

— DATA CENTER COOLING

DATA CENTER COOLING DESIGN GUIDE

FOR NEW FACILITIES · 2026

How engineers size, specify, and de-risk cooling systems — the tradeoffs and decision criteria behind real project planning.

A NOTE BEFORE YOU START

This guide is written for the people making cooling decisions under real constraints — mechanical engineers writing specifications, design firms planning new facilities, and operators preparing for future growth. It focuses on the considerations, tradeoffs, and decision criteria commonly encountered during project planning and specification.

Here's what you'll find — practical guidance around the decisions that continue to shape data center cooling projects:

01 How much cooling capacity to build — and when

02 How to structure redundancy appropriately

03 How to evaluate refrigerants for long-term viability

04 What matters when assessing cooling equipment suppliers

Use the sections most relevant to your current project and skip the rest.

— THE G&D CHILLERS ENGINEERING TEAM

An Ingersoll Rand Company

WHAT'S IN THIS GUIDE

Five decisions shape nearly every new data center cooling project.
This guide takes them in turn.

-
- 01** How to size cooling capacity without overbuilding or stranding capital
 - 02** When to use air, water, or hybrid cooling systems
 - 03** Refrigerant selection in the A2L era
 - 04** A practical vendor evaluation checklist
 - 05** Data center cooling terminology and definitions
-

FOUR PRESSURES SHAPING COOLING DESIGN

Four industry pressures continue to influence how cooling systems are being designed and specified.

01

Heat density is climbing fast

Rack-level loads have moved from 8–15 kW to 50–100+ kW for AI and high-density computing. Direct-to-chip liquid cooling, CDUs, and rear-door heat exchangers now appear in projects that wouldn't have considered them a few years ago.

02

Supply chain certainty is now a design consideration

Long lead times for electrical infrastructure and specialized components drive earlier procurement. Cooling system selection is no longer just an engineering decision — it is also a schedule-risk decision.

03

The refrigerant landscape is in transition

The AIM Act phase-down continues to drive lower-GWP refrigerants. A2L options are becoming the preferred choice for new specifications on equipment expected to remain in service 15 years or more.

04

Sustainability requirements shape design

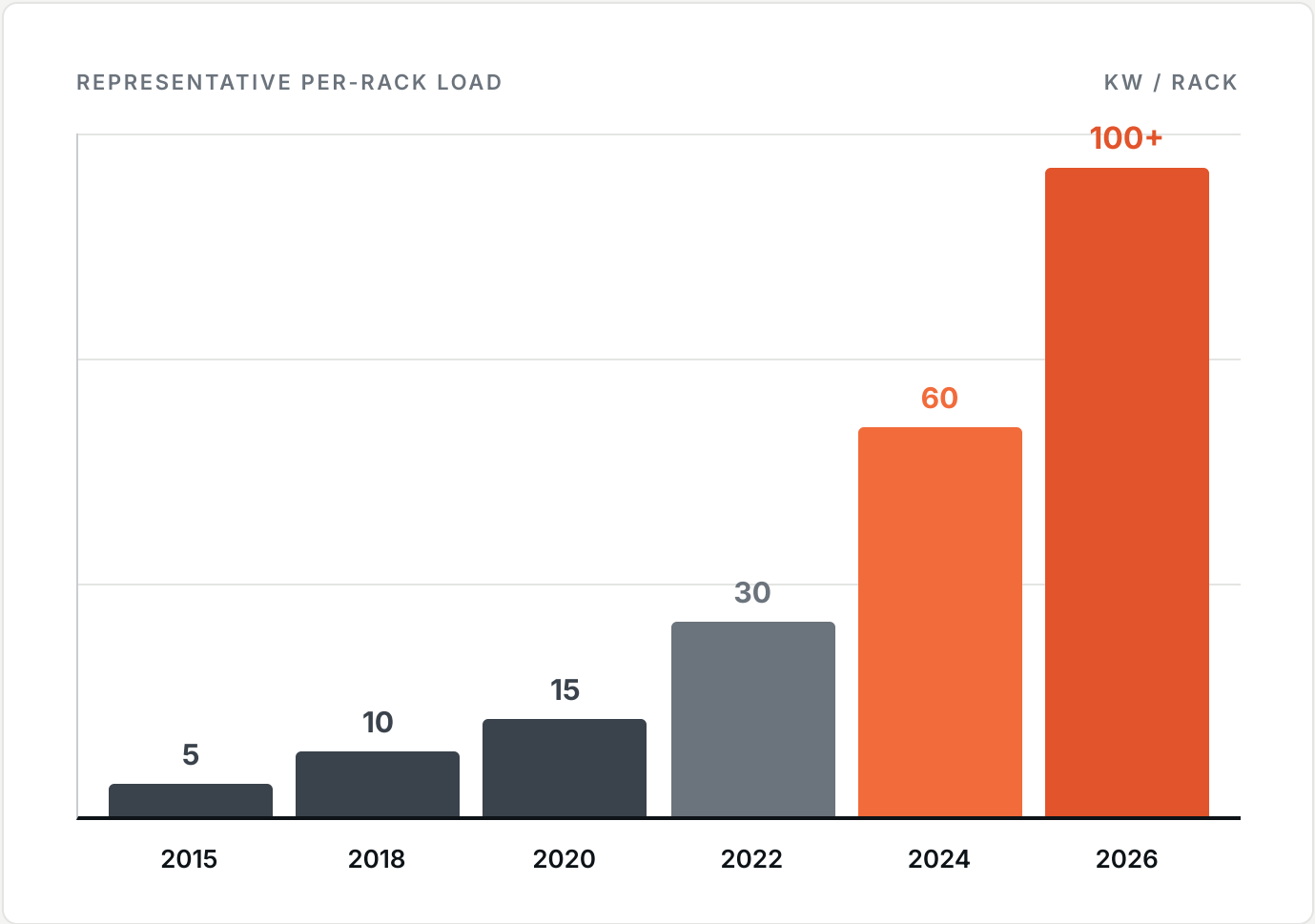
PUE targets, refrigerant management plans, and energy-efficiency requirements are now standard. What were once sustainability initiatives are frequently written into design specifications and procurement requirements.

