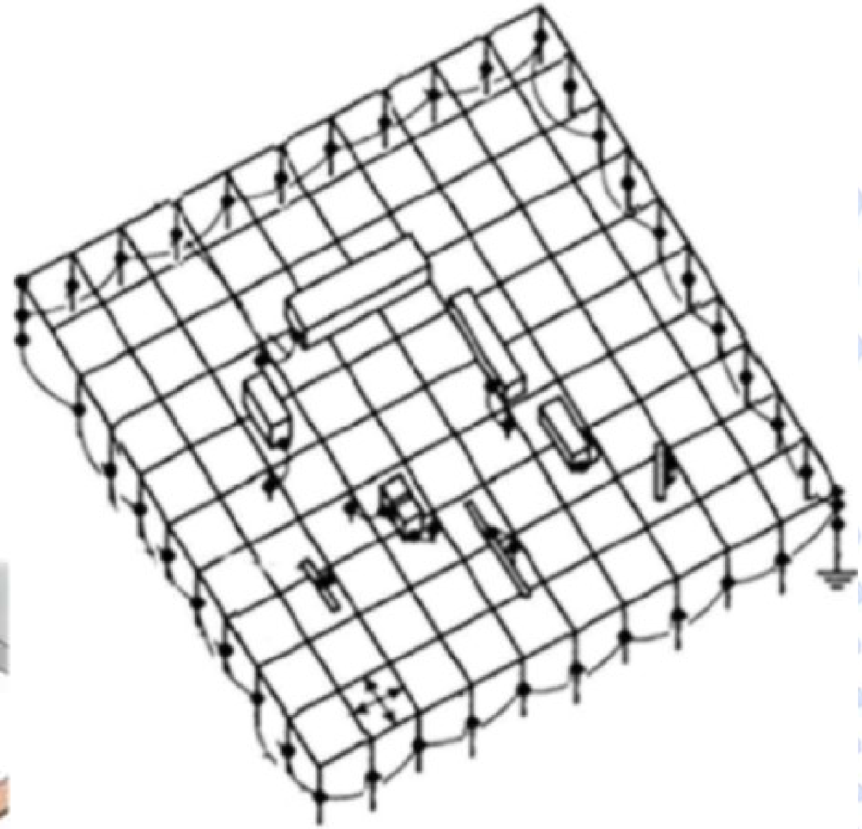
- **European Standard BS/EN 12825**
  - The raised floor must be capable of withstanding a uniform load of 1,220 kg/$m^2$ or a load of 454 kg on any 6.5 $cm^2$, with a maximum deflection of 2.5 mm
- **UK-PSA MOB PF2 standard (Property Services Agency)**
  - Light : 1.5kN over 25$mm^2$ (PL), not more than 6.7kN/m2(UDL)
  - Medium : 3.0kN over 25$mm^2$ (PL), not more than 8.0kN/m2 (UDL)
  - Heavy : 4.5kN over 25$mm^2$ (PL), not more than 12kN/m2 (UDL)
  - Extra Heavy : 4.5kN over 25$mm^2$ (PL), not more than 12kN/m2 (UDL)
    - Also sustain a total load of 11kN applied equally on four points, each point 25mm2 on a 200 x 200mm square area
- **US-CISCA (Ceiling and Interior Systems Constructors Association)**
- **NFPA 251, Fire resistant for at least 1 Hour**
- **IEC-61000-4-2, Anti-static properties**

Do Not Forget to Add the Weight of the Raised Floor to Building Floor Load

# Signal Reference Grid and Grounding

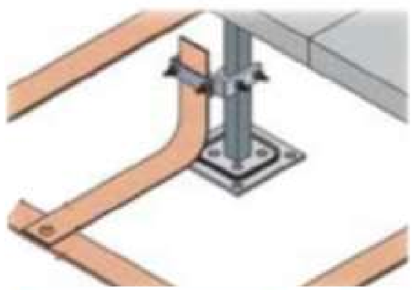
**Raised Floor Guidelines**

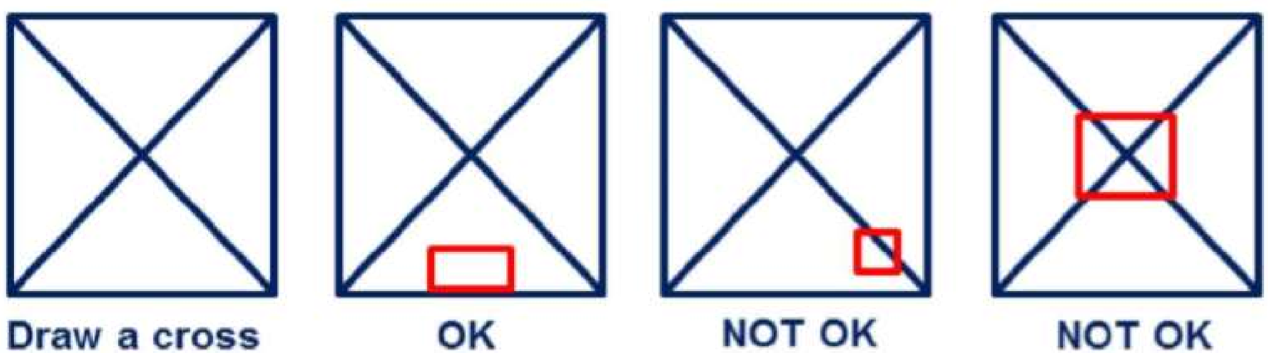
1. Height : 300 mm – 1 m
2. Ramp Slope = 1 : 12
3. Ramp Width : 600 mm
4. Aisle Width : 600 mm
5. Wheel Chair Road : 1 m
6. Rand Rail beside Ramp
7. No Plumbing (Optional)



