

# Connecting Light, Data, Engineering & Intelligence: A Unified View of the Data Center

This presentation explores how data centers unite optical communications, engineering principles, and data science to power our digital world.

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# Optical vs. Electrical Communication: Foundation of Connectivity

## Optical Fiber (Light Pulse)

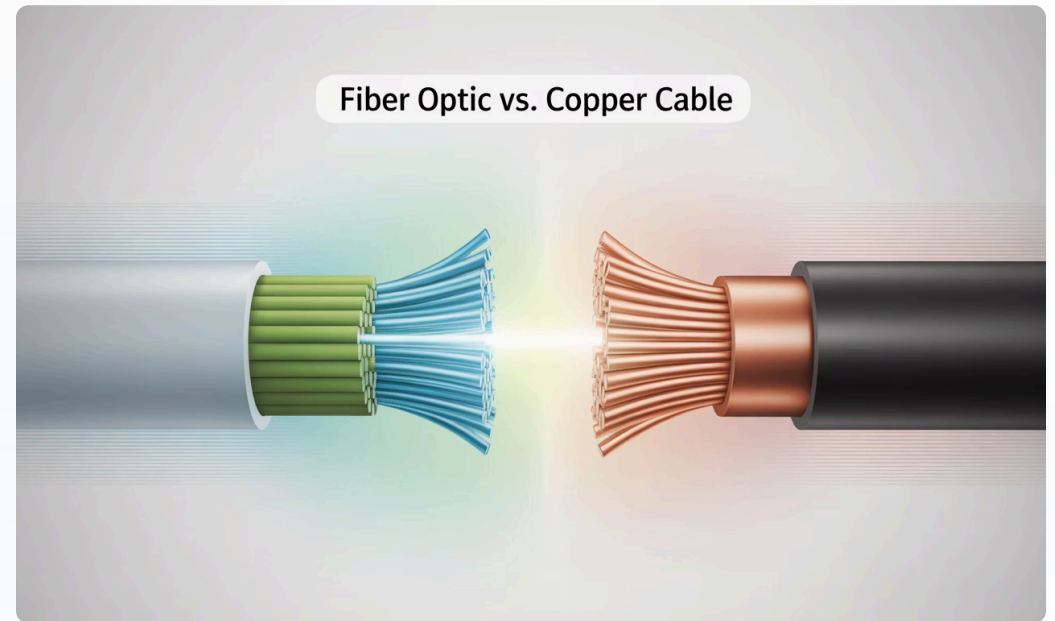
Transmits data via light. Offers high bandwidth and EMI immunity.

Speed:  $v = c/n \sim 2 \times 10^8$  m/s

## Electrical (Copper Cable)

Transmits electrons through copper. Cheaper for short distances.

Degrades with resistance:  $V = IR$



Optical used in backbone/distribution; Copper used in short-distance access layers.

# Light vs. Electricity: Data at the Speed of Innovation

Optical fiber uses light for high-speed, long-distance transmission.