8 → 100_{kW}

Per-rack loads have climbed roughly 7× as AI workloads move mainstream — the single biggest driver behind liquid and hybrid cooling adoption.

HEAT DENSITY IS CLIMBING FAST

Typical per-rack loads have climbed roughly 20× over the past decade — the single biggest driver behind liquid and hybrid cooling adoption.



Traditional enterprise

8–15 kW per rack — well served by air-cooled architectures and room-level cooling.

AI & high-density compute

50–100+ kW per rack — driving direct-to-chip liquid cooling, CDUs, and rear-door heat exchangers.

AIR, WATER, OR HYBRID

There is no universal best solution. The right architecture depends on workload density, facility objectives, water availability, operational preferences, and future expansion plans.

ARCHITECTURE	CAPACITY BAND	BEST FIT
Air-Cooled	Up to ~2.5 MW per skid	Most new builds, edge deployments, and colocation facilities
Water-Cooled	0.25 MW – 3.3 MW	Large facilities with chilled-water loops or cooling tower infrastructure
Hybrid Air + Liquid Cooling	Sized according to workload mix	AI, HPC, and mixed-workload environments

SITE CONSIDERATIONS

Air-Cooled - No cooling tower required - Lower water consumption - Simplified infrastructure - Climate-dependent free cooling	Water-Cooled - Requires tower or condenser water loop - High-efficiency potential - Water treatment requirements - Site water availability	Hybrid Systems - Supports high-density AI workloads - Requires rack-level integration - Increased design complexity - Scalable for changing profiles
--	---	---

For greenfield projects, architecture decisions are increasingly driven by workload density, water availability, sustainability objectives, and long-term scalability. For many AI and HPC environments, hybrid designs that combine facility chillers with liquid cooling are becoming a common approach.

A NOTE ON SIZING

Converting IT load into cooling capacity is straightforward. Accounting for growth, redundancy, operational flexibility, and technology change is where the challenge begins.

QUICK SIZING REFERENCE

IT LOAD	BASELINE (TONS)	N+1 INSTALLED	2N INSTALLED
0.5 MW	~140	175 – 200	~280
1.0 MW	~285	350 – 420	~570
2.0 MW	~570	700 – 850	~1,140
5.0 MW	~1,425	1,750 – 2,100	~2,850

ASSUMPTIONS

- ~1 ton = 3.5 kW of cooling capacity
- PUE range: 1.2 – 1.4
- Includes sensible heat and supporting loads
- Excludes specialized liquid-only deployments

CAPACITY CONTINGENCY

- Contingency should be determined by project-specific factors:
- Projected load growth & local ambient conditions
 - Redundancy strategy & cooling architecture
 - Deployment of AI and liquid-cooled environments

Facilities supporting high-density AI workloads or liquid-cooled environments may require additional engineering analysis beyond traditional sizing methods.