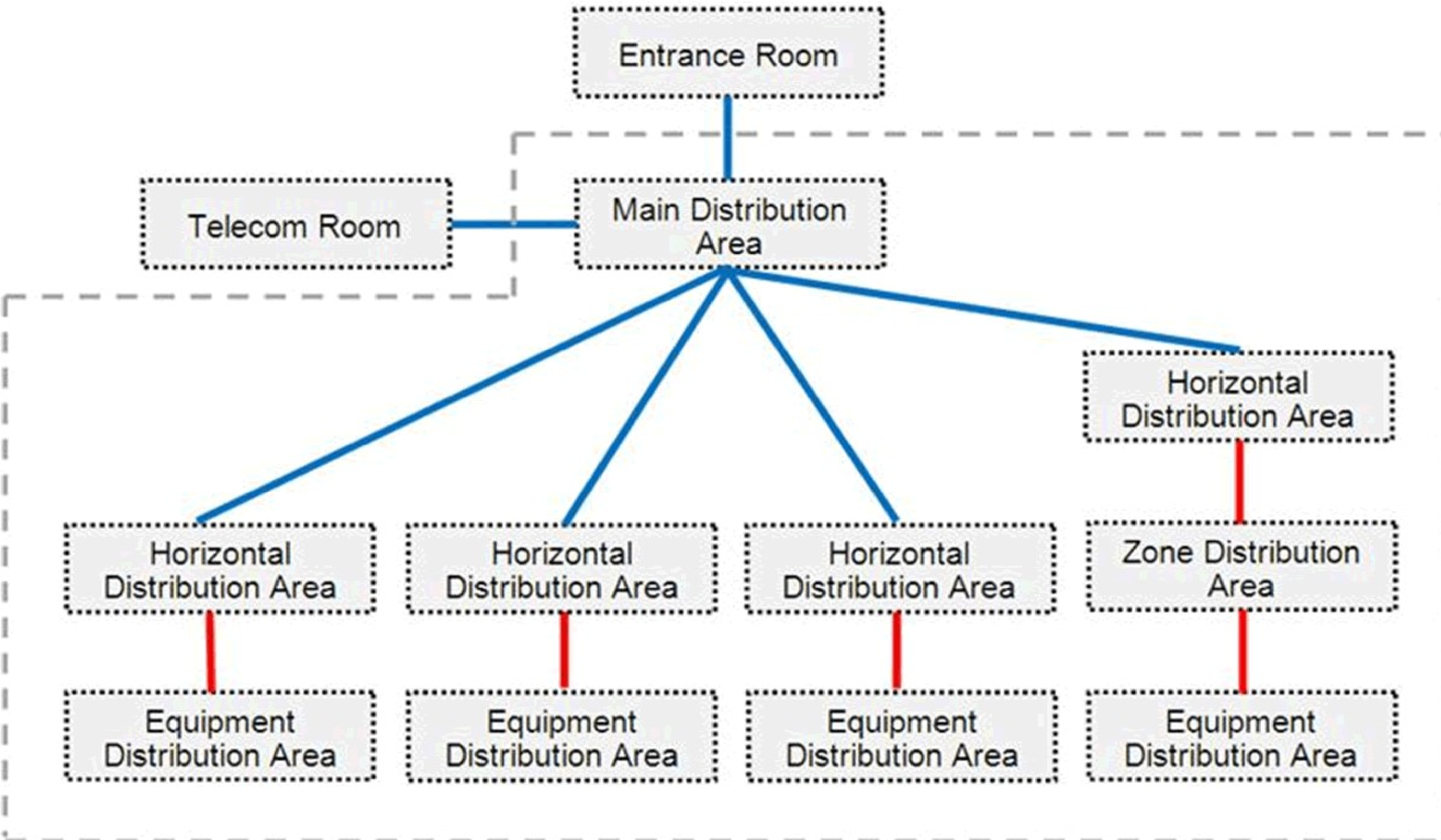
**Bonding-Earthling Guidelines**

1. Individual Device Bond
2. Serial Bonding : NA
3. IEEE-1100 to Follow
4. Ground < 1 Ohm [9 Hole]
5. Code of AHJ to Follow



