Engineering Data Center Design for the Rapidly Advancing AI Environment

April 29th, 2025

CTS Group

Health & Safety Moment

Fire Exits

Locate exits around the Auditorium

Emergency Procedure

Exit safely in orderly manner

Engineering Data Center Design for the Rapidly Advancing AI Environment

Today, the landscape of data center construction is undergoing rapid transformation, driven by AI workloads and their unprecedented power demands. This paradigm shift is reshaping how data centers are designed, built, and operated.

Seán A. Timmons, PE, MBA, B.Eng.(H)
Senior Vice President
of Design, Engineering, Technology & Sustainability

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About Sean A. Timmons

1 Background

Raised in Cork, Ireland and gained my education from MIT Cork, London Southbank University and University of San Francisco (B.Eng.(H), MBA, PE, LEED AP).

2 Experience

Built and operated an SBE AIA award-winning Consulting Practice for 25 years with a global perspective and a sustainability ethos.

3 Current Role

Joined CTS in 2023 as Design & Engineering Management in Oslo, driving DC projects with emphasis on ***Innovation & Excellence.***

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Congratulations!

❖**Tik Tok** – Norway - **DCD European Project of the Year 2024**, Designed and Built by **CTS Group**

❖Nominated for the **Tech Capital** Global DC Award 2025

Congratulation! *To the* ***CTS Design and Build Team*** *and all associated with this incredible project in addition to our respected* ***Client - Green Mountain*** *and* ***End Customer - Tik Tok.***

Thank you for the Opportunity in allowing CTS Group to help you realize your project Goals!

CTS Group is Meeting the Challenge of AI

Paradigm Shift

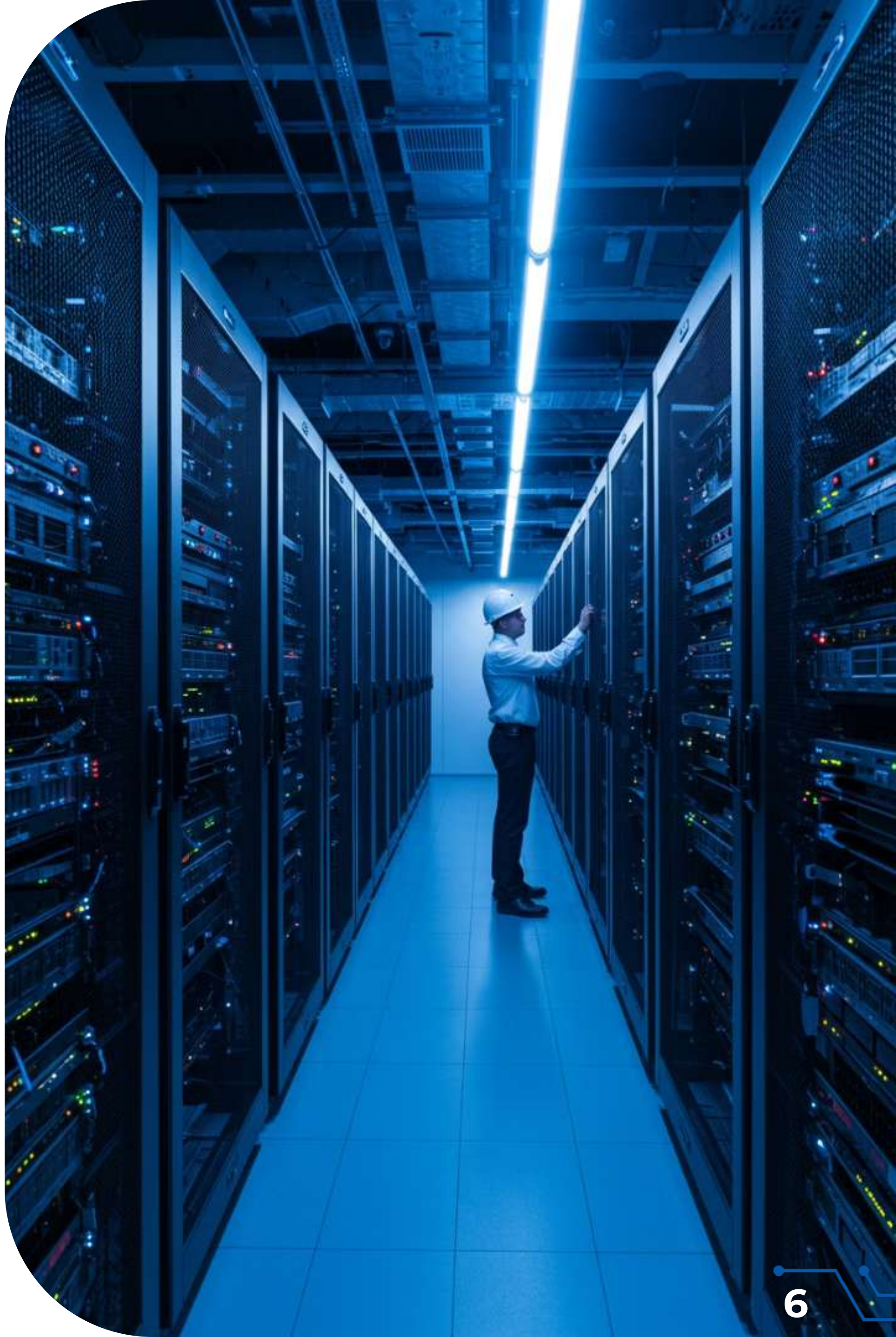
AI applications across industries are driving a recalibration of priorities in data centers.

Key Challenges

Available power, time to market, sustainability, and escalating costs are formidable hurdles.

Balancing Act

Securing equilibrium between innovation, environmental stewardship, and financial viability is imperative.



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Redefining Data Centers as Critical Facilities

Critical Infrastructure

Data centers have gained recognition as Critical National Infrastructure in certain EU countries.

Leading Countries

Ireland, UK, Germany, France, Netherlands, and Spain have already made this classification.

Growing Trend

Italy, Norway, Sweden, Finland, Denmark, and Belgium, are in the process of similar classification.

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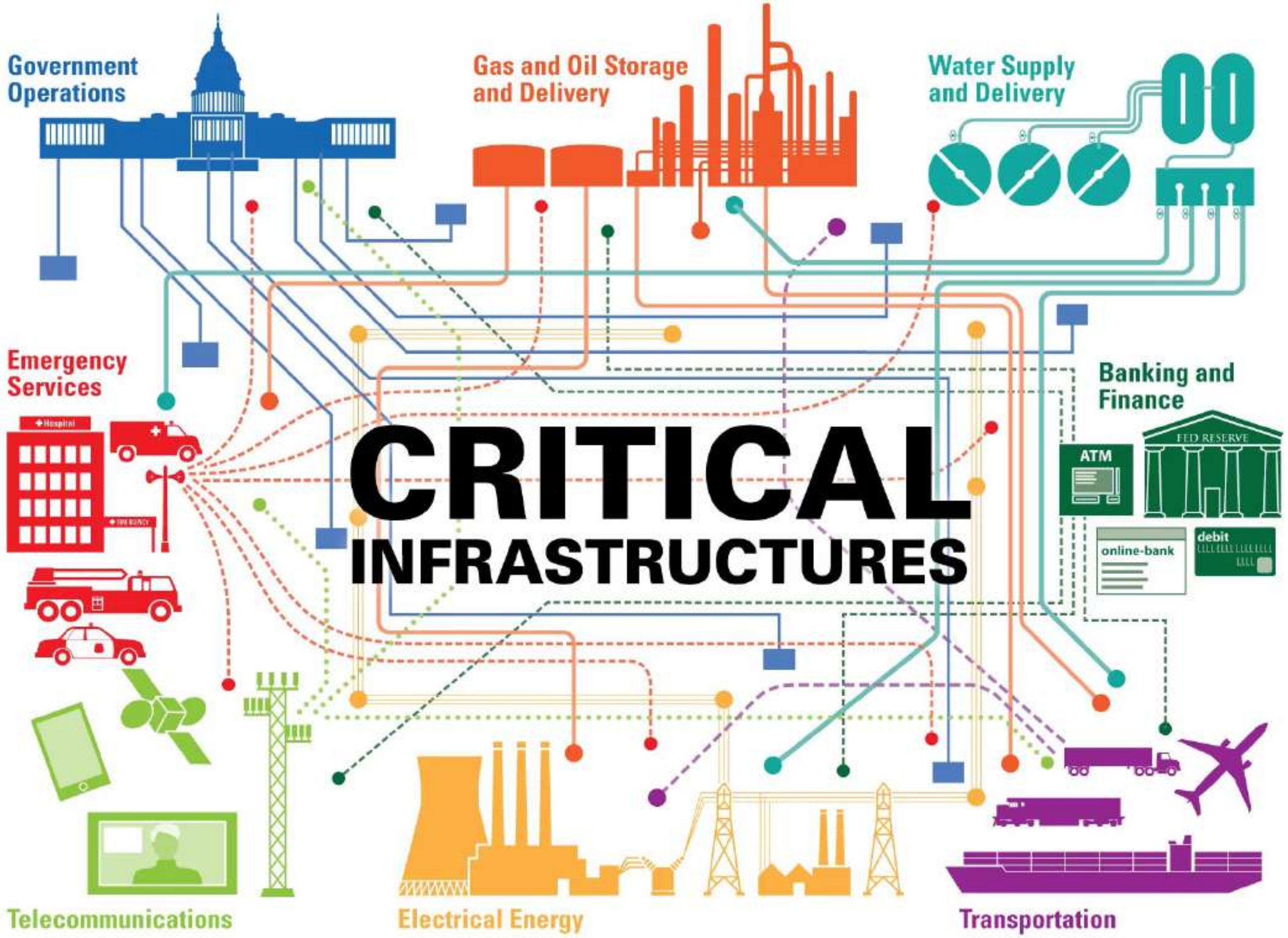
Benefits of Critical Infrastructure Classification

Protection

This classification helps protect critical data infrastructure from various threats.

Reassurance

Provides healthcare facilities, government, and businesses with greater reassurances in our digital world.



Understanding AI Infrastructure

1

From **Data Center** to **Compute Center**

AI infrastructure relies on GPUs, consuming significantly more power than traditional CPUs used in data centers.

2

Power Density Shift

Traditional data centers focused on storage with 10 kW/rack. AI requires 40-600 kW/rack for compute-heavy applications.

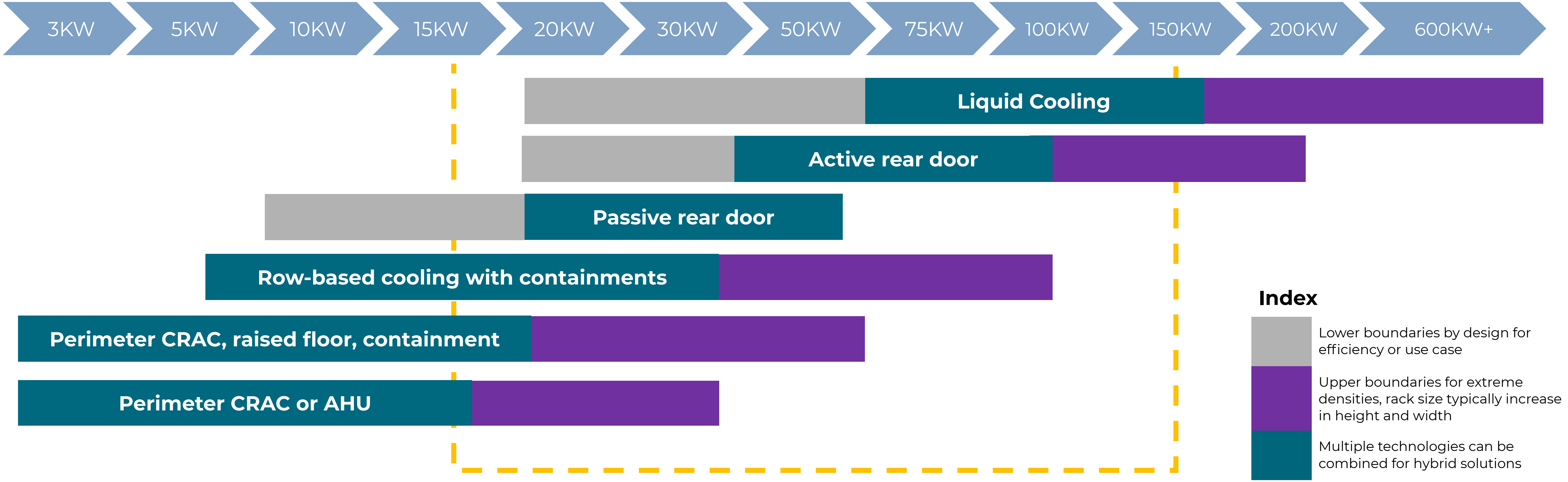
3

New Requirements

While HPC sites are optimized for raw computational power, AI inference workloads need high availability and lightning-fast response times.