TWO COMMON SIZING MISTAKES

Overbuilding Day One

Excess installed capacity can leave capital underutilized, reduce part-load efficiency, and negatively affect long-term operating costs.

Underbuilding Future Capacity

Conservative growth assumptions can create future expansion challenges that require costly modifications while supporting active IT loads.

THE MIDDLE PATH

MODULAR GROWTH STRATEGIES

Modular plant strategies help balance day-one capital investment with future expansion requirements — reducing the risk of both overbuilding and capacity constraints. While not always the lowest initial-cost option, they often provide the greatest long-term flexibility.

UPTIME & RISK

REDUNDANCY, BRIEFLY

N+1

One additional cooling unit beyond minimum required capacity.

2N

Complete duplication of critical cooling infrastructure.

2N+1

Full redundancy plus additional backup capacity.

Redundancy should be aligned with business risk, uptime requirements, and service-level commitments rather than simply targeting the highest possible tier.

REFRIGERANT SELECTION IN THE A2L ERA

If equipment specified today is expected to remain operational for fifteen years or more, refrigerant strategy should be a primary design consideration. The market transition toward lower-GWP refrigerants is already underway.

WHAT IS DIFFERENT ABOUT A2L REFRIGERANTS?

Mild Flammability

Classified as mildly flammable and lower toxicity under ASHRAE standards. Applied per current codes, they can be safely deployed in commercial and industrial applications.

Lower Global Warming Potential

Common transition refrigerants include:

R-454B

R-32

R-1234ze

Compatibility With Modern Equipment

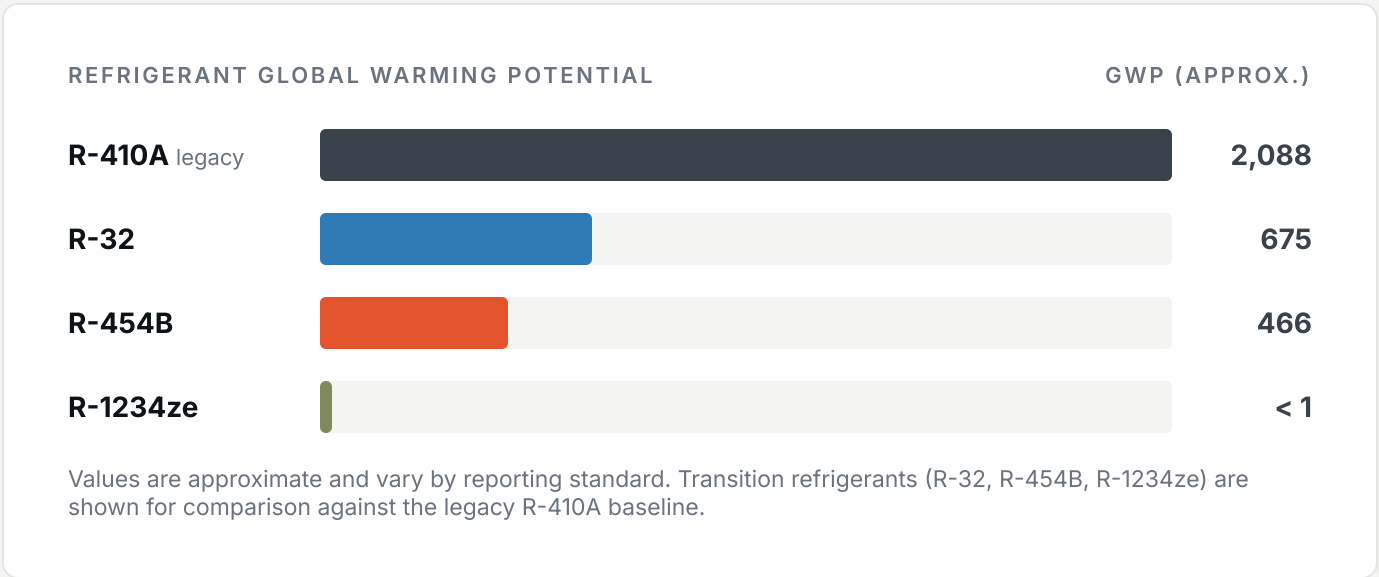
Many modern chiller platforms are designed specifically for low-GWP refrigerants and can support future regulatory requirements more effectively than legacy equipment.