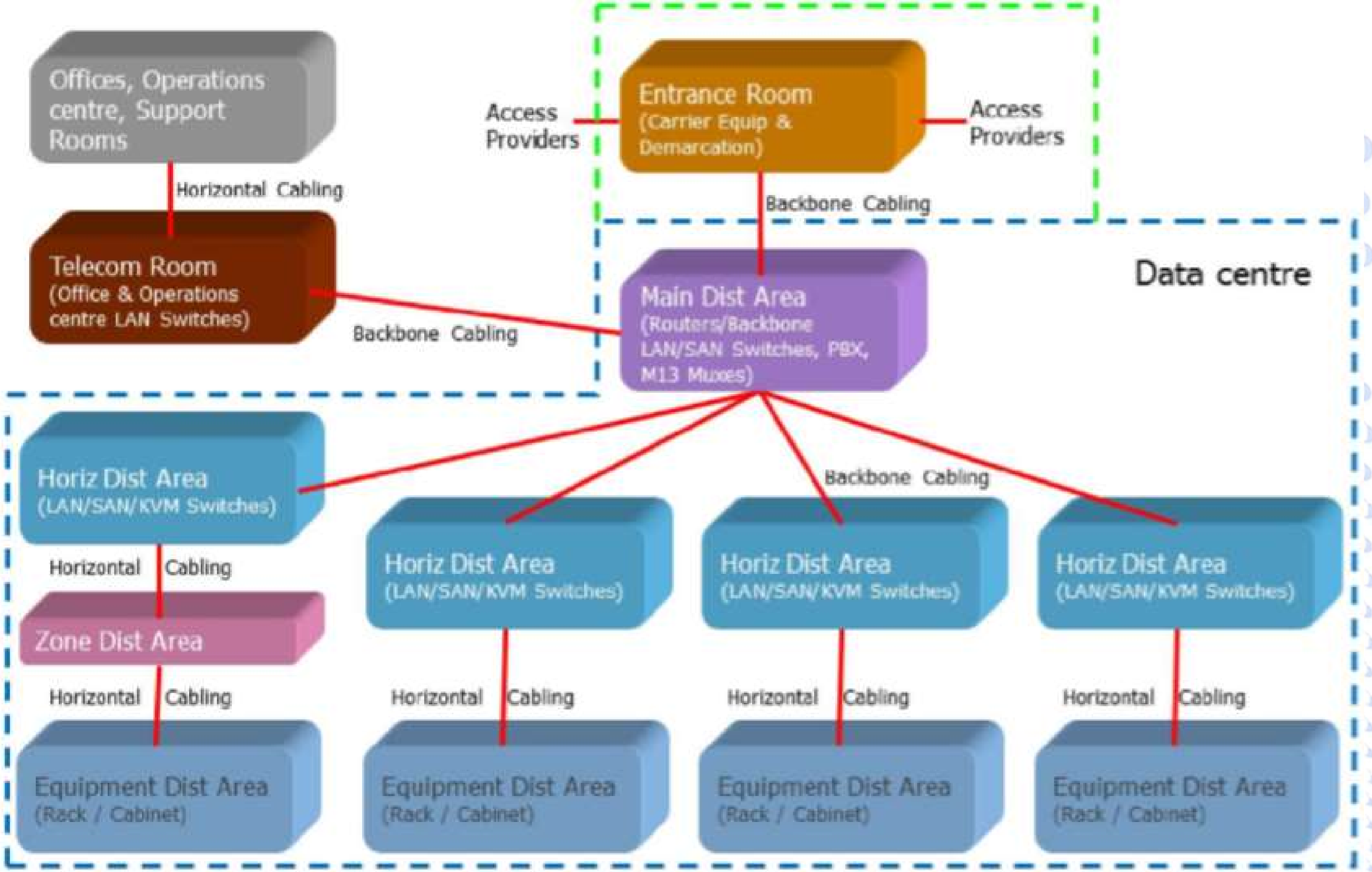


# TIA-942 Cabling Standard



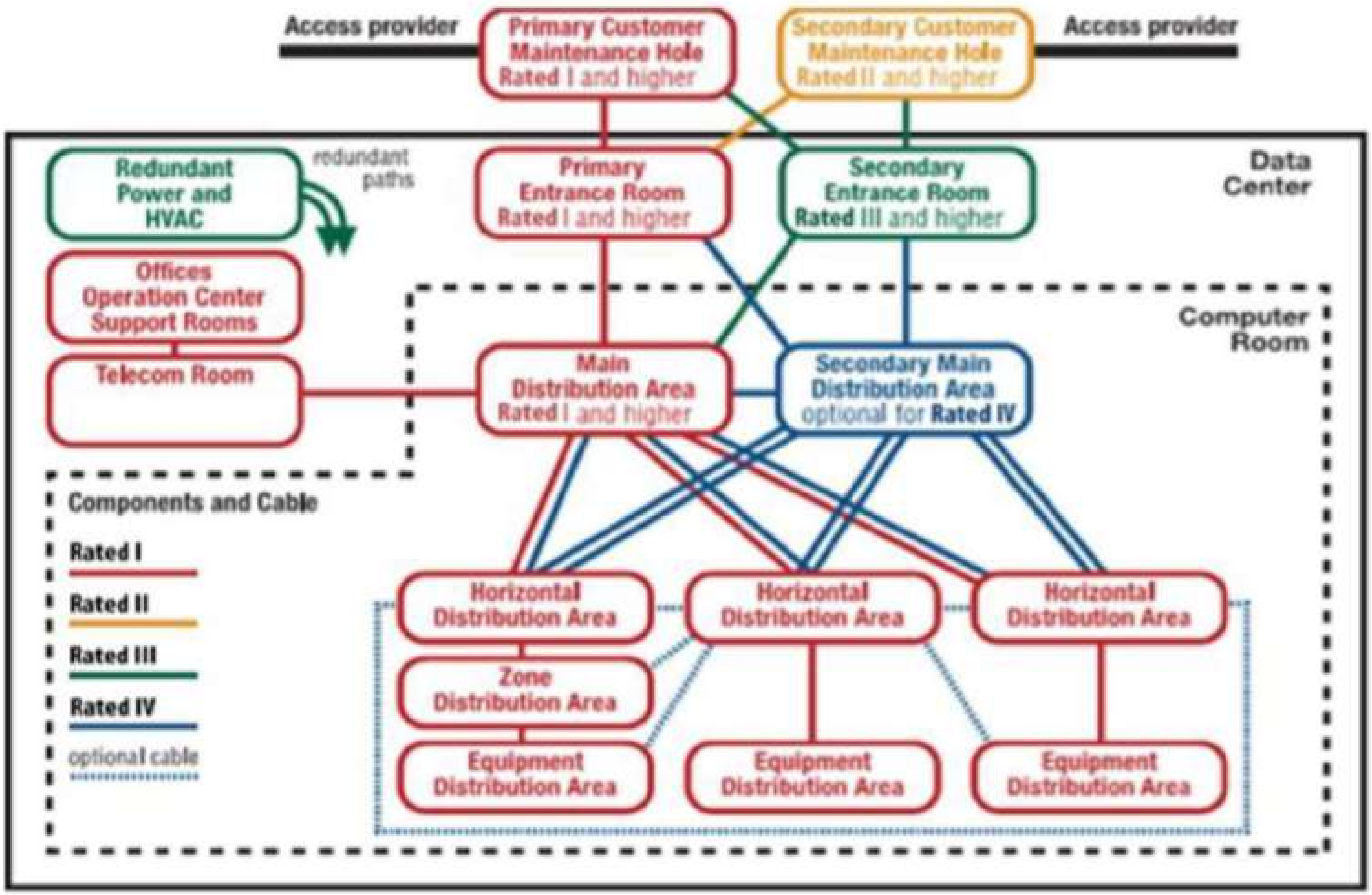

| | | | | | |
|---|---|---|---|---|---|
| ER : Carrier | MDA : MMR | HDA : DH-MMR | ZDA : End of Row | HDA : Top of Rack | EDA : Rack |