Power Density Shift

- IT cooling challenges continue escalating as new server-accelerated compute technologies, machine learning, artificial intelligence, and high-performance computing drive higher heat densities in the data center environment.
- Liquid cooling is rapidly emerging as the technology for efficiently handling power-dense hot spots.
- As the chart shows, as rack density increases in the data center, air is not as effective as liquid in cooling the load.



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AI Data Center Use Cases

Security

AI-driven facial recognition revolutionizes identity verification and surveillance by analyzing unique facial features.

Bitcoin Mining

Companies like Core Scientific are retrofitting Bitcoin mining sites to support AI computing capacity.

Healthcare

Platforms like Atomwise accelerate drug discovery while Viz.ai analyzes medical images to identify critical conditions.

AI's Specific Requirements for Data Centers

High Performance Computing

Systems running at speeds one million times faster than commodity systems.

Machine Learning

Enabling machines to learn from data and improve performance without explicit programming.

Tier III Facilities

Concurrently maintainable with multiple distribution paths for power and cooling, no shutdown needed during maintenance.

Liquid Cooling

Methods to lower temperature of CPUs and GPUs, essential for high-density computing.

Liquid Cooling Technology

1 Key Technology

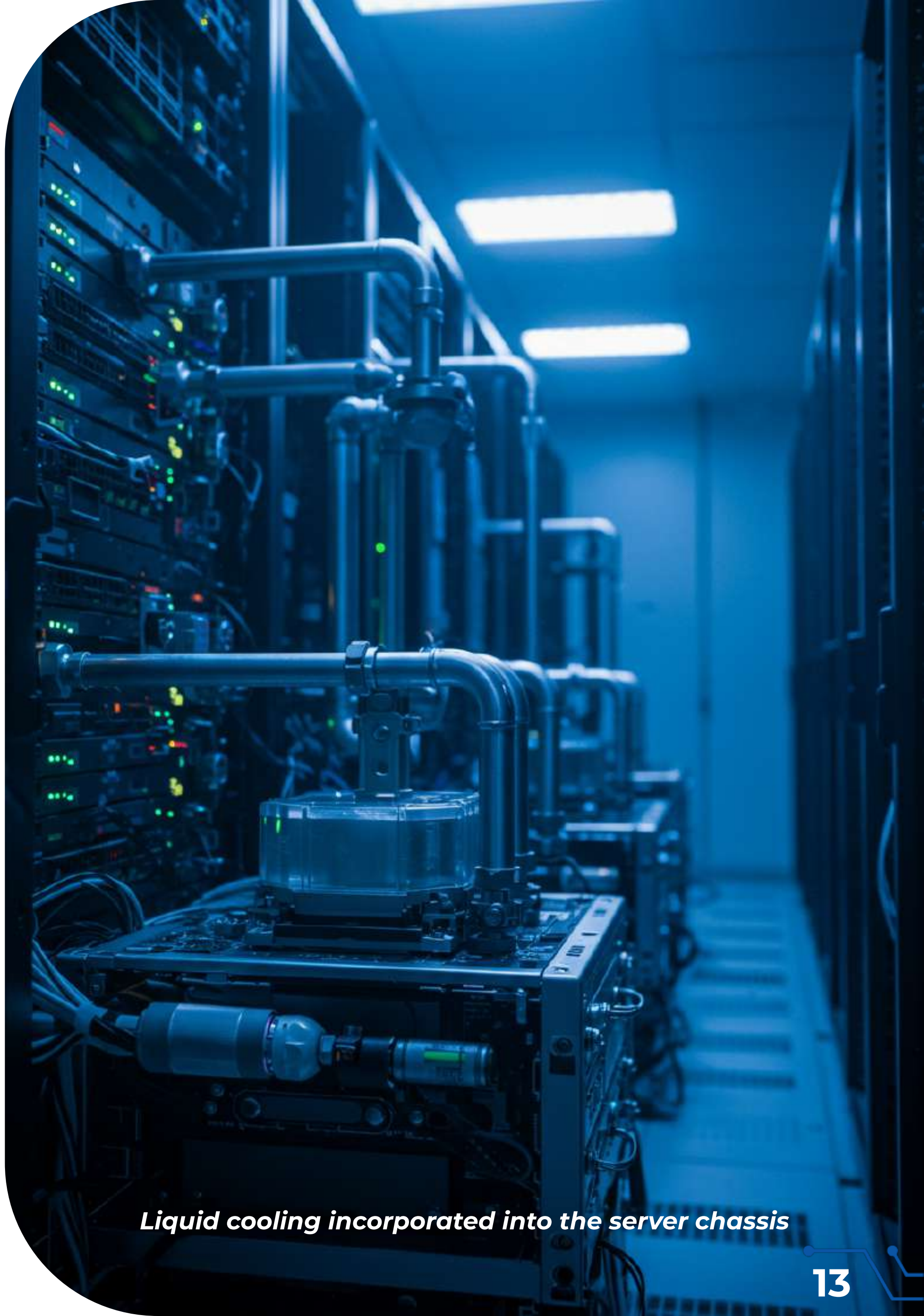
Efficiently handles power-dense hot spots in data centers

2 Superior Efficiency

Water conducts heat 30 times faster than air

3 Precise Control

CDUs provide temperature control and redundancy



Liquid cooling incorporated into the server chassis

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CDU Integration for Controlled Cooling

1

Circulation System

CDU circulates coolant in closed-loop system

2

Efficiency Boost

Introduced where heat exceeds air-cooling capability

3

Heat Exchange

Transfers heat between building systems and CDU loop

Advantages and Disadvantages

Liquid cooling systems offer key benefits and considerations:

Advantages:

- **Greater Cooling Capacity:** Delivers substantially more cooling power than conventional methods
- **Temperature Accuracy:** Maintains precise temperatures for optimal component performance -20°C (-4˚F) up to a maximum of +70°C (158˚F).
- **Higher Component Density:** Enables more compact hardware arrangements
- **Faster Heat Removal:** Rapidly dissipates heat from critical components
- **Quieter Operation:** Eliminates noisy fans for quieter computing
- **Power Efficiency:** Reduces overall energy consumption
- **Redundancy:** Redundant pumps and power inputs ensure continuous operation, and that precise temperature, flow rate, and pressure are continuously maintained, thus ensuring uptime and increasing reliability.

Disadvantages:

- **More Maintenance:** Requires regular checks and fluid replacement
- **Greater Upfront Cost:** Higher initial investment than traditional cooling
- **Risk of Leaks:** Potential for liquid damage to components

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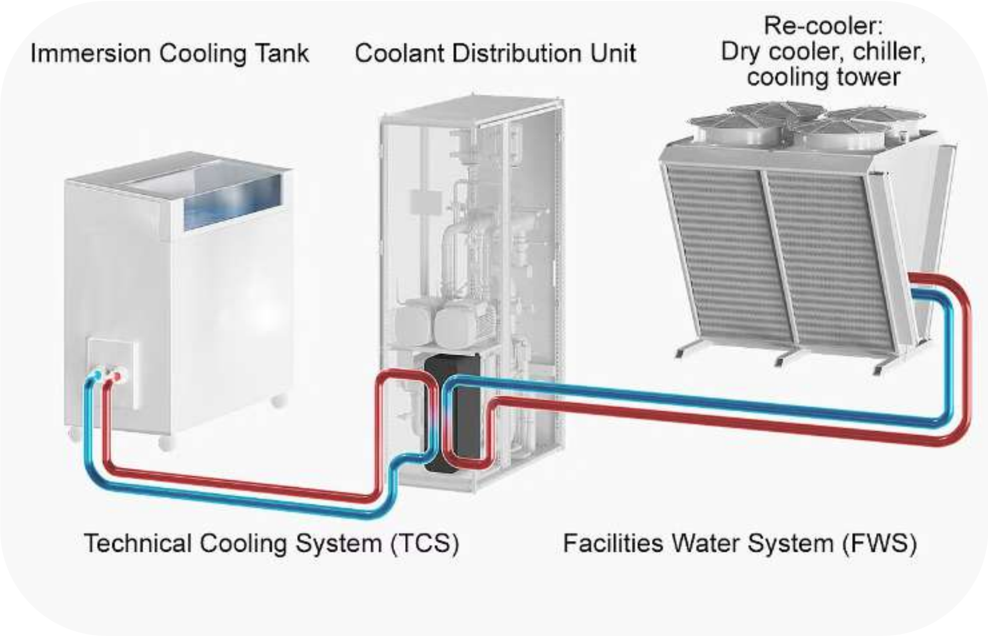
Facility Water System (FWS) and Technology Cooling System (TCS)

Technology Cooling System (TCS): serves as a dedicated loop intended to perform heat transfer from a datacom equipment cooling system into the chilled-water loop.

Facility Water System (FWS): *consists of a system between the data center chiller(s) and the Cooling Units (CUs); the chilled-water system includes the chiller plant, pumps, hydronic accessories, and necessary distribution piping at the facility level.*

The CDU isolates the TCS from the harsher FWS. Due to the very small, millimetric, water paths inside the ITE, **TCS water quality is much more demanding than FWS water quality**.

TCS operates with Propylene Glycol at 25% concentration to avoid microbiological growth.



Technology Cooling System (TCS). Classes

Temperature Classes

TCS systems are divided into temperature classes, from S30 to S50.

S30 Definition

S30 means that the TCS water supply temperature must be 30°C or less.

Future Development

To deal with the demands of HPC, **ASHRAE is considering the addition of lower temperature classes**.

ASHRAE TC 9.9 – Liquid Cooling Guidelines. Table 6.1

TCS Fluid Class	Equipment Environment Specifications for Liquid Cooling		
	Typical Infrastructure Design		Maximum TCS Supply Temperature °C (°F)[a]
	Common FWS Facilities	TCS Facilities	
S30	Chiller / cooling tower	CDU	30 (86)
S35			35 (95)
S40	Cooling tower		40 (104)
S45	Cooling tower / dry cooler		45 (113)
S50	Dry cooler		50 (122)

a) Minimum water temperature for all classes is 2°C (3.6°F) above the measured data center air dew point, to avoid condensation

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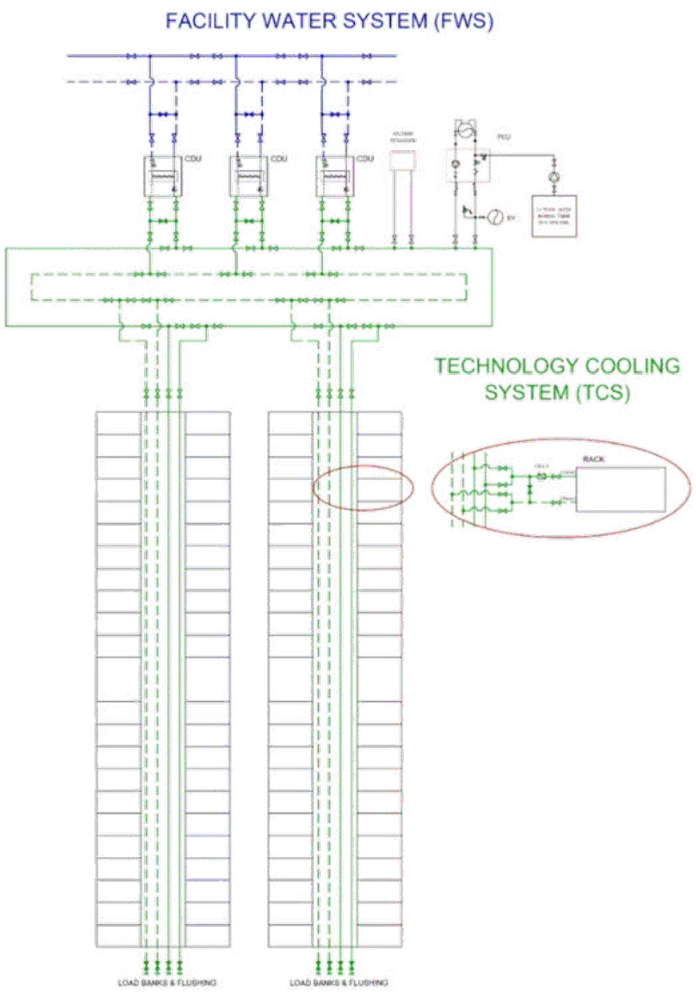
Technology Cooling System (TCS). Schematic.