REFRIGERANT SELECTION CHECKLIST

- ☐ Does the refrigerant comply with anticipated regulations during commissioning — not just specification?
- ☐ Are state requirements more restrictive than federal regulations?
- ☐ Does the manufacturer have a documented refrigerant roadmap?
- ☐ Will refrigerant availability remain viable throughout the equipment lifecycle?
- ☐ Is long-term service support available for the selected platform?

THE A2L TRANSITION

Lower-GWP refrigerants dramatically reduce climate impact relative to legacy blends — and the AIM Act phase-down sets the schedule equipment must be specified against.



AIM ACT HFC PHASE-DOWN

- 2020

AIM Act enacted, authorizing an 85% phase-down of HFC production and consumption through 2036.
- 2022

Phase-down begins — initial 10% step-down from the established baseline.
- 2024

40% reduction step takes effect, accelerating the shift to lower-GWP blends.
- '25-'26

Sector-based GWP limits restrict higher-GWP refrigerants in new equipment — including many chiller applications.
- 2036

Full 85% reduction from baseline — the endpoint equipment specified today must remain viable against.

DATA CENTER COOLING DEFINITIONS

A2L Refrigerant

Low-global-warming-potential refrigerants classified as mildly flammable and lower toxicity under ASHRAE standards.

CDU — Coolant Distribution Unit

Equipment that transfers heat between facility cooling systems and liquid-cooled IT hardware.

Direct-to-Chip Cooling

A liquid cooling method that removes heat directly from processors and accelerators through liquid-cooled cold plates.

Economization

Using favorable outdoor conditions to reduce mechanical cooling requirements.

GWP — Global Warming Potential

A measure of a refrigerant's climate impact relative to carbon dioxide.

MW — Megawatt

One megawatt equals 1,000 kilowatts and is commonly used to measure data center IT demand.

N+1 Redundancy

One additional unit beyond minimum required cooling capacity.

PUE — Power Usage Effectiveness

The ratio of total facility power to IT equipment power. Lower values indicate better operational efficiency.

RDHx — Rear Door Heat Exchanger

A liquid-cooled heat exchanger mounted to the rear of a server rack to capture heat before it enters the room.

Turbocor® Compressor

Oil-free magnetic-bearing compressor technology designed for high-efficiency chiller applications.

FIVE QUESTIONS TO ASK ANY COOLING VENDOR

The quality of a cooling system is often determined by factors that never appear on a specification sheet.

1

What is your refrigerant roadmap?

Does the platform support future regulatory requirements and long-term refrigerant availability?

2

How are supply chain risks being managed?

Ask about manufacturing capacity, component sourcing, lead-time management, and contingency planning.

3

What percentage of the system is factory tested before shipment?

Factory testing can reduce startup issues, shorten commissioning schedules, and improve project predictability.

4

How does efficiency perform at part load?

Most data centers spend significant time operating below full design capacity. Understanding part-load performance is critical.

5

What support will be available in years 5, 10, and 15?

Evaluate service coverage, spare-parts availability, technical support resources, and remote monitoring capabilities.

EVALUATING CHILLER VENDORS: A PRACTICAL CHECKLIST

Used by engineering teams for vendor evaluation. Bring this into vendor conversations and document the responses.

ENGINEERING

- ☐ Where is the engineering team located?
- ☐ Operating hours accumulated in mission-critical environments?
- ☐ Validated in a controlled testing environment?

REFRIGERANT

- ☐ Refrigerant type?
- ☐ Long-term refrigerant roadmap?
- ☐ Regulatory compliance strategy?

SCHEDULE & DELIVERY

- ☐ Lead time from PO to shipment?
- ☐ Commissioning support included?

CAPACITY & SCALABILITY

- ☐ Capacity per skid?
- ☐ Maximum plant capacity?
- ☐ Part-load and turndown performance?
- ☐ Expansion strategy?

SERVICE & SUPPORT

- ☐ Proprietary or standard components?
- ☐ Service network coverage?
- ☐ Spare-parts support at years 5, 10, 15?
- ☐ Remote monitoring capabilities?

If a vendor cannot confidently answer most of these questions, it may be worth taking a closer look before making a commitment.

WHERE GDX FITS

G&D Chillers offers multiple platforms designed for mission-critical cooling applications.