# TIA-942 Cabling Standard



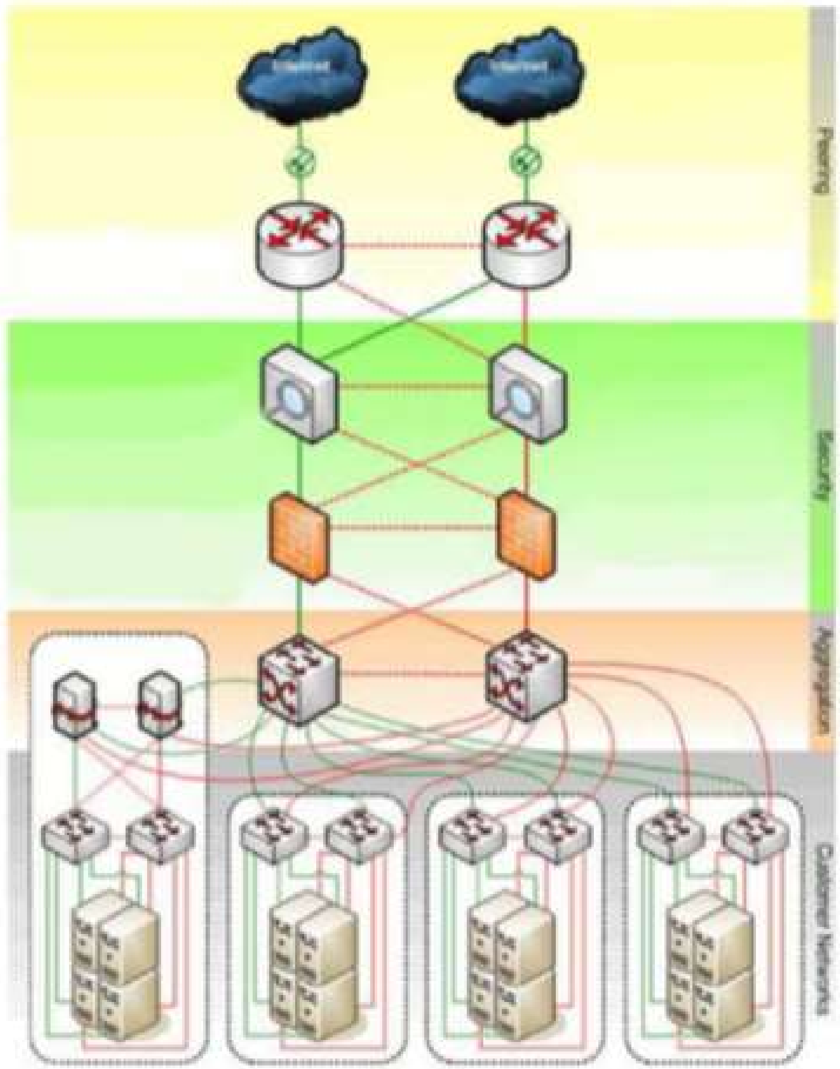
# TIA-942 Cabling Standard

SANOG



# TIA-942 Cabling Standard

SANOG



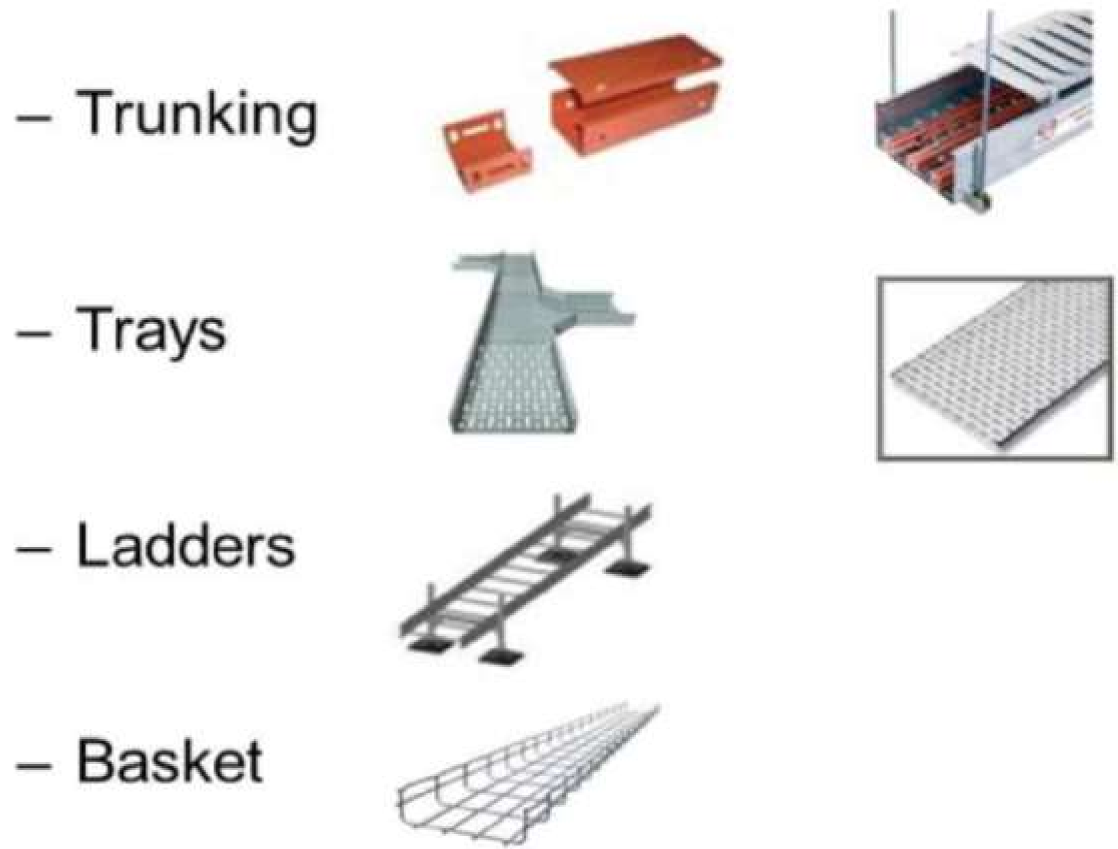
- Network diversity
- Network redundancy
- Redundancy on the backbone
- Redundancy in the data centre
  - Redundant network equipment in sub-racks
  - Redundant cable paths
  - Separate office building management networks
- Ensure separate physical routes

| Peering | Security | Aggregation | Data Centre |
|---|---|---|---|

# TIA-942 Cabling Standard

| TIA-942 Cabling Standard | Requirement |
|---|---|
| Structured Cabling | Applicable for Enterprise DC |
| On-Demand Cabling | Applicable for Internet DC / Colocation DC |
| Copper Media | Cat 7, 7A or Higher |
| Fibre Media (Single Mode) | OS2 or Higher |
| Fibre Media (Multi Mode) | OM4 or Higher |
| Fibre Termination (Patch Panel) | MPO |
| Building to Building Connectivity (Fixed Site) | Hard Wired |
| Building to Building Connectivity (Fixed Site) | Canopy (Point to Point / Access Point) |
| Building to Building Connectivity (Temporary) | Free Space Optics (Requires LOS) |

# Cable and Pipe Distribution

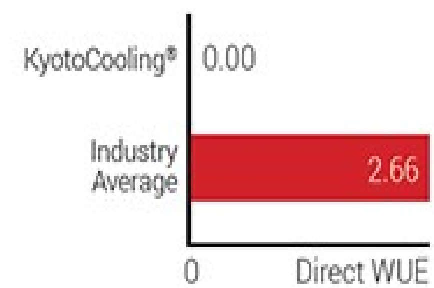



- Solid Tray as Drain to Over-Head Water Pipe
- RCC Duct for Underground Cable Tunnel

# Data Centre Efficiency : The Green Grid

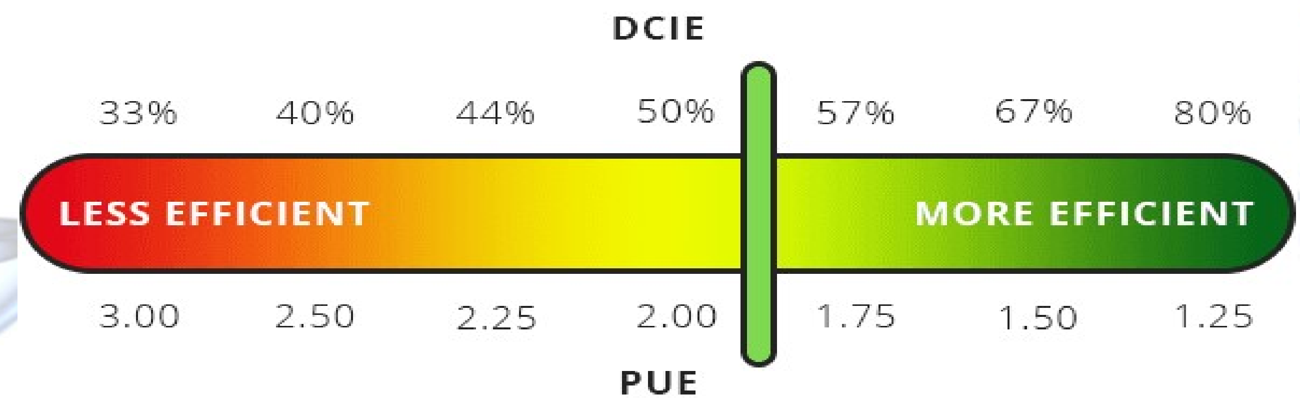
| Metric Description | Metric Formulation |
|---|---|
| Power Usage Efficiency | $PUE = \frac{Total\ facility\ power}{Total\ IT\ power}$ |
| Data Center Infrastructure Efficiency | $DCiE = \frac{Total\ IT\ power}{Total\ facility\ power}$ |
| Carbon Usage Effectiveness | $CUE = \frac{Total\ CO2\ emissions\ from\ DC\ energy}{Total\ IT\ Equipment\ energy}$ |
| IT Equipment Utilization | $ITEU = \frac{Total\ measured\ energy\ of\ IT}{Total\ specification\ energy\ of\ IT}$ |

$$\frac{\text{Annual Site Water Usage}}{\text{IT/Equipment Energy}} = \textbf{WUE}$$



# Data Centre Efficiency Scale

| PUE | DCiE | Level of Efficieny |
|---|---|---|
| 3.0 | 33% | Very Inefficient |
| 2.5 | 40% | Inefficient |
| 2.0 | 50% | Average |
| 1.5 | 67% | Efficient |
| 1.2 | 83% | Very Efficient |