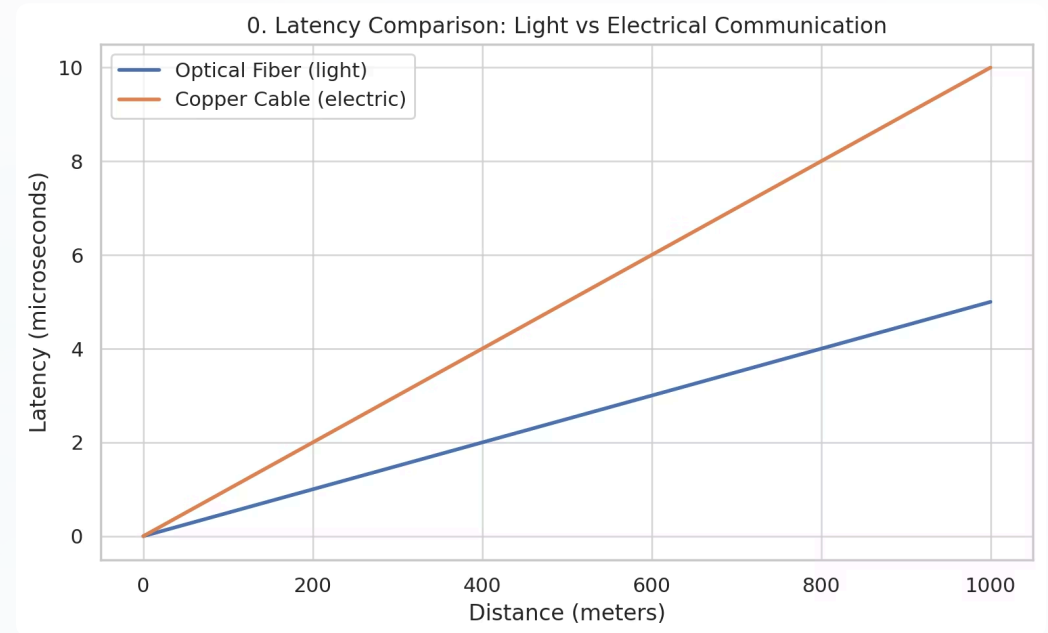
Copper cable uses electrons—lower cost, higher resistance.

## Fiber Formula

$$v = \frac{c}{n}$$

## Copper Degradation

$$V = IR$$



# What Powers the Cloud: Data Centers

## Computing Infrastructure

Centralized facility for computing, storage, and networking.



## Cloud Foundation

Hosts cloud infrastructure, enterprise apps, and AI workloads.



## Innovation Hub

Unites optical fiber, RF sensors, AI, and cloud technologies.



## Global Enabler

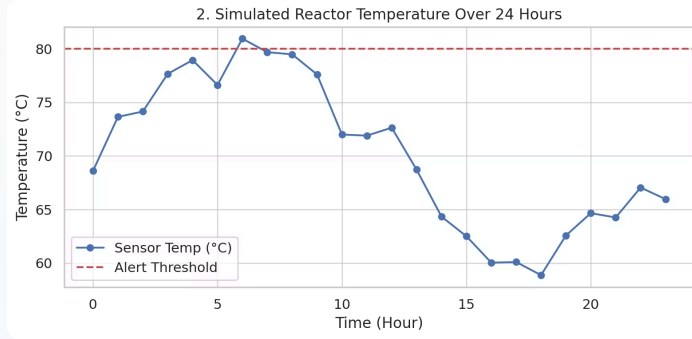
Powers internet, financial, military, and scientific systems.

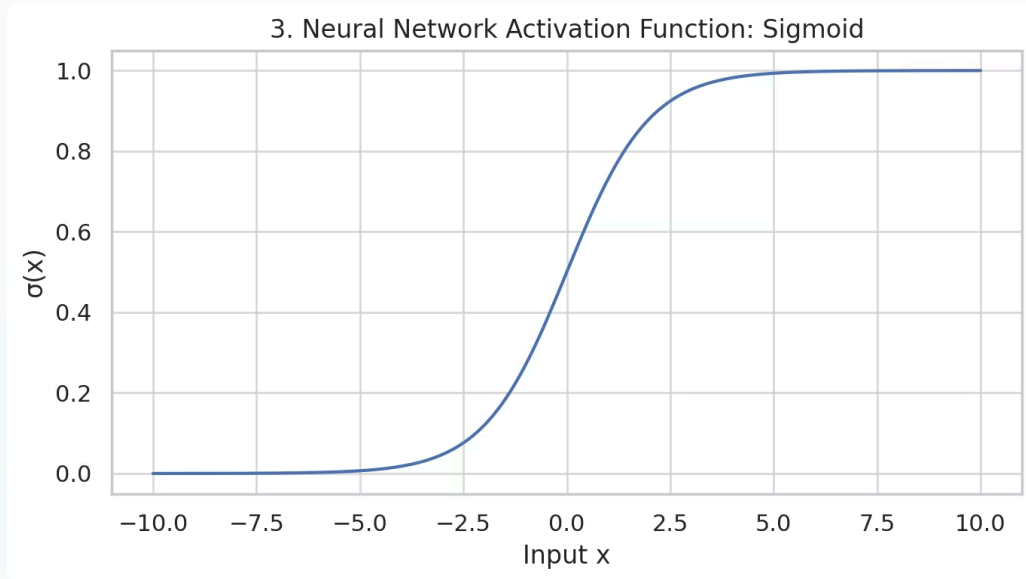


Chemical engineering principles fundamentally shape modern data centers:

- Heat transfer and thermodynamic principles govern cooling systems
- Fluid dynamics optimize airflow patterns across server racks
- Process control methodologies ensure stable operating conditions
- Energy balance calculations maximize power efficiency

The same engineering principles that optimize chemical plants now drive data center innovation and sustainability.





- Chemical engineering principles drive modern data center design
- Apply thermodynamics, fluid dynamics, and materials science
- Efficiently manage thermal loads and power distribution
- Engineering fundamentals optimize performance of facilities
- Enable effective operation of thousands of servers



# Chemical Engineering Meets Data Infrastructure



## IoT Sensors

Monitor temperature, flow, pressure in chemical plants.



## Data Transfer

Sent to cloud/data centers via fiber/RF for analysis.



## Smart Operations

Enables predictive maintenance and digital twins.

Digital Twin

Digital Twin

# Thermodynamics Inside the Rack

## Dew Point Control

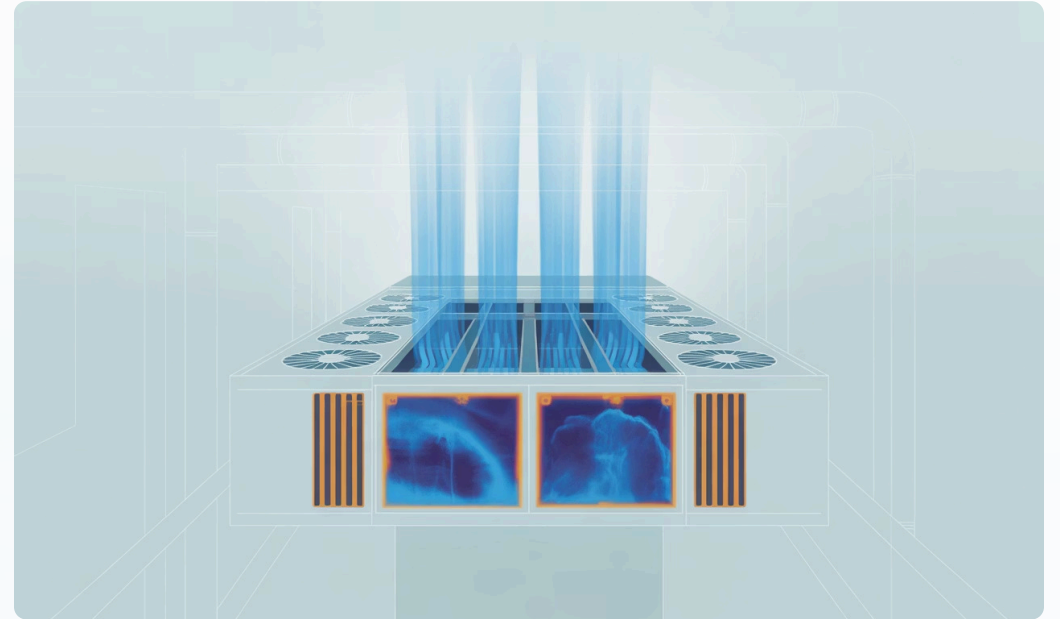
Affects corrosion and condensation in server environments.

## Airflow Engineering

Dry air & heat transfer dictate CRAC cooling efficiency.