A typical TCS system schematic includes:

- N+1 CDUs operating as group
- Buffer tanks on the return pipe to the CDUs
- Tier III coolant distribution piping system
- Constant water flow, balanced at the CDUs with Pressure Independent Control Valves or Flow Limiters
- Automatic refill and pressure control system
- Vacuum degassing
- Advanced CDU control systems ensuring a stable Leaving Water Temperature (LWT) even when rapid IT load changes occur

DATA CENTER BUILDING – FAN WALL / CDU MECHANICAL – Cooling System Diagram

Fan Wall System

Provides primary air movement through the facility

CDU Integration

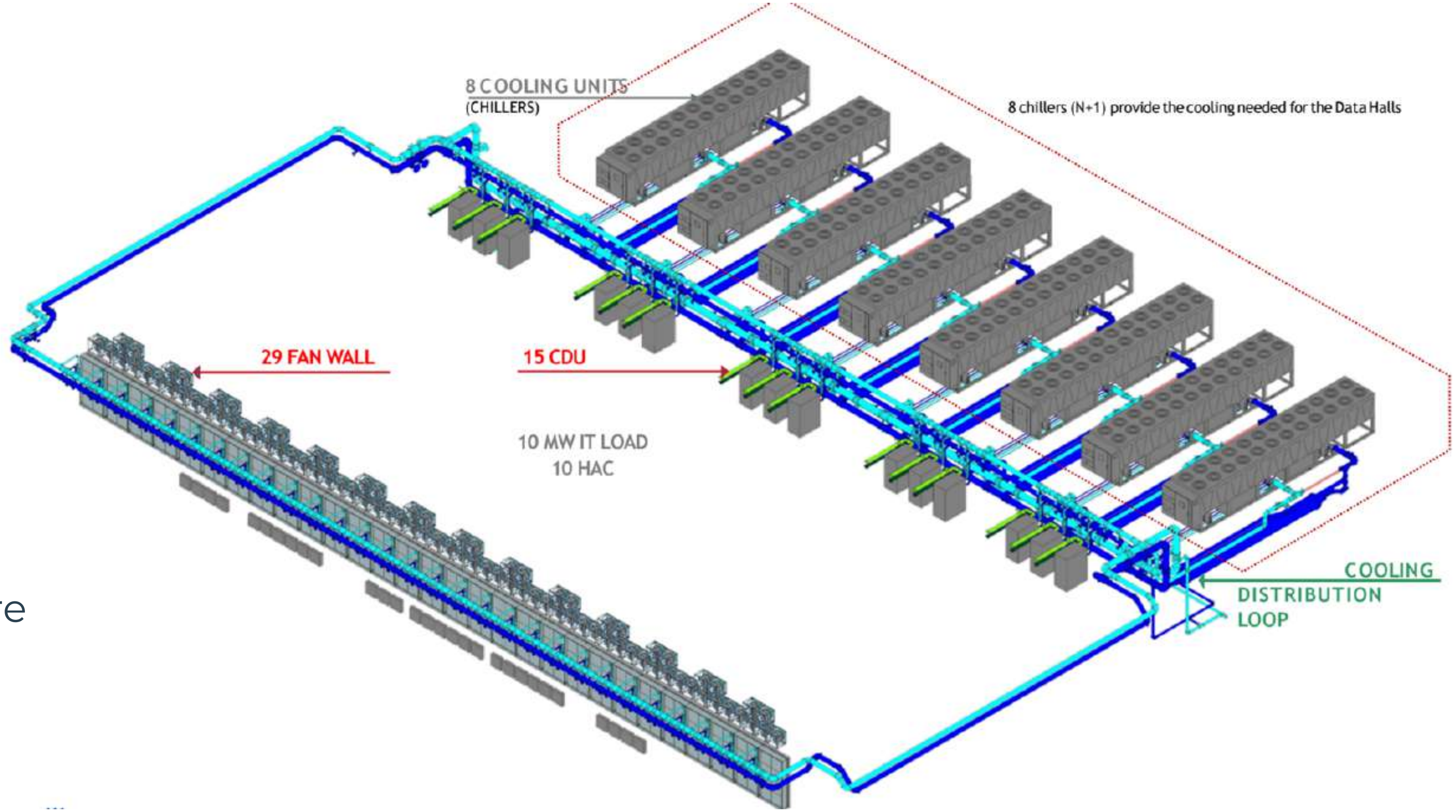
Cooling Distribution Units manage heat transfer

System Flow

Ensures efficient cooling distribution

Temperature Control

Maintains optimal operating conditions



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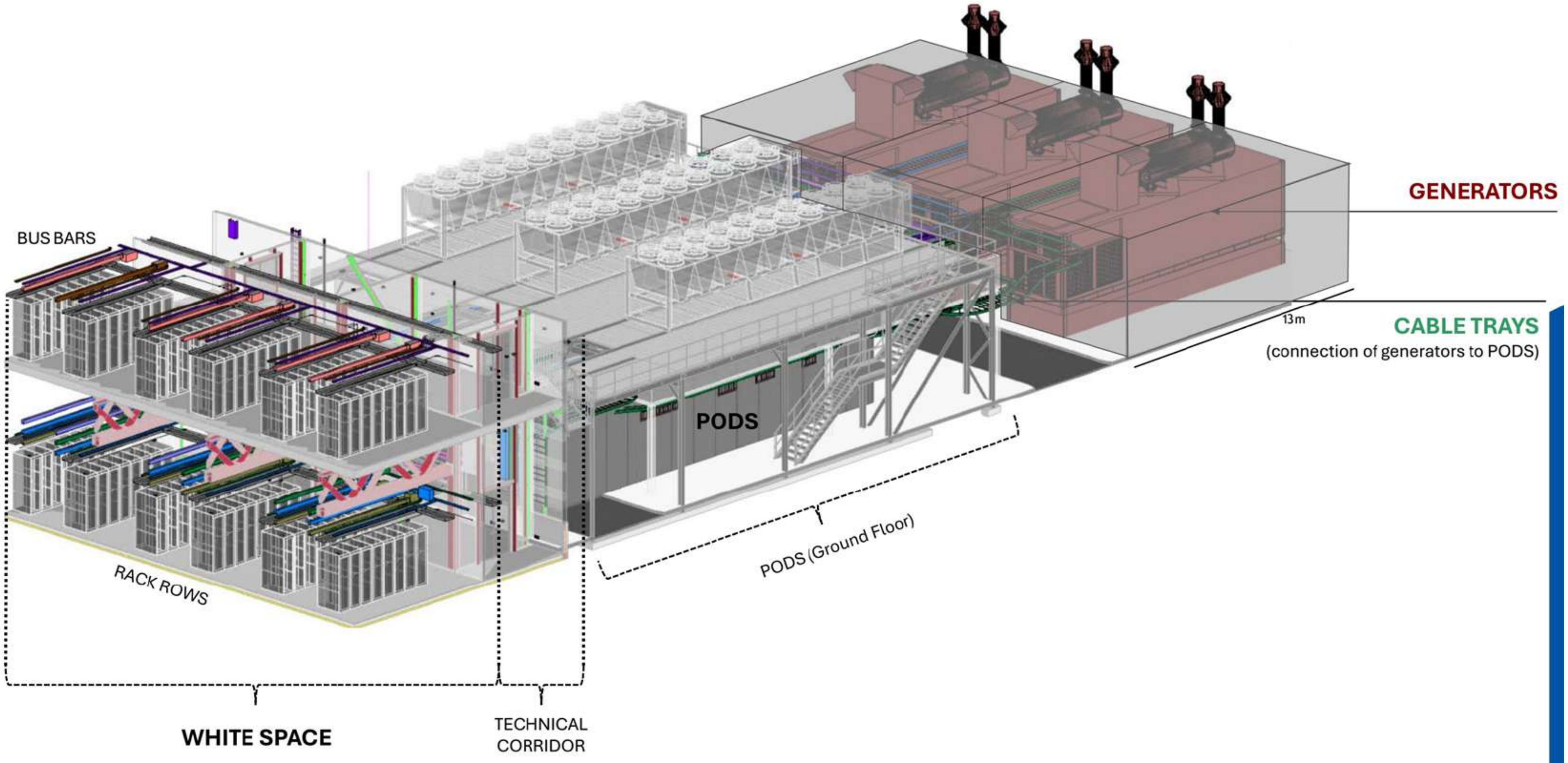
ELECTRICAL – Power Supply System Diagram
CONNECTION OF GENERATORS TO PODs & PODs to DATA HALL



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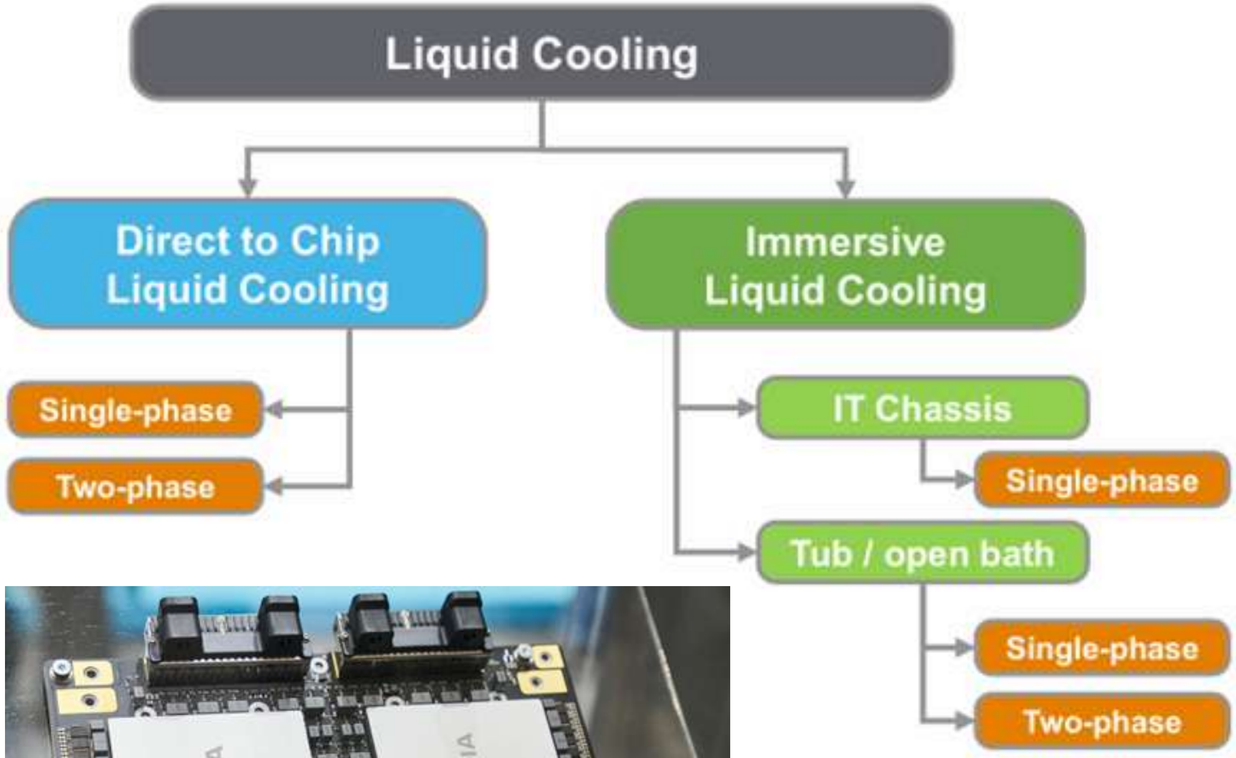
Direct Liquid Cooling (DLC)



Choosing the Suitable Cooling Approaches

The selection of the suitable system is based on

- Heat load per rack (kW/rack)
- TCO (total cost of ownership)
- Energy efficiency goals (PUE target)
- Space and infrastructure limits
- Sustainability and water use