# PUE Calculation : Thumb Rule

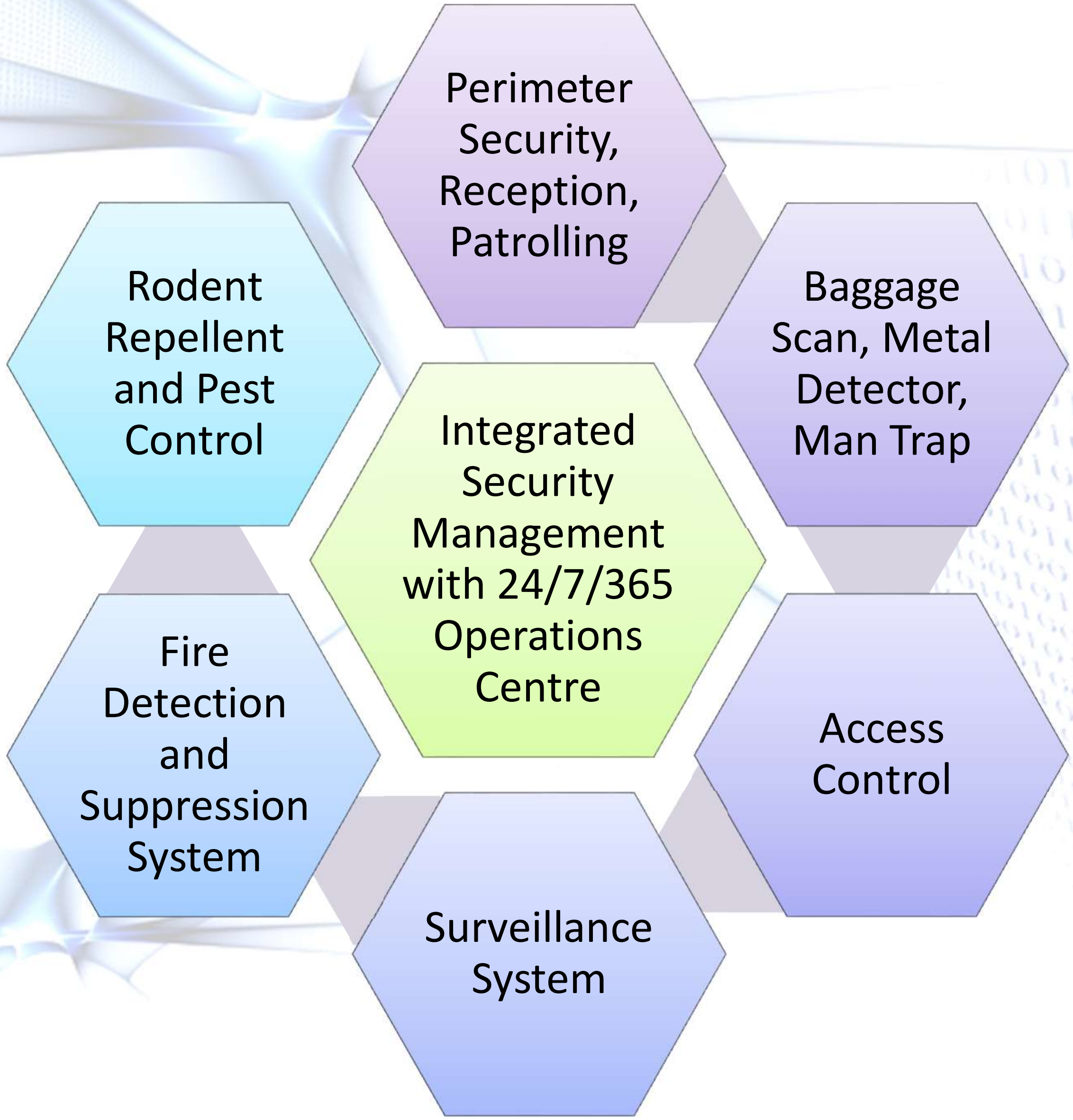
| Cooling Technology | PUE |
|---|---|
| Natural / Free Cooling | 1.3 |
| Comfort AC | 1.9 |
| VRF System | 1.85 |
| Precision AC | 1.8 |
| DX Chiller (Scroll Compressor) | 1.75 |
| Air Cooled Chiller (Screw Compressor) | 1.6 |
| Water Cooled Chiller (Magnetic Compressor) | 1.45 |
| Water Cooled Chiller (Screw Compressor) | 1.6 |
| Water Cooled Chiller (Centrifugal Compressor) | 1.7 |