## Energy Balance

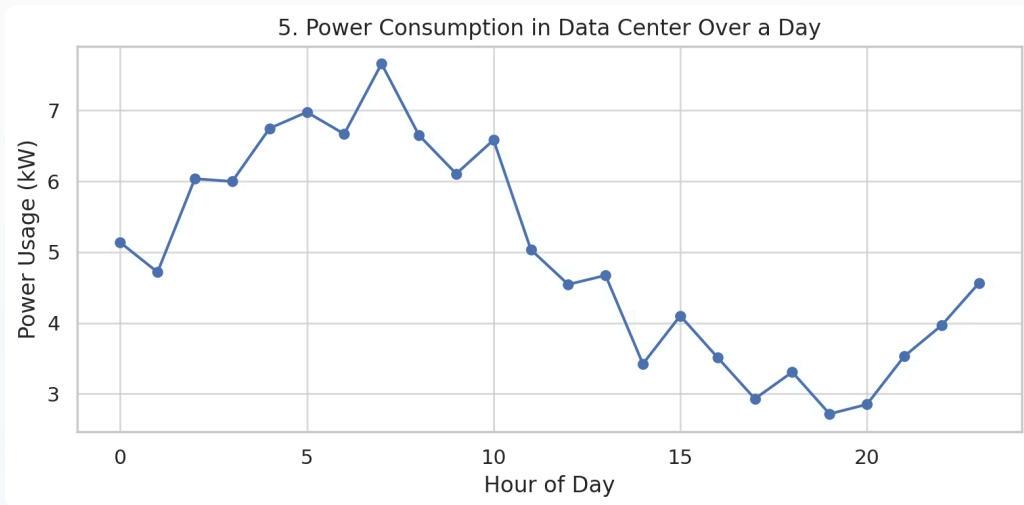
Linked to DC energy consumption and server uptime.





# The Wireless Evolution

- RF technology forms the backbone of modern data center connectivity
- Enables wireless communication between devices and systems
- Radio frequency signals transmit critical data at various wavelengths
- Creates an invisible network of information exchange throughout the facility
- Complements fiber optic backbones with greater flexibility
- Provides connectivity where physical connections are impractical
- Maintains high-speed data transmission necessary for today's computing demands



# The Wireless Bridge: RF + Data Center Synergy

RF sensors collect data wirelessly from remote/industrial sites.

Transmit to gateways, then to cloud/data centers for processing.

Signal power equation:

$$P_r = \frac{P_t G_t G_r \lambda^2}{(4\pi d)^2 L}$$



Critical in military, IoT, environmental, and industrial data acquisition.

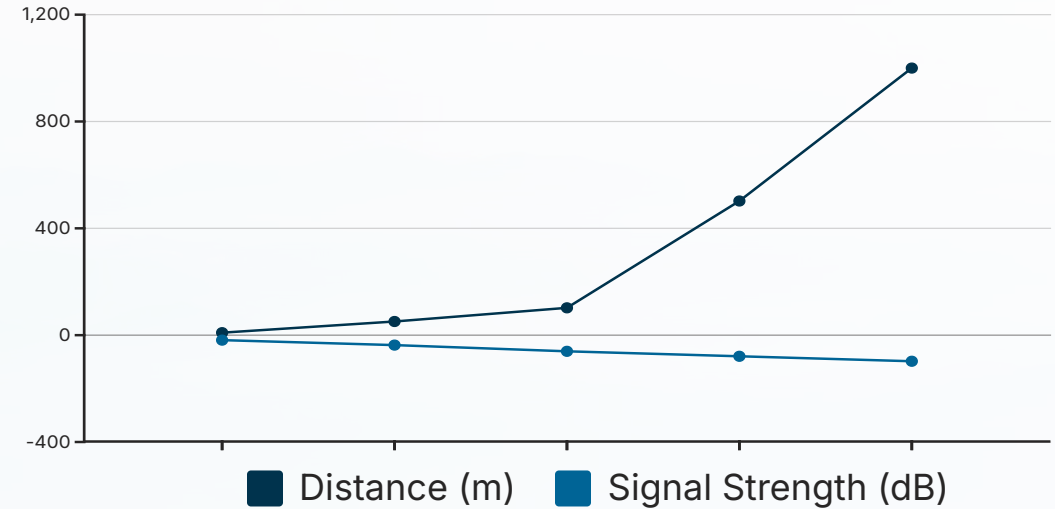
# Invisible Inputs to Visible Intelligence

RF sensors in harsh environments send real-time data to data centers.