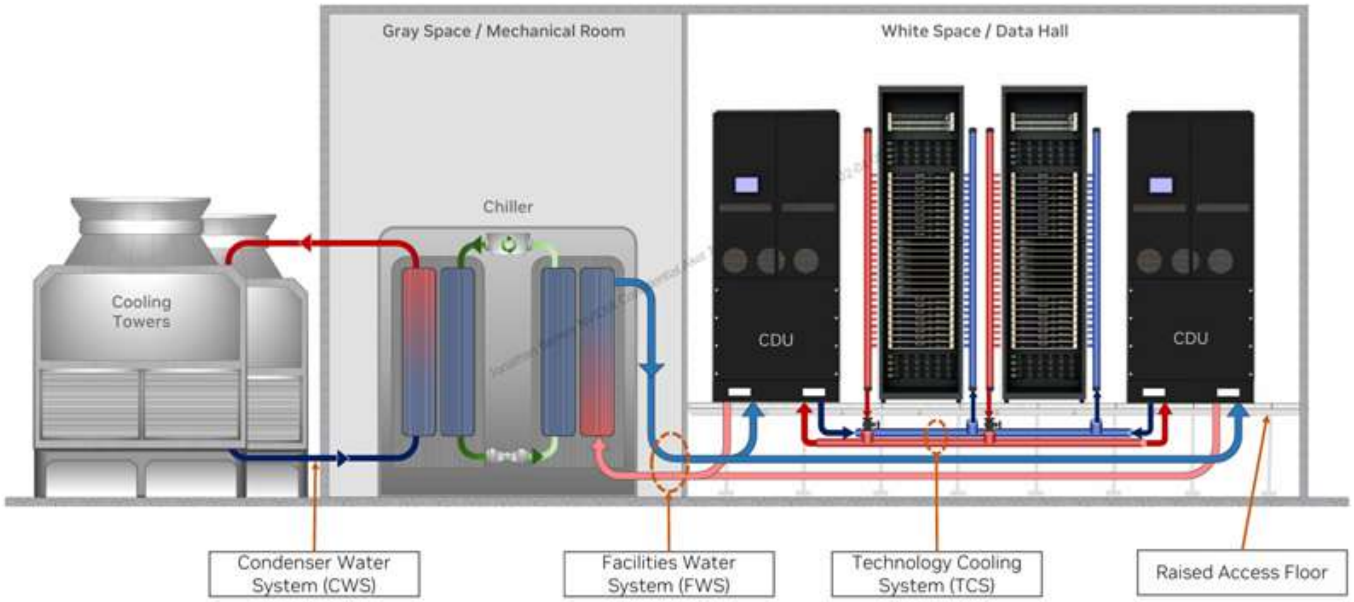
Direct Liquid Cooling (DLC)

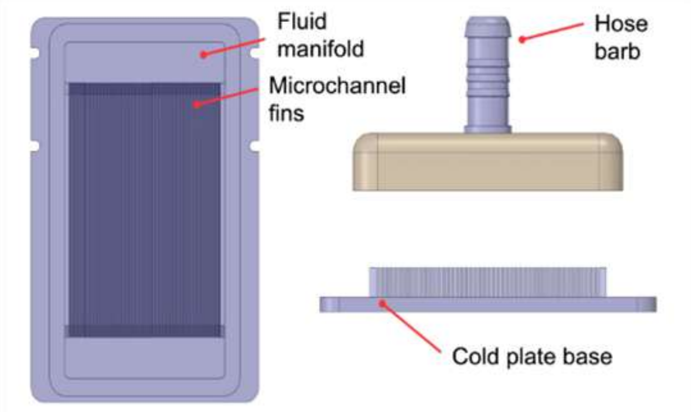
Single-phase Direct to Chip (D2C) Liquid Cooling

The coolant distribution units (CDU) supply secondary coolant to the IT and network hardware cold plates.

The coolant absorbs the heat generated by the chips.

The heated secondary coolant is returned to the CDU which performs as heat exchanger with the facility cooling water (primary coolant).





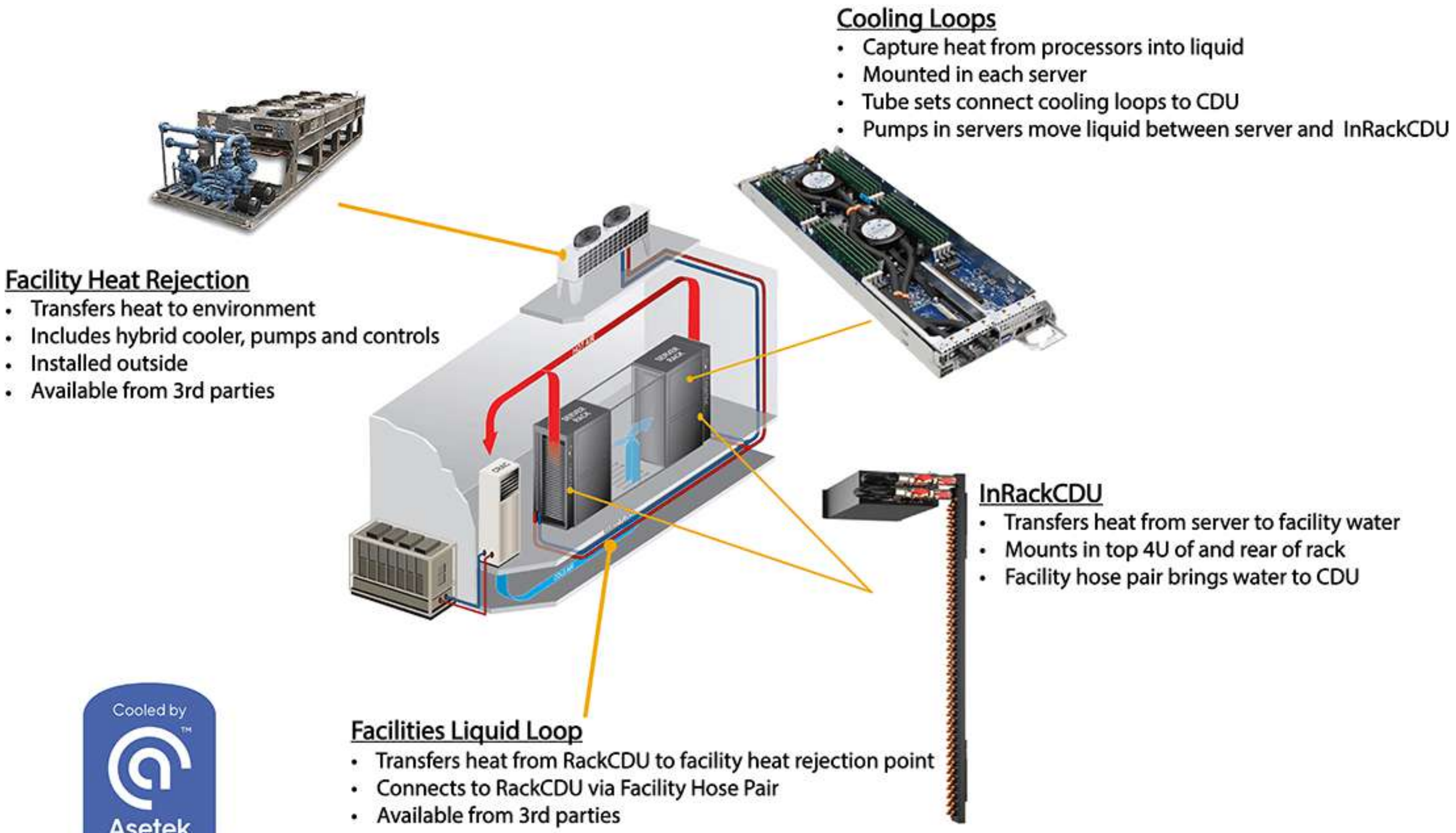
Direct Liquid Cooling (DLC)

Two-phase Direct to Chip (D2C) Liquid Cooling

Two-phase requires cold plates that allow for controlled boiling, not just heat exchange.

Two-phase loops may require vapor and liquid lines, vs single-loop in single-phase. A condenser to return vapor to liquid is needed.

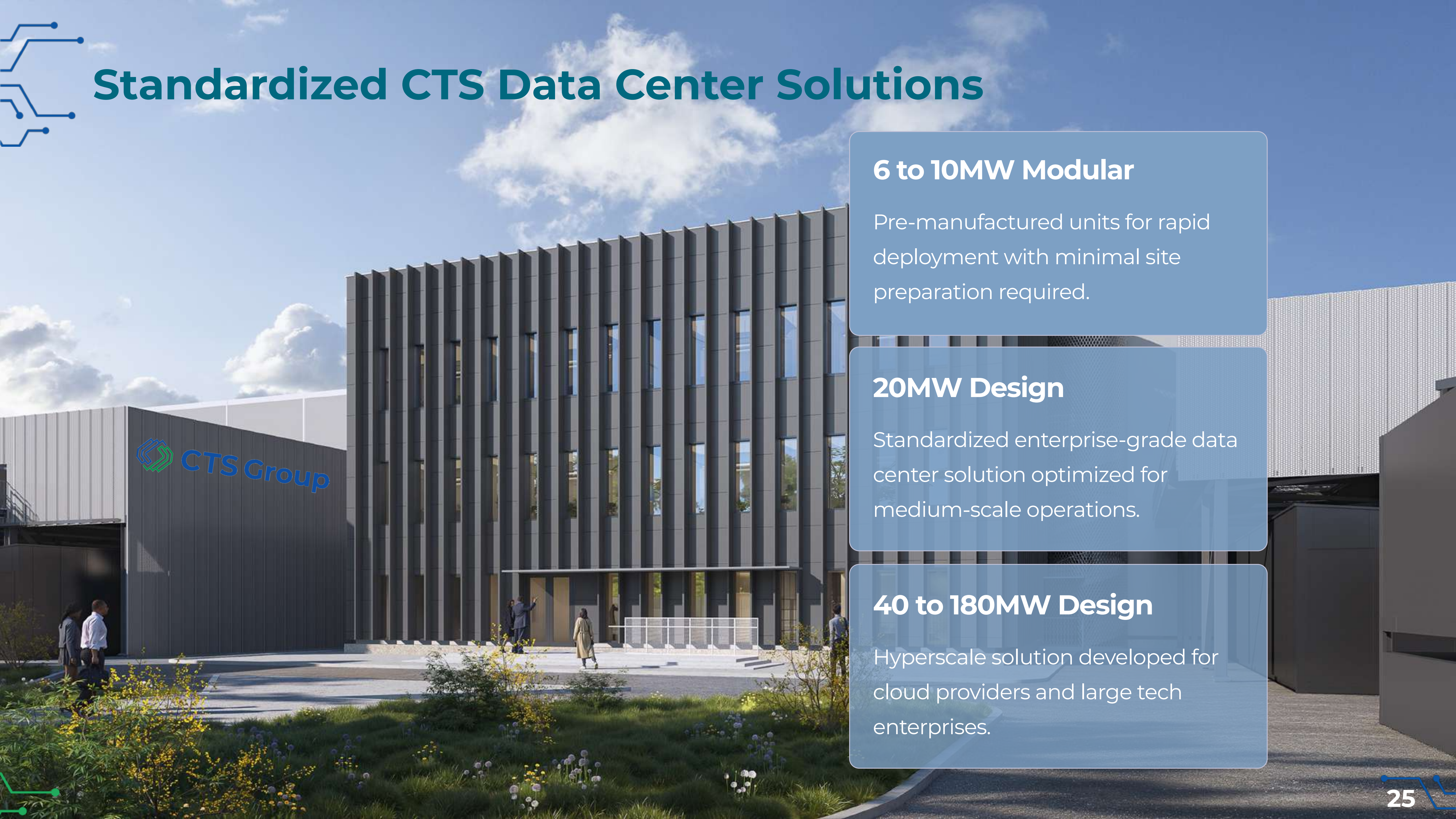
Vapor generation introduces higher and variable pressures that must be carefully managed.



Cooled by™ Asetek

Cooling Method	Type	Mechanism/Working principle	Pros	Cons	Use Case
Superfluid Cooling (e.g., Liquid Helium)	Superfluid / Cryogenic	Superfluid helium absorbs heat with zero viscosity and achieves near-zero temps	Near-zero resistance, ultra-efficient at near-absolute zero, best thermal conductivity	Extremely costly, complex infrastructure, still science fiction and not practical for most data centers	Quantum computing, research facilities, extreme environments
Laser Cooling	Optical / Photonic	Uses tuned lasers to cool particles (via anti-Stokes fluorescence). Photons reduce atom kinetic energy via anti-Stokes fluorescence	No moving parts, silent, theoretical ultra-precision	Experimental, not yet scalable, not viable for large-scale / macro systems or general computing yet	Quantum tech, research labs, nanoscale / atomic-scale systems
Thermoelectric (Peltier)	Solid-state	Voltage applied to semiconductor plates creates cooling	No moving parts, precise spot cooling	Inefficient at scale, adds heat to surroundings	Component-level cooling, IoT devices
Phase Change Material (PCM)	Passive	Absorbs heat during melting, releases it during solidification	Passive, no power needed, short-term heat buffering	Limited capacity, not continuous cooling	Emergency backup, hybrid with other systems

Standardized CTS Data Center Solutions



6 to 10MW Modular

Pre-manufactured units for rapid deployment with minimal site preparation required.

20MW Design

Standardized enterprise-grade data center solution optimized for medium-scale operations.

40 to 180MW Design

Hyperscale solution developed for cloud providers and large tech enterprises.