Measurement
PDU Level

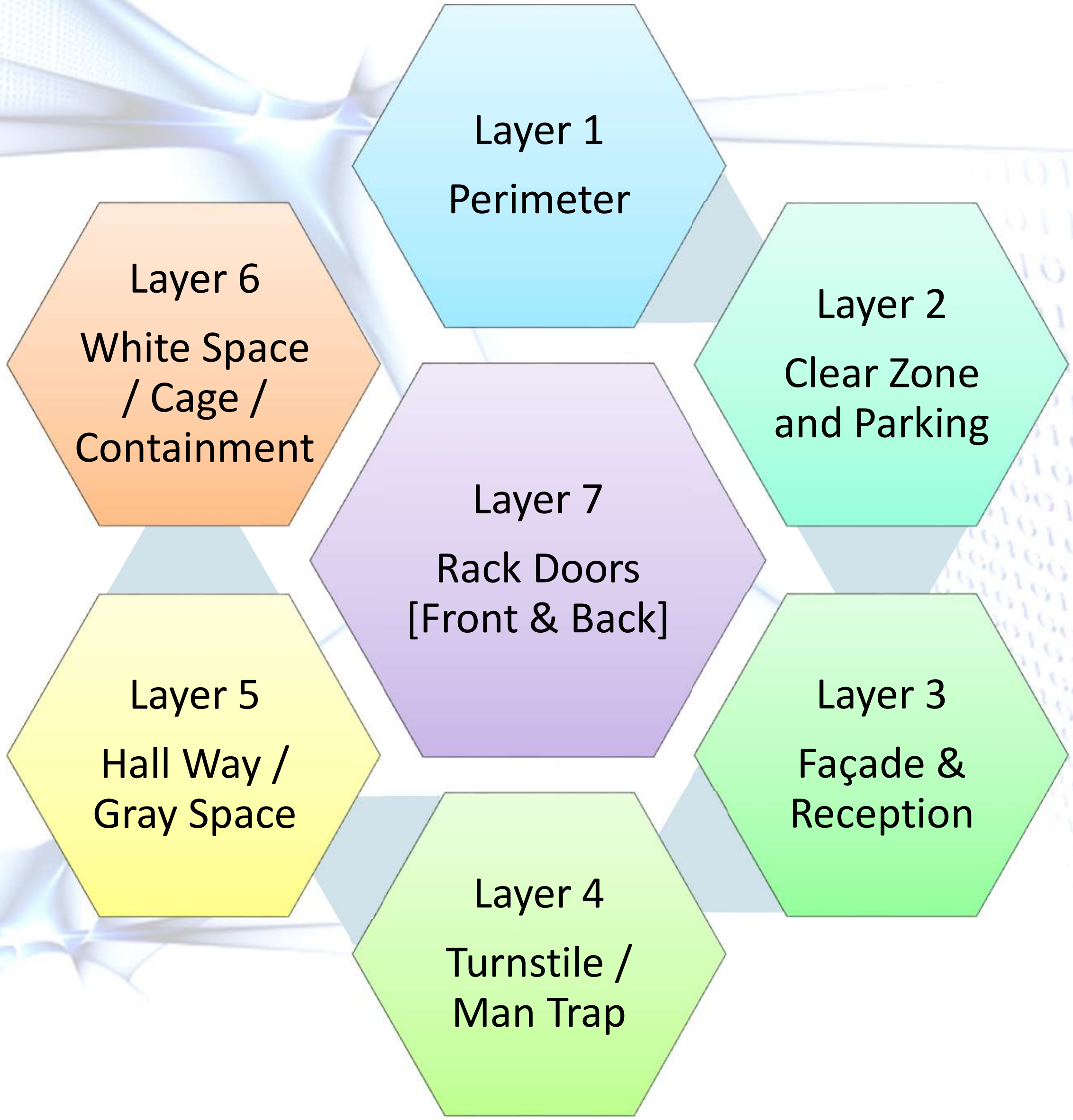
Green DC
PUE < 2 | DCIE > 50%

Inefficient DC
PUE > 2 | DCIE < 50%

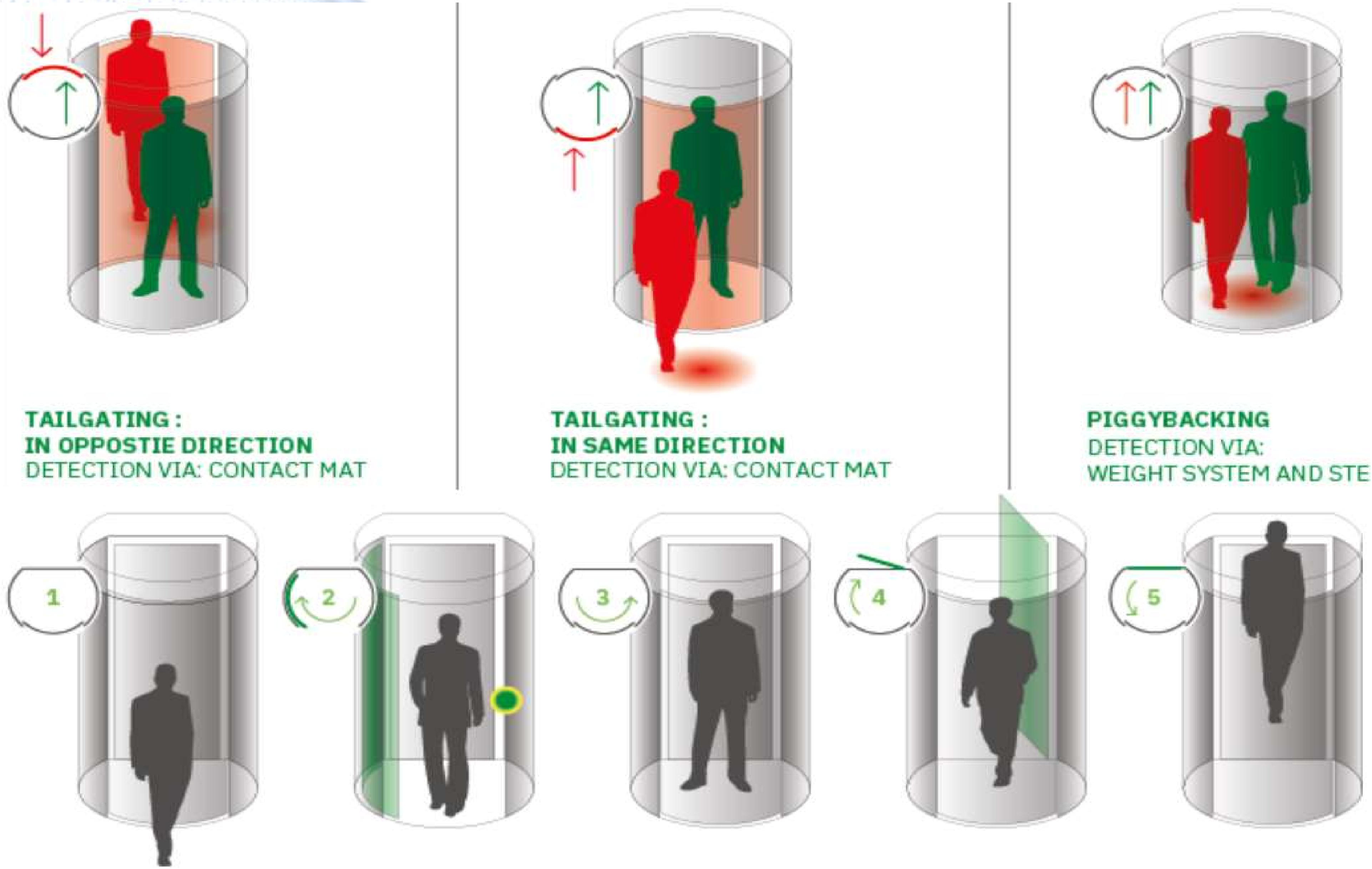
# Physical Security & Risk Management



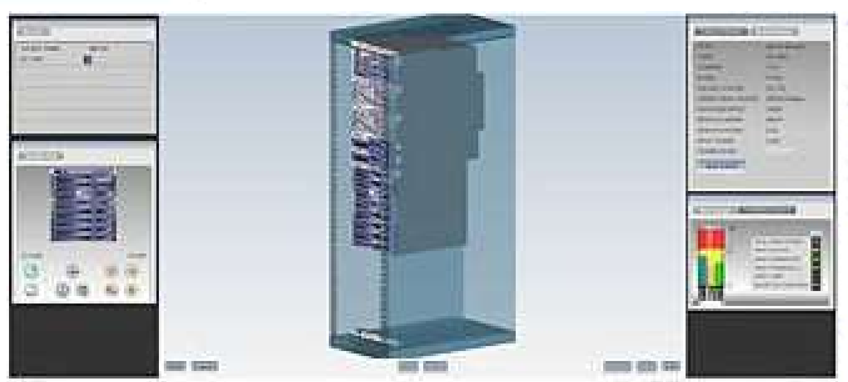
# Access Control & Surveillance System



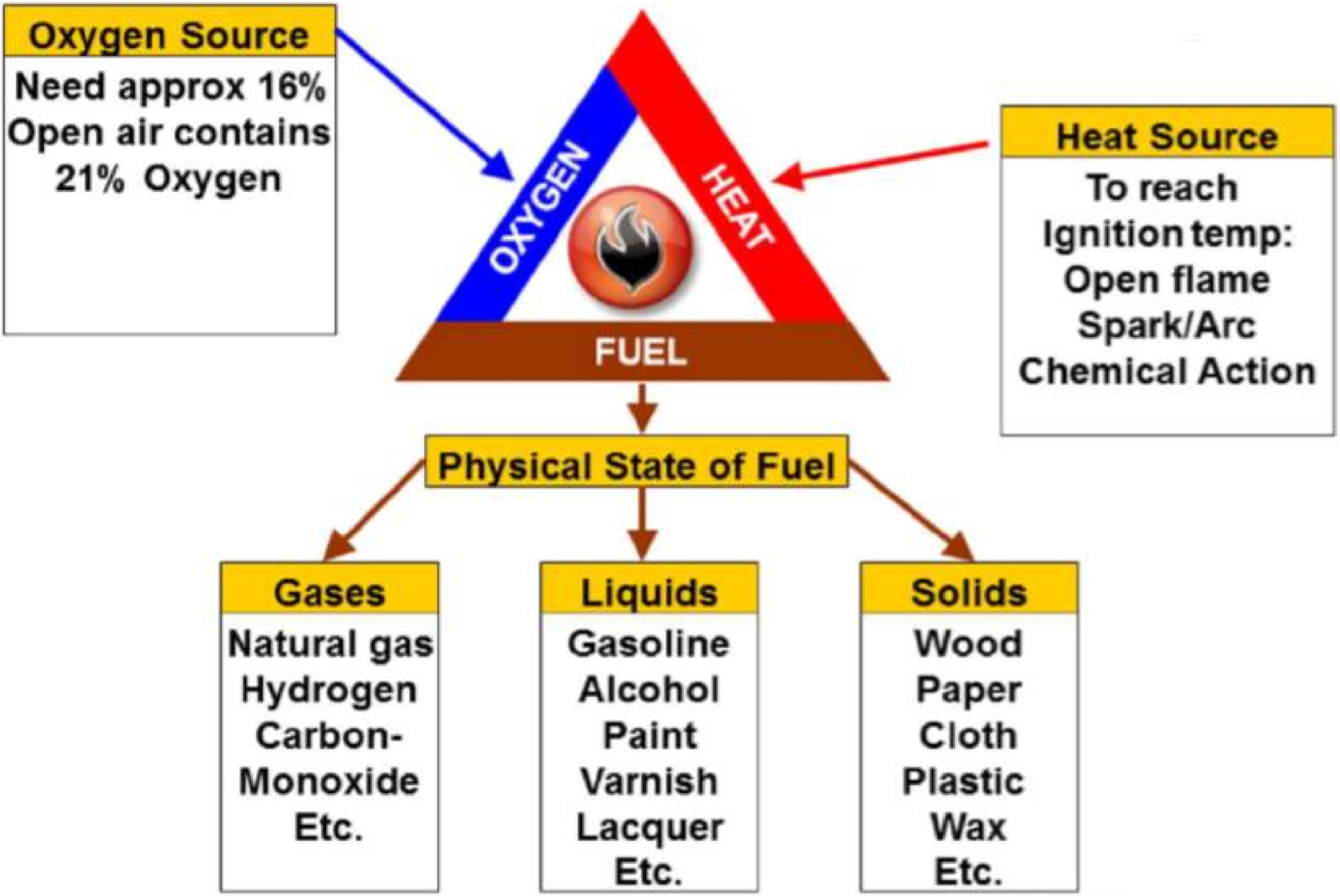
# Layer 4 : Tailgating and Piggybacking



# Data Centre Infrastructure Management



# Fire Triangle



# Fire Suppressant Gas : Modus Operandi

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There are four means used by the agents to extinguish a fire. They act on the "fire tetrahedron":

- Reduction or isolation of fuel. No agents currently use this as the primary means of fire suppression.
- Reduction of heat. Representative agents: Clean agent FS 49 C2 (NAF S 227, MH227, FM-200), Novec 1230, pentafluoroethane (NAF S125, ECARO-25).
- Reduction or isolation of oxygen: Representative agents: Argonite / IG-55 (ProInert), $CO_2$ carbon dioxide, IG-541 Inergen, and IG-100 (NN100).
- Inhibiting the chain reaction of the above components. Representative agents: FE-13, 1,1,1,2,3,3,3-Heptafluoropropane, FE-25, haloalkanes, bromotrifluoromethane, trifluoroiodomethane, NAF P-IV, NAF S-III, NAF S 125, NAF S 227, and Triodide (Trifluoroiodomethane).

# Fire Suppression System

- Install VESDA/HSSD type of system
- Use any of the gas based systems as primary fire suppression system
- Use pre-action sprinkler as secondary system
- Ensure that the room is properly sealed
- Ensure that gas content is enough to achieve concentration levels required
- Create extraction vents
- Proper maintenance

# Fire Class

- **Class A**
  - Fires involving the combustion of ordinary materials such as wood, cloth, paper, plastics etc.
  - The extinguishers contain pressurized water or water based extinguishing agents.
- **Class B**
  - Fires involving combustible or flammable liquids such as gasoline, kerosene and many chemical agents including gases.