Applications range from smart factories to defense systems.

Friis Equation:

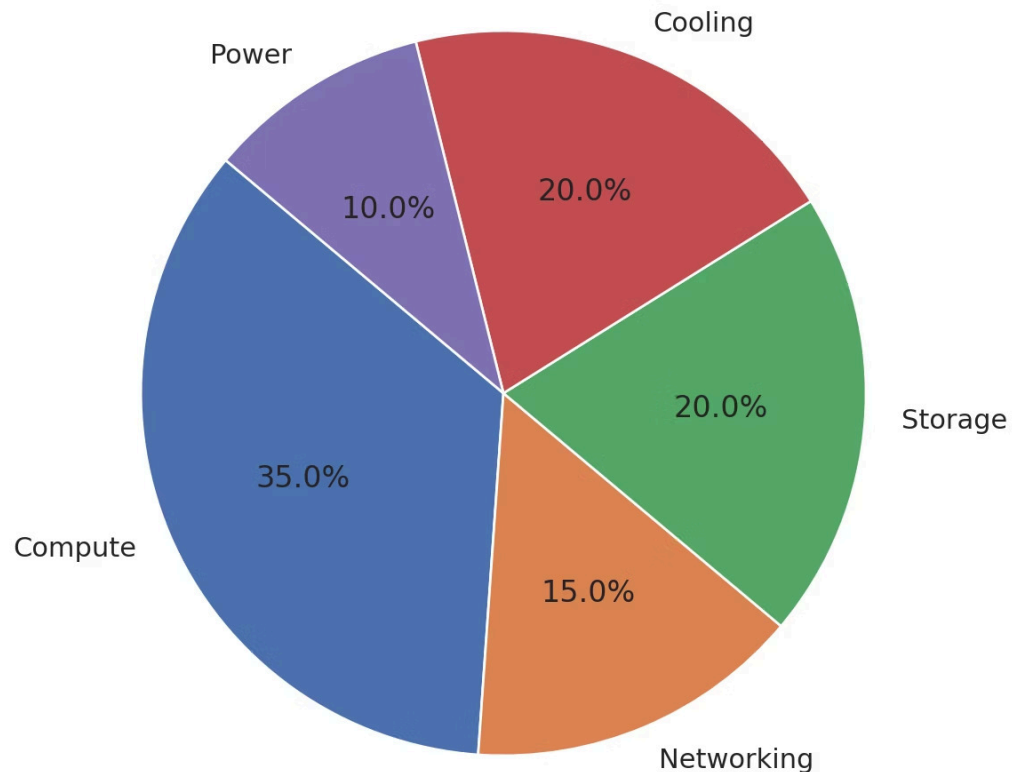
$$r = \frac{P_t G_t G_r \lambda^2}{(4\pi d)^2 L}$$



# Digital Nerve Centers: Inside a Data Center

Modern data centers are sophisticated ecosystems that form the backbone of our digital world, carefully orchestrated to maximize performance and reliability.

1. Data Center Resource Distribution



## Critical Infrastructure Components

- High-density compute servers processing millions of operations per second
- Multi-tiered storage arrays managing petabytes of data
- Redundant networking equipment ensuring constant connectivity
- Precision cooling systems maintaining optimal temperatures
- Uninterruptible power supplies with backup generators