Implementation of New Technologies to meet AI Demand

To meet the growing demand of AI we need to be at the leading edge of Technology

CTS Group is leading the way in the DC environment thru early adoption of technology by ensuring we understand what is available on the market and how effective this technology can be to help to deliver Faster, Better and Cheaper Design and Build data centers

CTS invests heavily its retained earnings to ensure we are providing the highest-quality product within the shortest period of time, to the highest standard.

Time to Market is Client Critical

Implementation of New Technologies

Concept Design → Execution Design → Production Pre-Fabrication → Execution/Build → Testing & Balancing + Commissioning → Operations

CTS Nordics

Concept Developed in CTS Nordics HQ
Oslo - Revit

BIMMS integrated engineering

BIM models creation for analysis, evaluation and simulations

- Integrated Database
- Calculations
- BIM / Revit
- List of Material

100% Digital, easy to interact and flexible

100% Clash free, improve and redefficiencyuce costs

Design

Unique database for documents, 3D models, specifications, costs.
Automated production of
- BoD
- BoQ
- Drawings
- Submittals

Real Time model update

Execution

Staying on-schedule and on-budget using 3D quality recognition and project controls.

Real-time understanding of the schedule

Onsite accuracy and daily progress by 3D visualization

Production

Prefab components, Data will be integrated in the production plan and execution

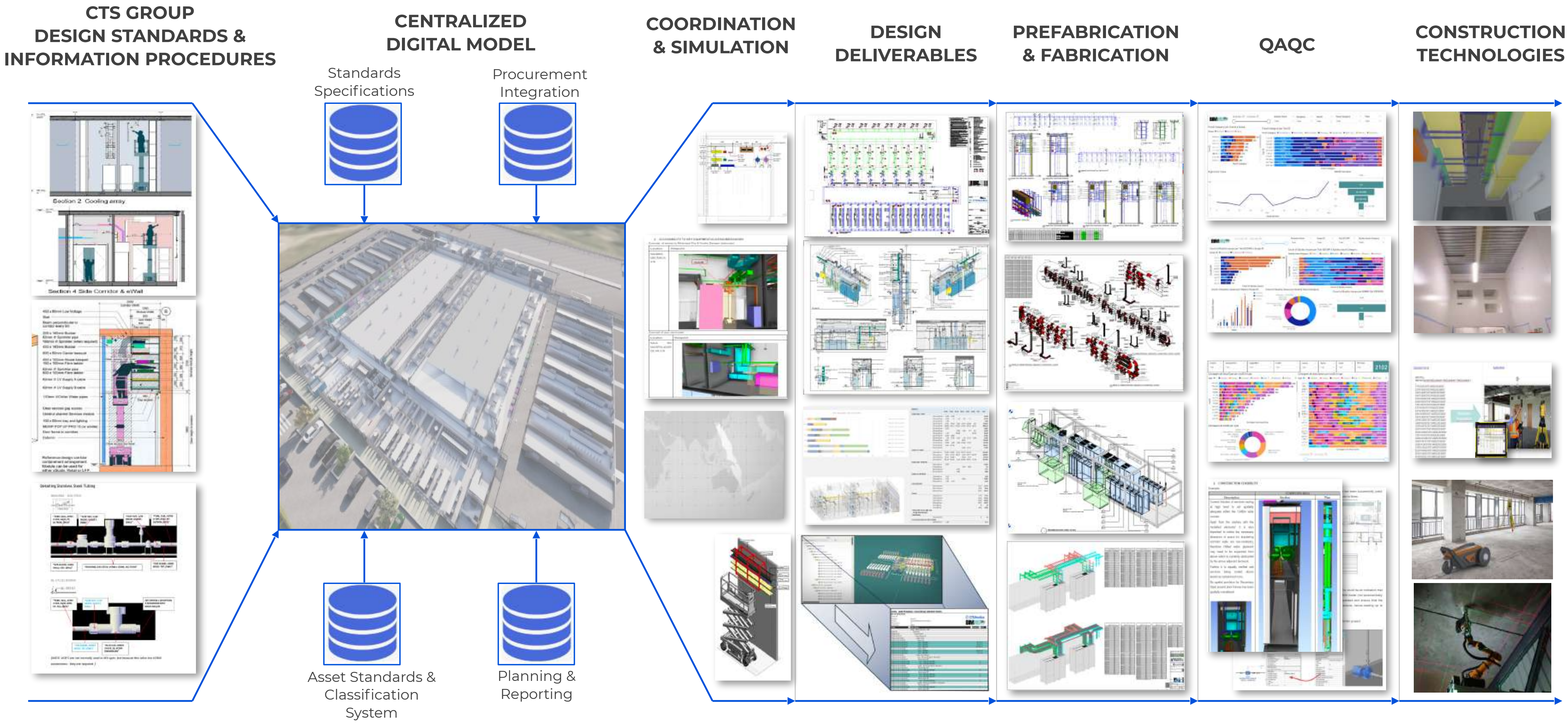
Software integration for all disciplines
- Eplan for electrical
- BFS for logistics
- Naviate for civil

Operation

Fully integrated platforms:
- PMS
- BMS
- CMMS
- Security
- Fire Detection

Central Control Room, optimizing the operation of different Data Centers.

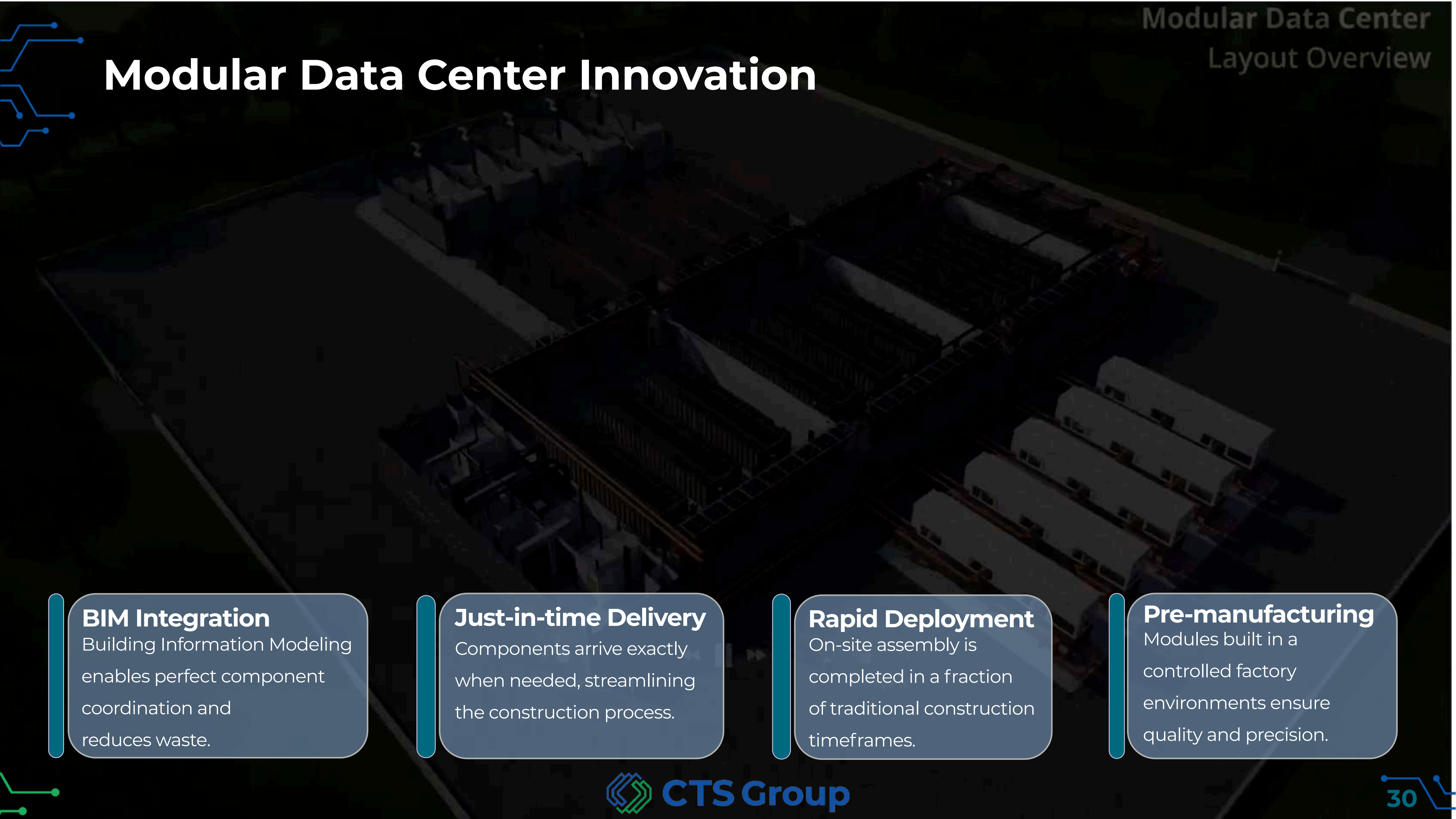
Design – Use of Digitalization and Technology



CTS Group Modular Design

- Ironically, AI itself is also being used to enhance the sustainability of data centers.
- AI algorithms can optimize power usage, cooling systems, and workload distribution, significantly reducing energy consumption.
- The rise of modular and edge data centers offers a more sustainable alternative by localizing computational resources, reducing the need for extensive energy use in centralized facilities.
- CTS Group has developed a CTS Modular 6 and 10 MW RDDC range, shipped within six weeks of order and delivered containerized for JIT Assembly.

Modular Data Center Innovation



BIM Integration
Building Information Modeling enables perfect component coordination and reduces waste.

Just-in-time Delivery
Components arrive exactly when needed, streamlining the construction process.

Rapid Deployment
On-site assembly is completed in a fraction of traditional construction timeframes.

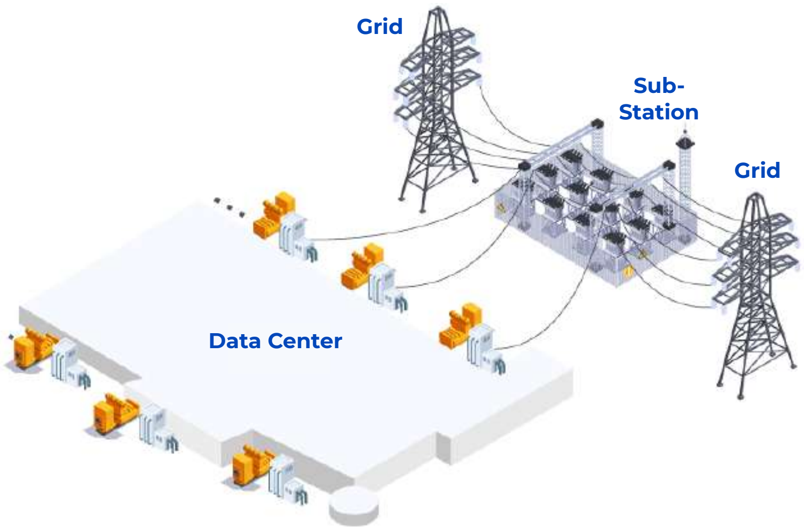
Pre-manufacturing
Modules built in a controlled factory environments ensure quality and precision.