  - Extinguishers contain carbon dioxide or a dry chemical extinguishing agent. When extinguishing electrical fires in or around sensitive equipment such as computers, a carbon dioxide extinguisher is preferred, as it does not leave any reside that will harm subsequent operation of the equipment

# Fire Class

- **Class C (Data centres)**
  - Fires involving energized electrical equipment such as appliances of all kinds, motors, computers etc.
  - Extinguishers contain carbon dioxide, Halon, dry chemical or liquid extinguishing agent.
- **Class D**
  - Fires involving combustible metals such as sodium, lithium, titanium, magnesium.
  - Extinguishing agent usually comes in dry powder form stored in a bucket.
- **Class K**
  - Fires involving cooking fats & oil in commercial cooking.
  - Extinguishing agent comes as liquid chemical.
- **NOTE: The indicator of classes can vary per country (class C can be indicated by class E)**

# Fire Suppression Primary System : Gas

SANOG

| Agent → ↓ Features | Halon 1301 [FE 13 / HFC 23] | $CO_2$ | FM 200 [NAF S 125] | NOVEC 1230 | Inergen [Argonite] |
|---|---|---|---|---|---|
| Production | Jan 1, 1994 [In Production] | In Production | Jan 1, 2022 | In Production | In Production |
| Environment | Ozone (65 Year) [243 Years] | Natural Gas | 33 Years [29 Years] | 5 Days | Natural Gas |
| Temperature | - 29 C to 54 C [- 20 C to 50 C] | - 15 C to 51.5 C | - 15 C to 100 C | - 17 C to 54 C | 0 C to 65 C [0 C to 54 C] |
| Pressure | 60 Bar | 35 Bar | 25 Bar | 40 Bar | 150 Bar |
| Flooding Height | 3.5 m [8 m] | 3.0 m | 3.5 m | 4.0 m | 4.0 m |
| Flooding Time | 10 Sec / Less | 10 Sec / More | 10 Sec / Less | 10 Sec / Less | 60 Sec / Less |
| Fire Zone | Not Possible | Not Possible | Not Possible | Not Possible | Possible |
| Working Principle | Heat Absorb | Oxygen Reduce (15%) | Heat Absorb [Heat + Oxygen] | Heat Absorb | Oxygen Reduce (12.5%) |
| NOAEL (Design) | 9% (7.5%) [30% (15%)] | 5% (35%) 9% (B), 34% (D) | 9% (7.5%) [7.5% (5%)] | 10% (5%) | 43% (40%) [43% (40%)] |
| Usage in DC | Banned [Partial] | Mostly Banned | Partial Ban | In Use | In Use |
| Look / Smell | Clean | White Mist | Clean [Lemon] | Clean | Clean |