## Digital Foundation

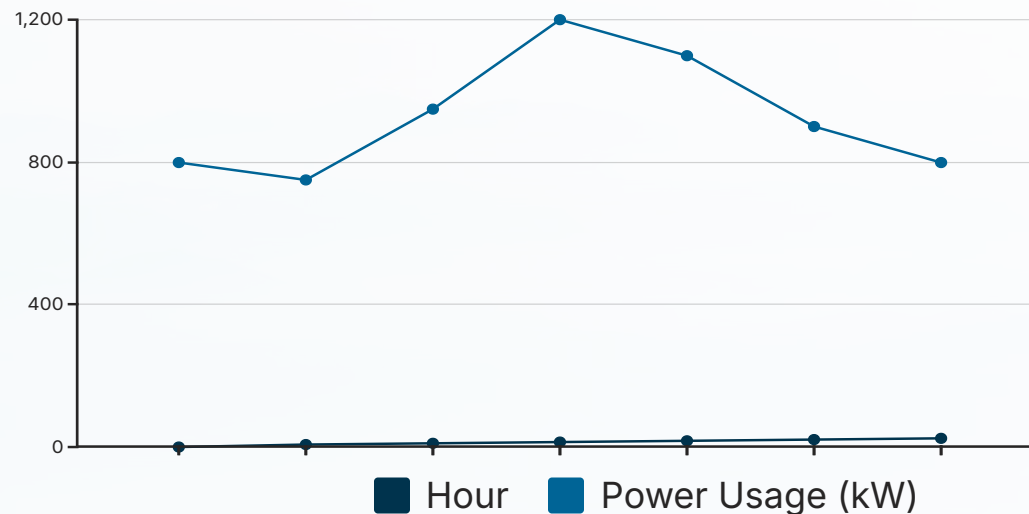
These facilities power essential services including hyperscale cloud platforms (AWS, Azure, GCP), AI/ML training environments, enterprise applications, and real-time IoT data processing that drives innovation across industries.

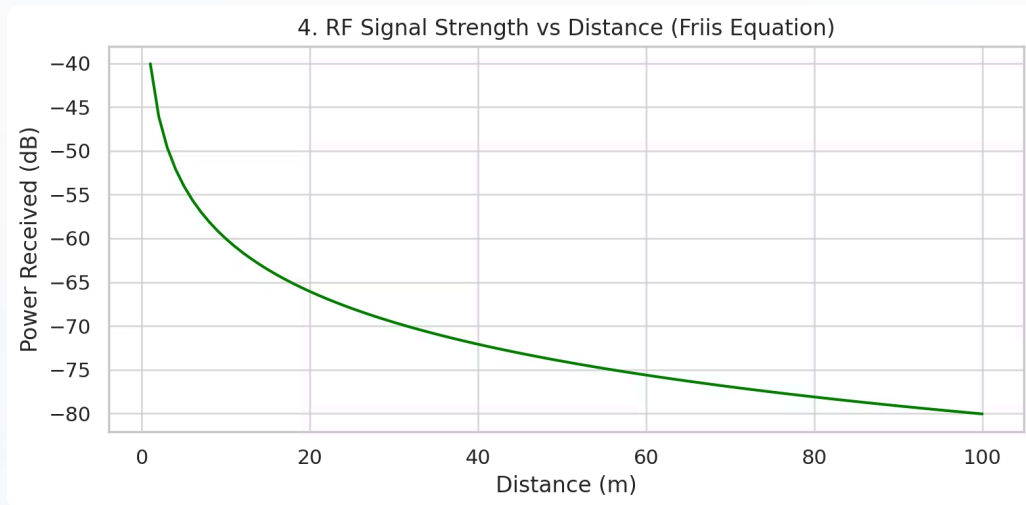
# Predicting and Managing Power in the Data Center

Data centers consume massive power across daily cycles.

Machine usage, cooling loads, and storage IO all fluctuate.

Predicting these patterns supports green DCs and cost savings.





- Advanced analytics and AI enable precise forecasting of power needs
- Real-time sensor telemetry provides critical operational data
- Operators can predict power demands with greater accuracy
- Workload balancing optimizes resource utilization
- Cooling systems adjusted based on predictive insights
- Energy costs reduced while maintaining performance
- System reliability enhanced through proactive management



# Ready to Build the Future



## Infrastructure Platform

Embrace data center infrastructure as your foundation for innovation.



## Edge Innovation

Work at the intersection of data, energy, and intelligence.



## Unique Position

skills in ChemE, RF, and DS create unique opportunities.