On-Site Power Generation

CTS NextGen DC

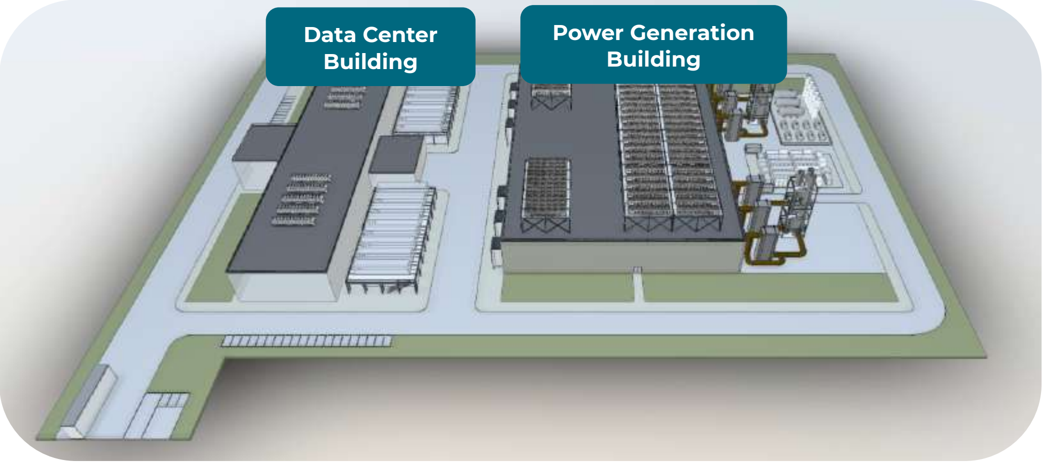
Current situation

- **Data Centers connected to the grid**



Our Solution

- **Modular On-Site Power Generation**

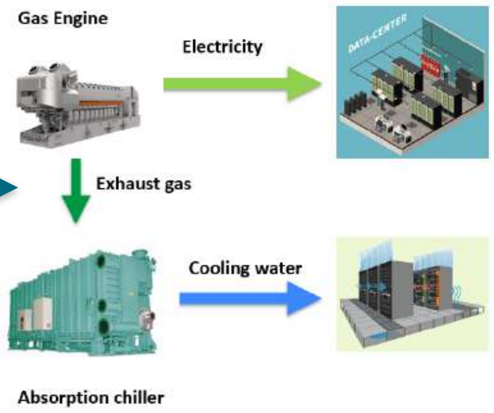


Key information

- Land plot ± > 200 MW
- With ± 20 to 30 MW backup power – Diesel Generators
- It takes more than two years to have the data center in operation

Advantages

- Data Center is RFS ready in one year
- Increase land value by providing power generation capacity
- No investment in diesel generators is required
- Cost savings through modular solutions
- Rely on proven technology and trusted vendors
- **Dual benefit:** This solution integrates power and cooling with absorption chillers



On-Site Power Generation

Core challenges

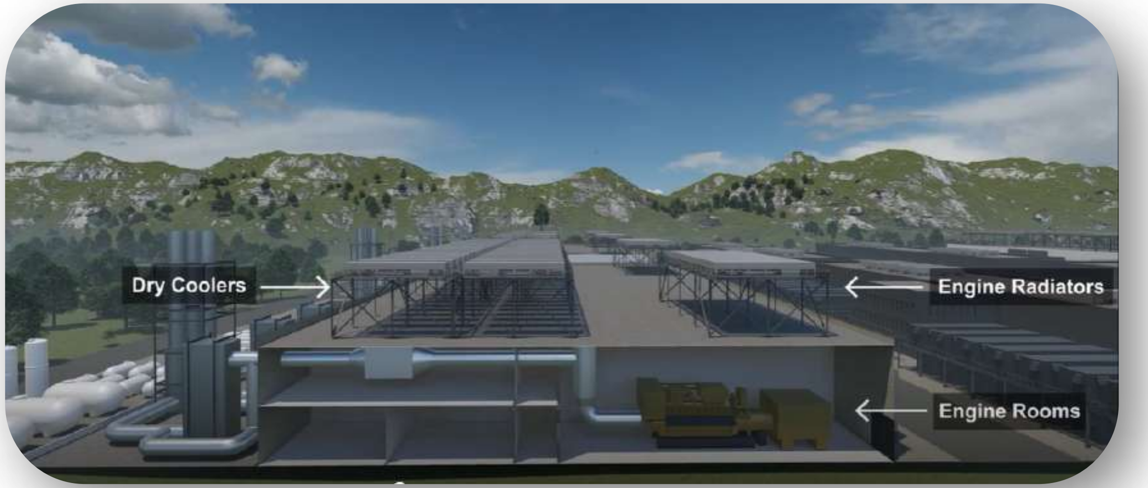
- Limitation on power grid capacity
- Competing power demands from other industries and communities
- Longer period for having power available (grid connection) – 3 to 6 years

Impact on Data Centers

- Delays in construction due to insufficient power infrastructure
- Increased operational costs as centers shift to alternative energy sources

Solution

- **Integrated Modular Power and Cooling System for Data Centers**



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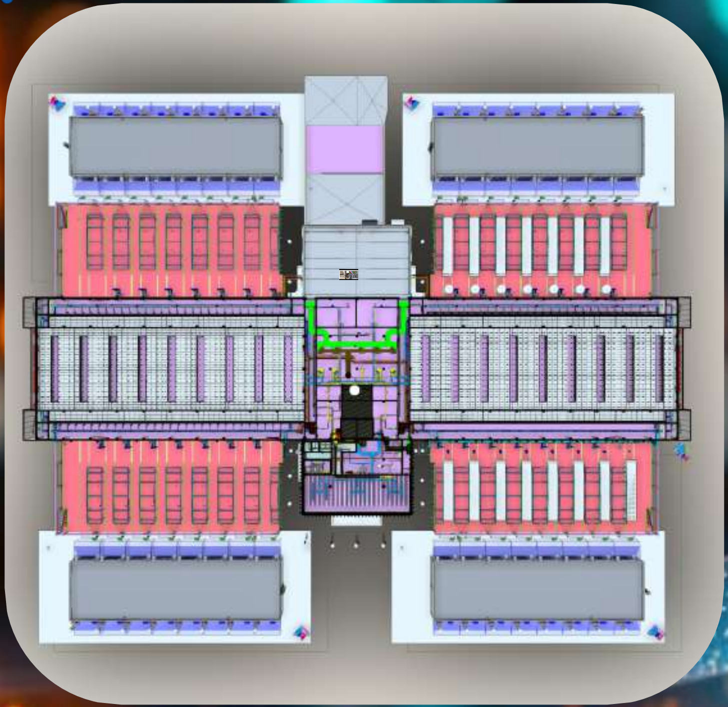
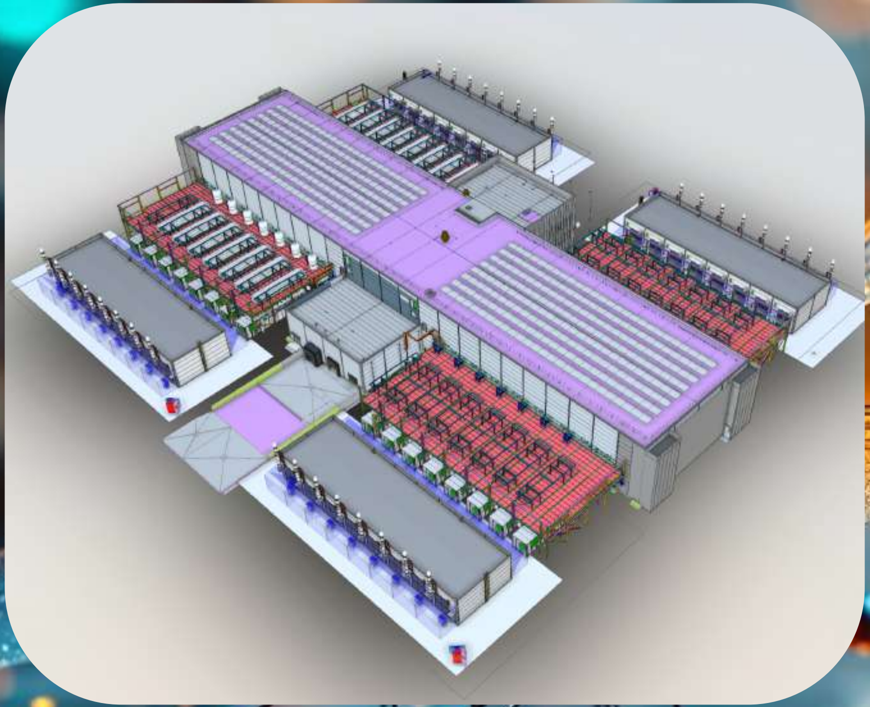
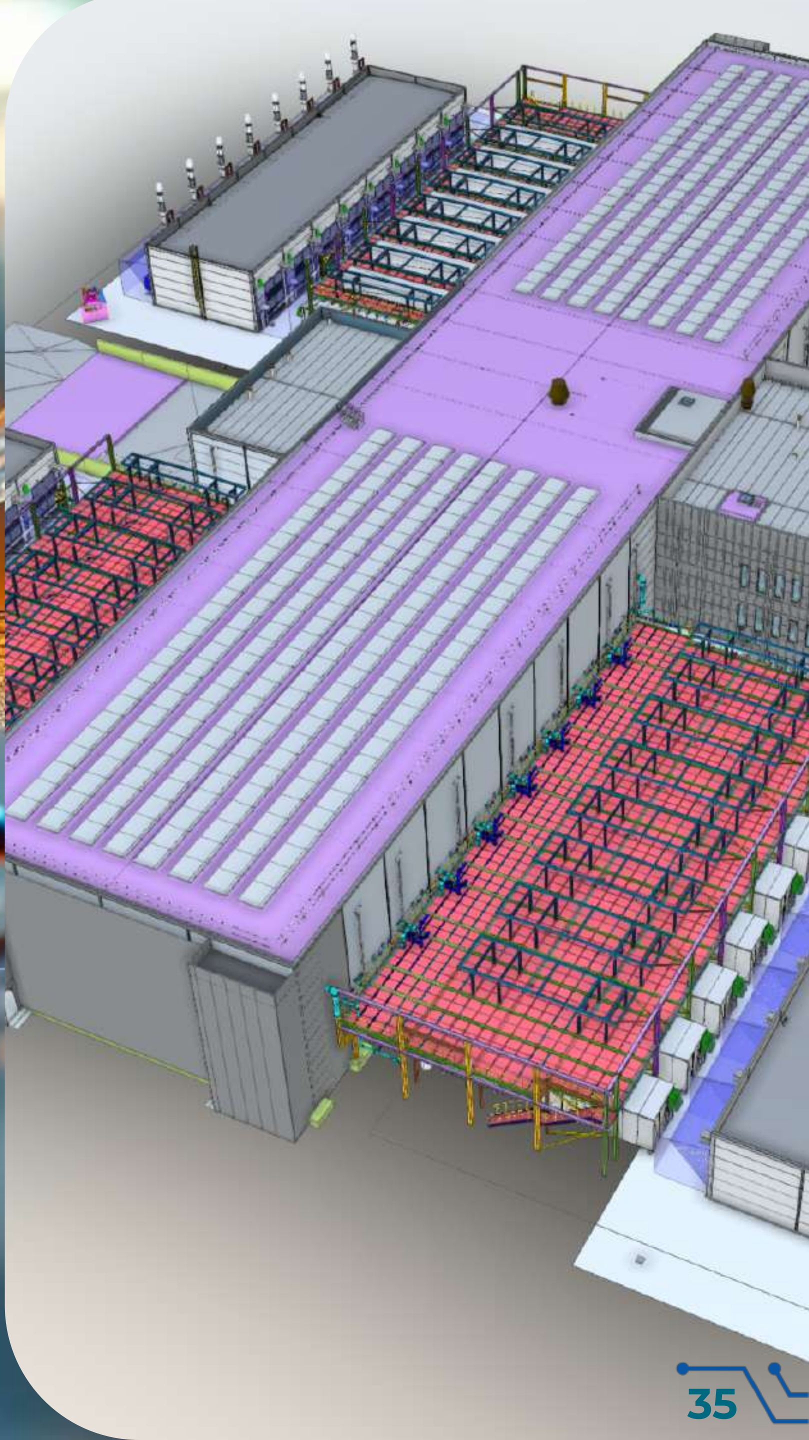
CTS Dragonfly DC