# Fire Suppression System : Selection

**Large (> 1000 $m^2$)**

1st (Mandatory)

Inergen / Argonite ; or,

2nd (Optional)

Pre-Action System
(Corrosion is a Problem)

**Small (< 1000 $m^2$)**

1st (Mandatory)

NOVEC 1230 (Green); or,
FE-13 (for High Void, Risky)

2nd (Optional)

Water Mist / Pre-Action System (Corrosion Check)

# Technology Selection and Options

SANOG

| Electrical and Power System | Mechanical and HVAC System |
| --- | --- |
| Static UPS (Modular / Stand Alone) with DG, AVR, PFI, Battery Bank, Synchronize | Water Cooled Water Chiller |
| Dynamic Rotary UPS | Air Cooled Water Chiller |
| Flywheel UPS backed by Static UPS | Precision Air Condition |

# Technology Selection and Options

SANOG

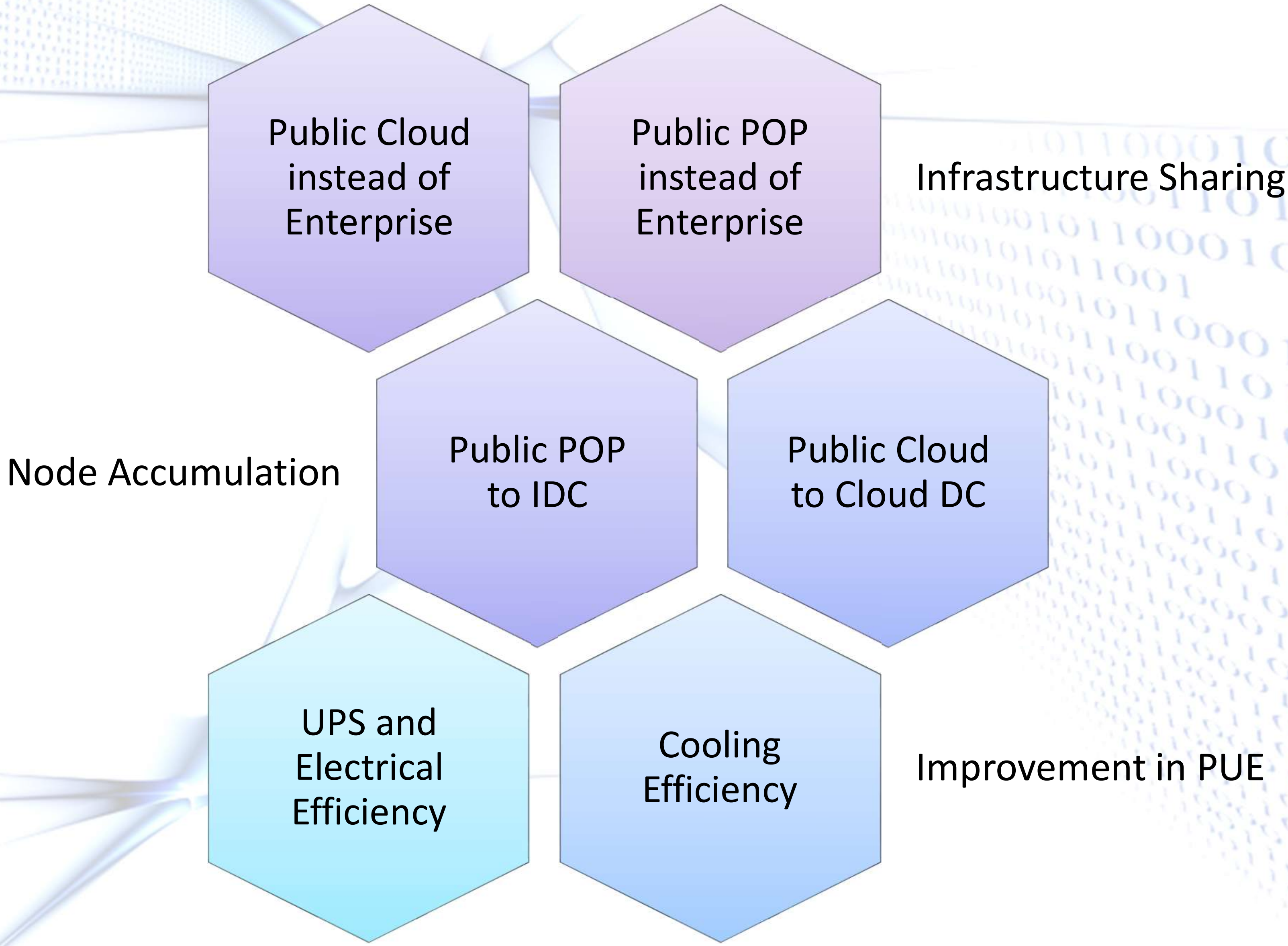
| Access Control System | Fire Suppression System |
| --- | --- |
| ☐ Plum Vein + PIN + Access ID | ☐ NOVEC 1230 + VESDA |
| ☐ Finger Vein + PIN + Access ID | ☐ INERGEN + VESDA |
| ☐ Irish / Finger Print + PIN + Access ID | ☐ NAF S-125 / Water Mist + VESDA |

# Technology Selection and Options

SANOG

| Power Distribution System | Cold Air and Hot Air Separation |
| --- | --- |
| Continuous Bus Way + Cast Resin BBT | Slab Floor, Chimney Return |
| Continuous Bus Way + Sandwich BBT | Any Slab, Smart Aisle (Rack Sensing) Containment, Room Return |
| Cast Resin / Sandwich BBT (both use) | Any (Raised / Slab) Slab, Aisle (Hot / Cold) Containment, Room Return |

# Transformation Towards Efficiency



# Quiz : Tier Topology Misconception

Raised Floor is Mandatory for DC Certification

YES / NO

Without Utility Power Supply We Can Acquire Tier Certification

YES / NO

Tier-III IDC with Average Per Rack Power Density is more than 4 KW, What Auditor will Ask in TCCF

UPS Setup of N+1 with Isolated Parallel Bus System, Can We Acquire Tier-IV from UTI in TCDD

# Quiz : Design Misconception

What is the Right Sequence:
Rack Door-Lock
Data Hall Access
Man Trap [2 Factor]
Data Hall Turnstile

Without Safety, Security & DCIM - We Can Acquire Tier Certification

YES / NO

Rated-3 requires Dual Utility Power Source

YES / NO

TIA-942, USA Awards DC Certification

YES / NO

# Question, Comment, Feedback, Advice