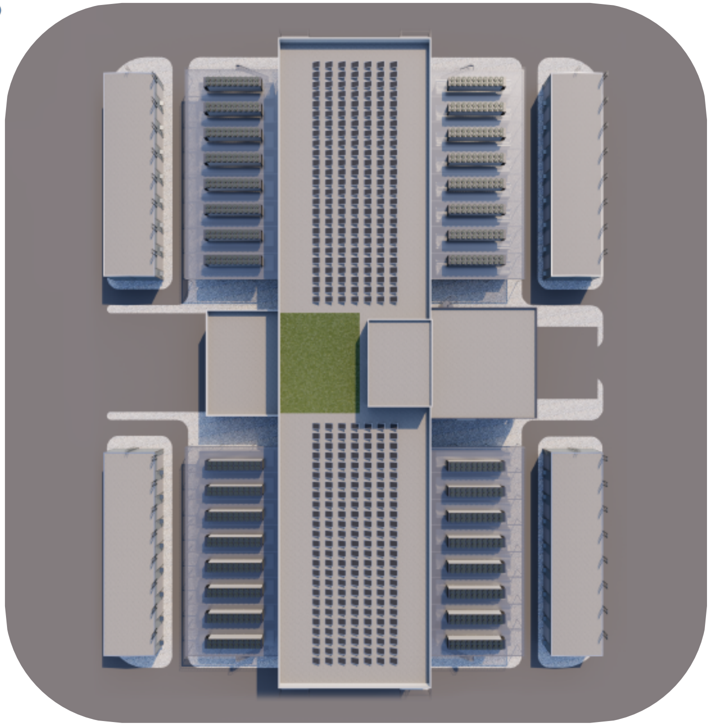
CTS Dragonfly DC

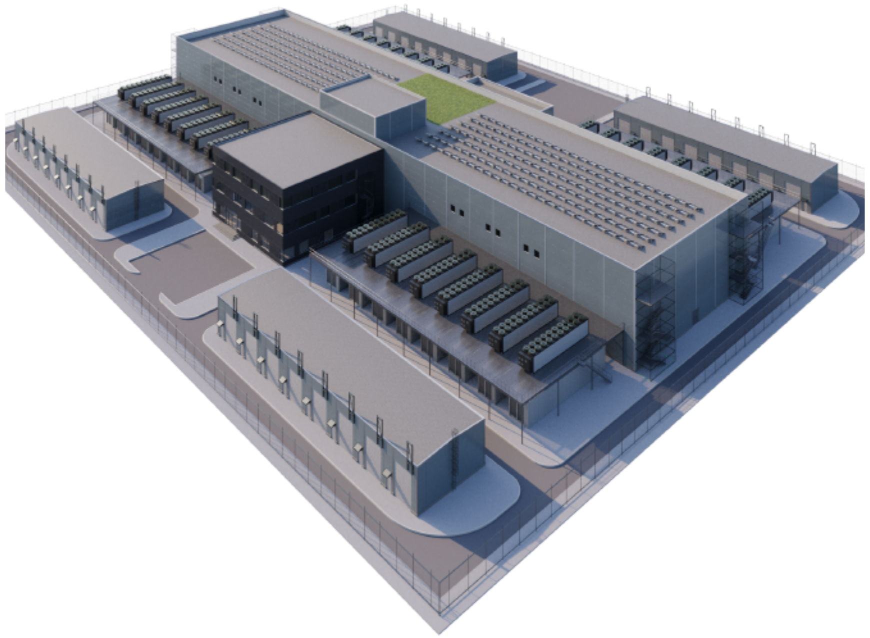


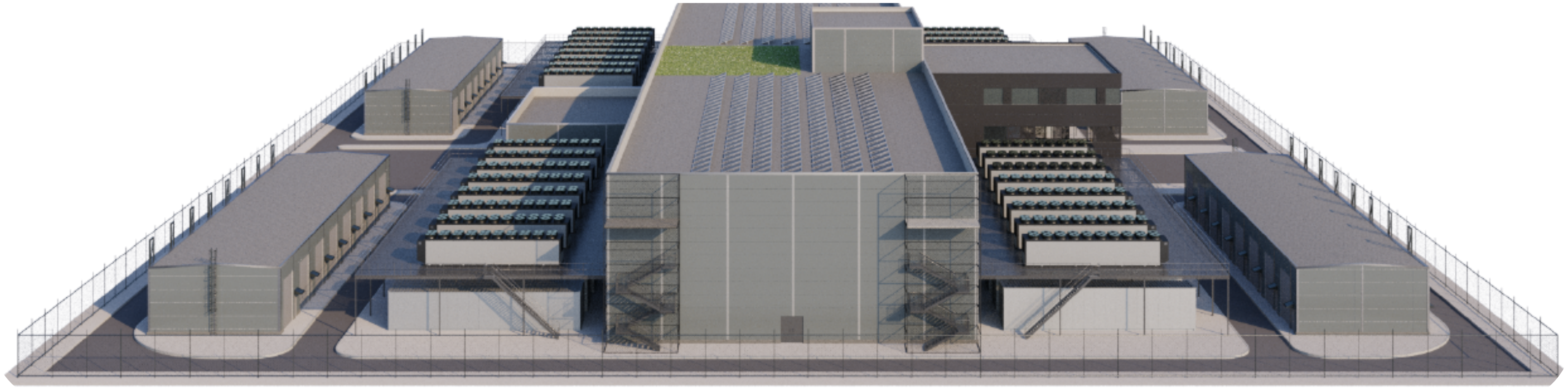




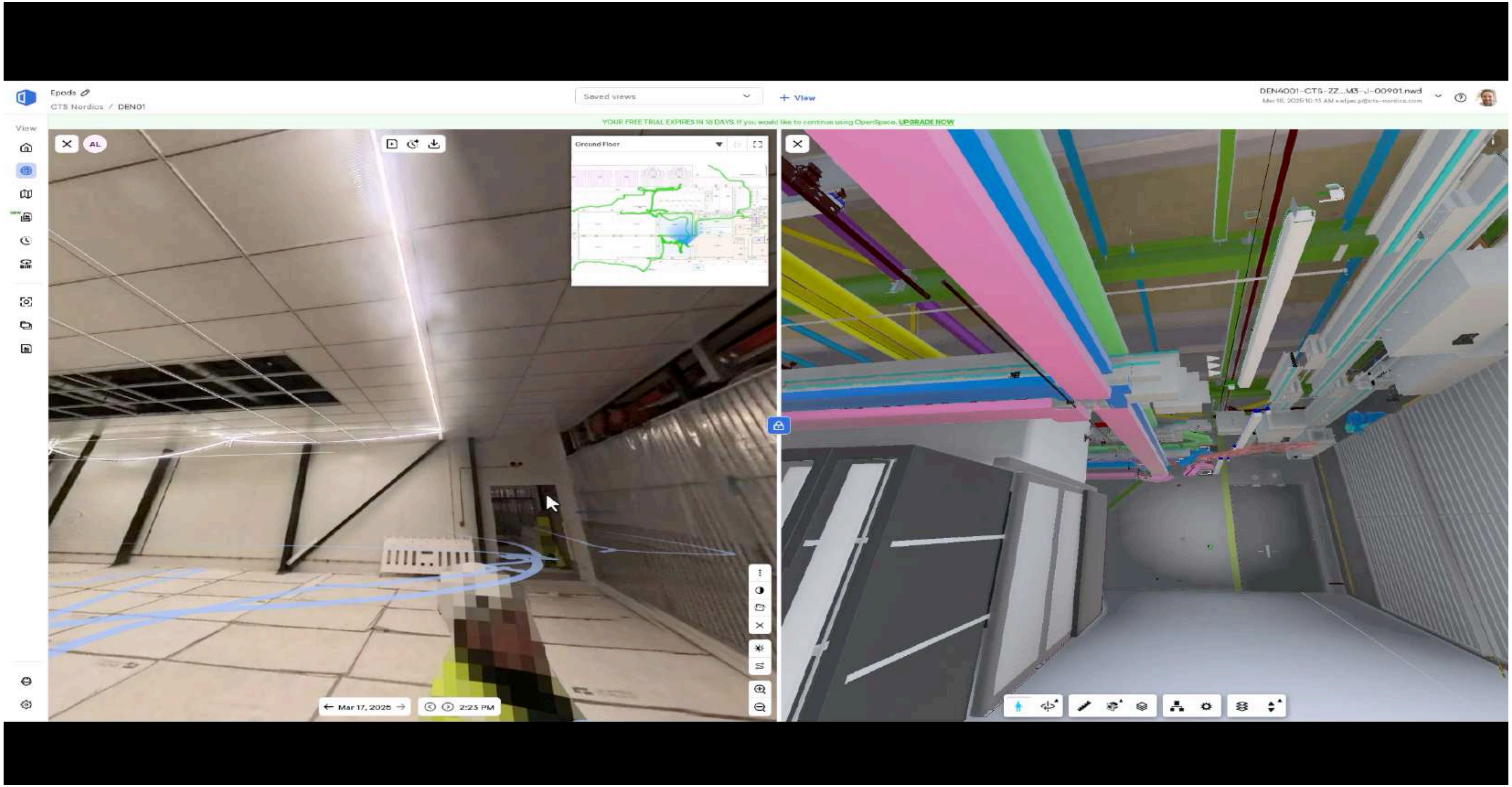
CTS Dragonfly DC - 40 MW







DEN01 OPEN SPACE CTS PROJECT IN DANMARK



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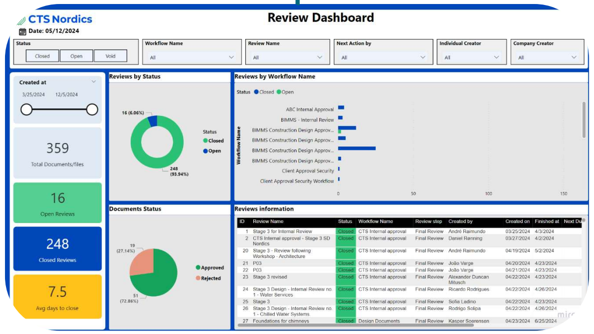
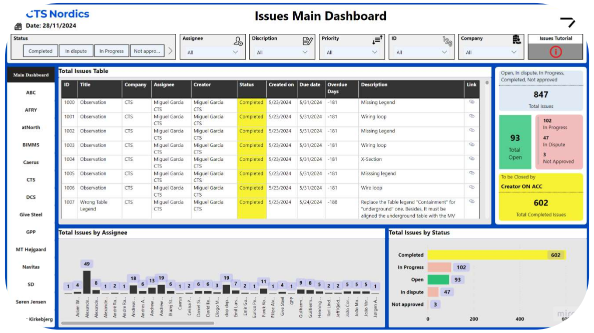
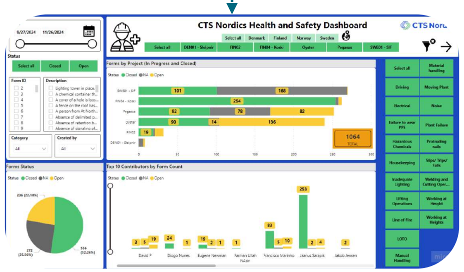
Build

Data visualization

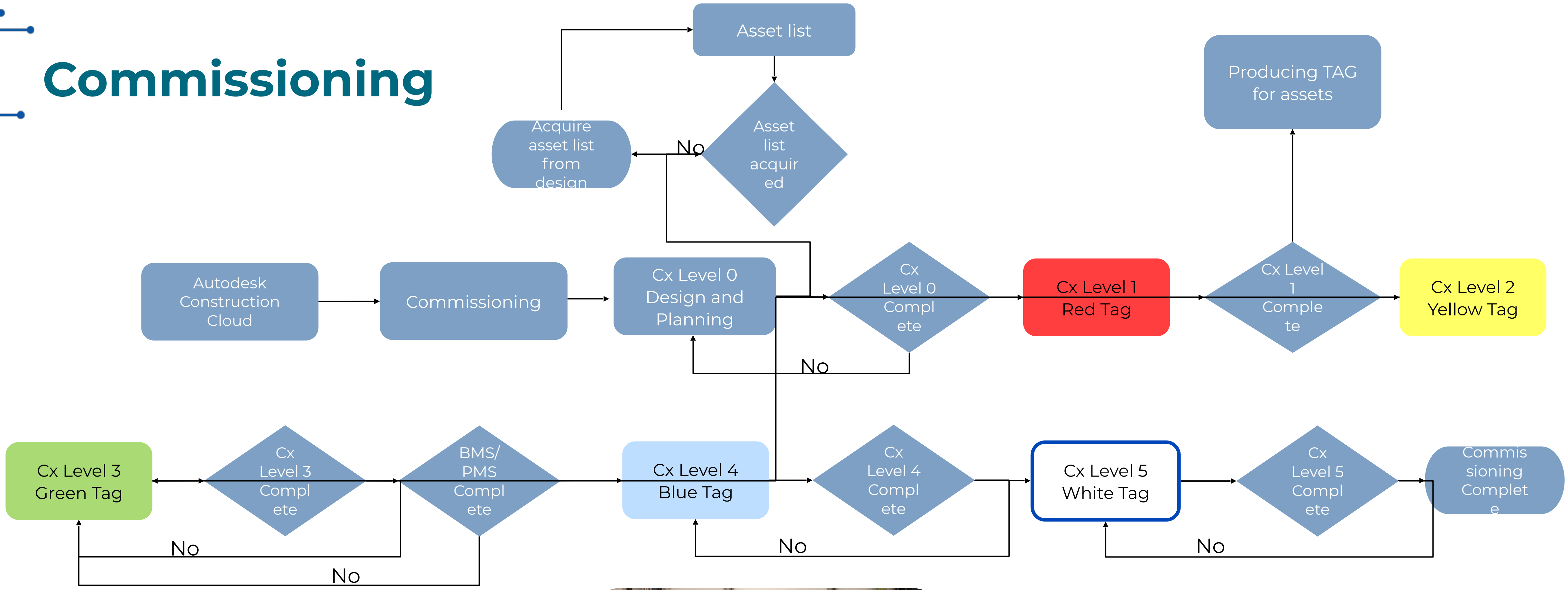




Approved IFC Drawings	Collections	Collections of IFC drawing's-based discipline or other
Sheets	To view drawings	
Red marking	Combination of markups and As-Build issue type	
QA checklists	Using forms	
RFI	Request for information from stakeholders	
Commissioning	Using forms and assets	
Issue reporting from the site	Doing stuff	
HSE and incident reports	Protection round	



Commissioning



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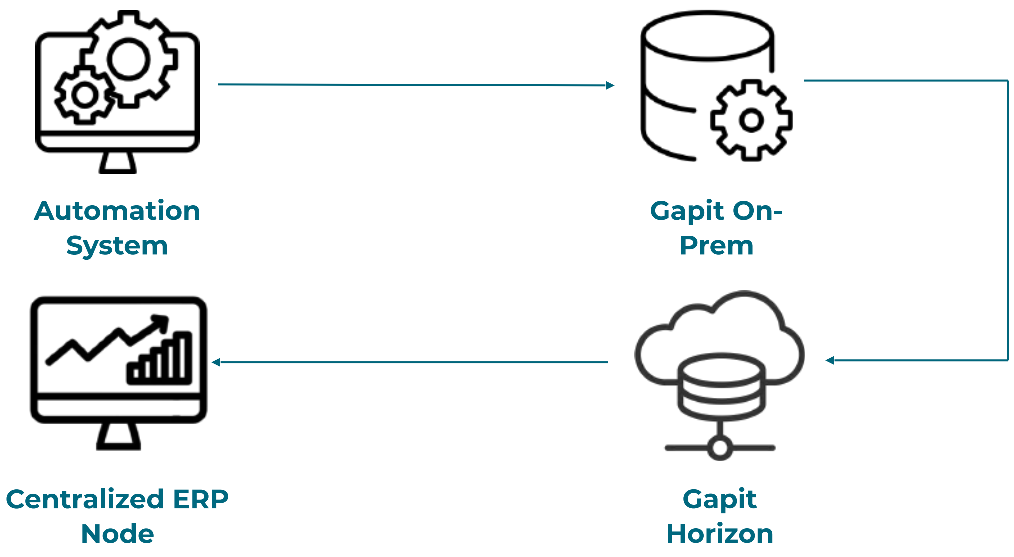
Centralized Control Room

ERGONOMICS COLLABORATION SECURITY
MONITORING AUTOMATION INCIDENT
RESPONSE
AI-DRIVEN INTEGRATION FUNCTIONALITY PERFORMANCE
RELIABILITY REDUNDANCY SCALABILITY **NOC**
DATA CENTERS NETWORK OPERATIONS CENTER
COMMAND CENTER **REMOTE MANAGEMENT**
REAL-TIME MONITORING
CLOUD-FIRST INFRASTRUCTURE PREDICTIVE
MAINTENANCE **SOC** ENERGY OPTIMIZATION
TRUSTED PARTNER SEAMLESS CONNECTIVITY
DASHBOARDS ALERTING SYSTEMS VISUALIZATION
VIDEO

Digitalization and Passport

The need for Data Center Digitalization is for the transformation of traditional data centers into more efficient, scalable, and flexible environments by adopting digital technologies.



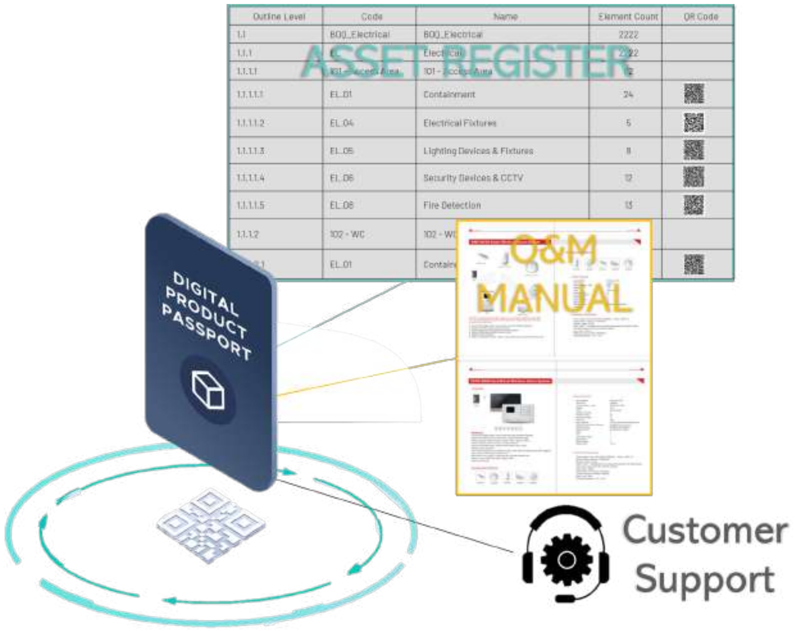
Key Aspects

1. Virtualization
2. Automation
3. Cloud integration
4. Edge Computing
5. Sustainability

Key Benefits

- Enhanced data-driven decision making
- Cost savings
- Enhanced security
- Fast deployment and innovation
- Improved reliability

A Data Center Passport is a conceptual or practical framework for maintaining detailed documentation, monitoring, and compliance tracking in data centers. It provides an organized system for documenting the lifecycle of a data center's assets, processes, and operations.



Key Aspects

1. Asset inventory
2. Operational documentation
3. Compliance and certifications
4. Access and security logs
5. Network topology
6. Lifecycle management

Key Benefits

- Improved efficiency
- Enhanced Security
- Compliance readiness
- Sustainability goals
- Risk management

The Future of AI Data Centers

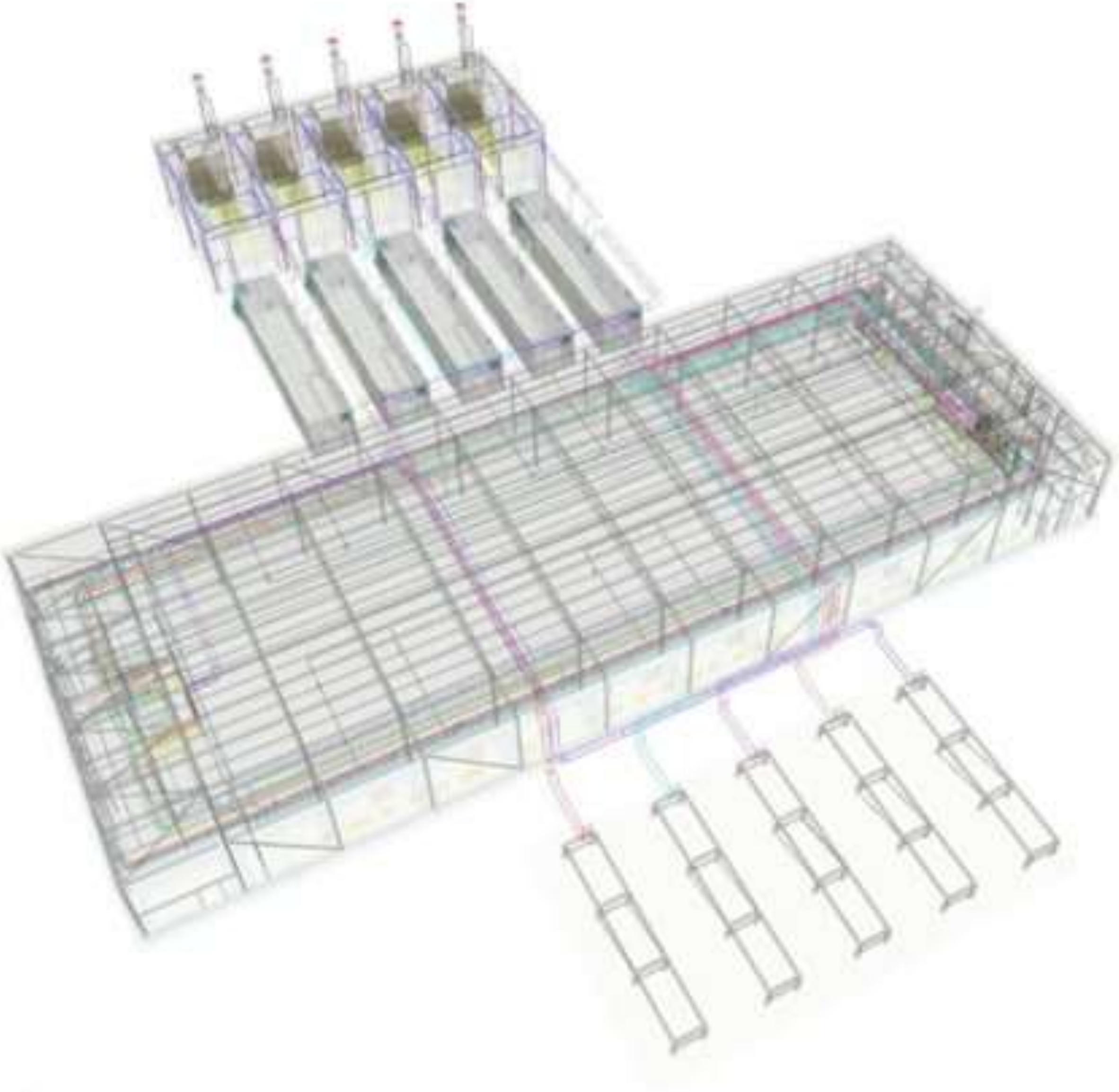
The role of AI data centers will continue to grow as AI applications become more complex and widespread.

Here's what we can expect moving forward:

- **Increased Automation:** Soon, AI will further manage and optimize data center operations, improving efficiency and reducing downtime.
- **Hybrid Models:** The integration of on-premises and cloud-based AI data centers will offer more flexibility and scalability.
- **Focus on Design and Engineering:** for Optimal Design Efficiency and Flexibility.
- **Focus on Sustainability:** Advances in renewable energy and energy-efficient technologies will make AI data centers more eco-friendly, reducing their environmental impact.

CTS Group - Exceeding the AI Sustainable Challenge

- Implementation a complete Sustainability and Environmental Division in 2024
- CTS commenced with all new projects meeting LEED Compliance.
- New Target for 2025 is to Design and Build our Data Centers to meet **LEED Gold** as a Standard
- **CTS R&D Division** is working on the development of new Cooling Equipment, allowing to reduce the PUE below 1,14



CTS Group - Sustainability and Environmental Division Establishment

New Division

CTS Group has established a Sustainability and Environmental Division (CTS VDC Services) in its new office in Dublin, Ireland, providing leadership in both Sustainability and Environmental expertise.

Integration Timeline

Preliminary Sustainable measures have been drafted with sustainability integration programs scheduled for early 2025 to meet the objectives set by CTS Group executives.

Comprehensive Approach

The division will support all CTS Design, Production and Construction workflow, ensuring environmental considerations are integrated throughout the project lifecycle.

Sustainability

Corporate Sustainability

- Implementing a program for compliance with the Corporate Sustainability Reporting Directive – CSRD
- Developing inventory for Corporate Green House Gas emissions
- Developing a professional design for a sustainability strategy
- CTS Group is a corporate member of the Imasons Climate Accord (as of Feb 2025)

Operational Sustainability

Product

- Developing sustainability standards for high impact materials (Concrete and Steel)
- Developing Environmental Product Declaration for NORDIC EPOD.

Design

- Developing approaches for LEED Gold as minimum standard
- Developing a structured approach for sustainability in Design for non-building projects

Construction

- Standards set for LEED implementation during construction
  - IAQ testing
  - Waste management
  - Air quality management

Heat Reuse for Sustainable Food Production

Transforming Waste into Value: Heat Reuse from Data Centers for Sustainable Food Production

To create a sustainable future where data centers not only power the digital world but also contribute to feeding the planet. By repurposing waste heat, we can drive innovation, reduce environmental impact, and enhance global food security.

How it works?

- Recovery Systems for excess heat generated by data center servers.
- Recovered heat is used to maintain controlled environments for greenhouses, vertical farms, and aquaponics systems.
- Data centers and food production facilities can be co-located to form a sustainable and synergistic energy ecosystem.

Key Benefits

1. Energy Efficiency
2. Year-Round Food Production
3. Reduced Carbon Footprint
4. Resource Optimization
5. Urban Food Security

Real-World Potential

Vertical Tomato Farming

Breeding of Micro Algae

Breeding of Shrimps and Gambas

AI Data Centers – Meeting the Challange

- As artificial intelligence becomes the norm, these data centers will become vital to the operation of critical infrastructures.

- It's imperative that design, engineering, construction and operations stay ahead of the curve and grasp their significance so that you can navigate the future.

- **CTS Group** is meeting the *paradigm shift* head on to ensure that the rapidly advancing AI environment is accommodated.

Innovation & Excellence

THANK YOU!