GDX-AIR

- Air-cooled configuration
- Danfoss Turbocor® oil-free magnetic-bearing compressors
- Up to 2.5 MW per skid
- Integrated free-cooling options · continuous-duty operation

GDX-SCREW

- Air-cooled screw chiller platform
- Up to 930 HP per skid
- Low-GWP refrigerant options
- Higher-capacity applications

TANDEM SCROLL

- 20 – 300 tons
- Suited for edge facilities and distributed infrastructure
- Service-friendly design
- Staged capacity control

WATER-COOLED

Available from approximately **0.25 MW to 3.3 MW** for facilities with cooling tower or chilled-water infrastructure.

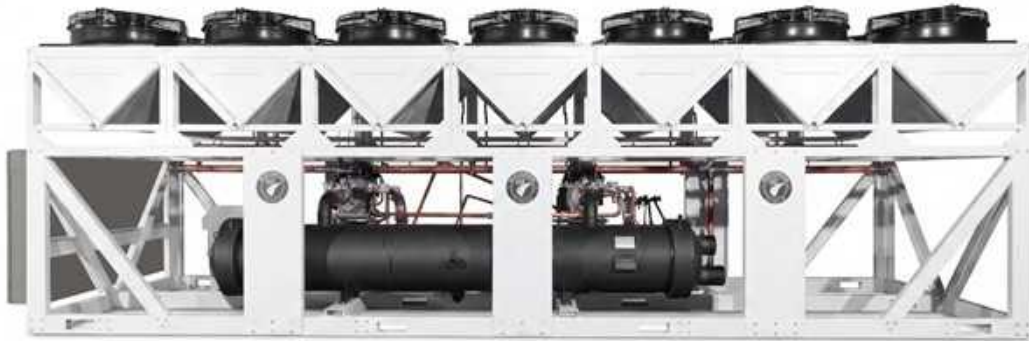
WHY OIL-FREE MAGNETIC-BEARING COMPRESSORS MATTER

Traditional centrifugal chillers rely on complex oil-management systems. Magnetic-bearing compressors eliminate many of these components.

The result is a platform designed for long-term continuous operation in mission-critical environments.

POTENTIAL BENEFITS

- Reduced maintenance requirements
- Lower friction losses
- Improved part-load efficiency
- Fewer wear-related failure points



Talk to an Application Engineer info@gdchillers.com

GDX platform with Danfoss Turbocor® oil-free magnetic-bearing compressors

A NOTE ON VALIDATION

Data center cooling systems leave little room for commissioning surprises. Manufacturers increasingly invest in dedicated testing environments to validate performance before deployment.

G&D's testing capabilities include simulated data center cooling environments operating production equipment configurations under controlled conditions. The goal is straightforward: reduce risk and minimize surprises during startup and commissioning.



Factory-assembled skids

Complete platforms are built and integrated in-house, reducing field installation complexity and commissioning time.



Precision refrigerant circuits

Copper-line routing and staged capacity control are validated before shipment to protect project schedules.



Full-plant configurations

Multi-skid arrangements are tested at representative load conditions to confirm real-world performance.

SERVICE, SUPPORT & THE LONG-TERM PARTNER QUESTION

The least-discussed specification decision is often the one that matters most after installation: **Who will support the system ten years from now?**

Are the parts proprietary?

Equipment built around proprietary components can limit service flexibility and long-term supplier options. Where requirements allow, standardized components improve lifecycle economics and service accessibility.

What does the service network look like?

Mission-critical facilities require support infrastructure that extends beyond the equipment itself. Response capability, technician availability, and parts access should be evaluated alongside technical specifications.

Will the manufacturer be here long-term?

A cooling system may outlast the team that originally specified it. Long-term stability, engineering support, parts availability, and service infrastructure all contribute to lifecycle value.

WHY THIS MATTERS IN PRACTICE

Most cooling systems outlive the teams that specified them. A successful partnership extends beyond installation to include:

Service support

Technical expertise

Parts availability

Future expansion guidance

Ongoing operational assistance

A chiller purchase is more than an equipment procurement decision — it is a long-term operating relationship.

“

Customer testimonial or engineering reference quote to be added.

PLACEHOLDER

CONTINUE THE CONVERSATION

NEXT STEPS

If you are:

- Designing a new facility in the next 6–24 months
- Evaluating air versus hybrid cooling architectures
- Navigating refrigerant transitions
- Planning future capacity expansion

Here are two ways to continue the conversation.

01

Talk to an Applications Engineer

A short discussion about your facility, cooling load, and project timeline.

info@gdchillers.com

02

Schedule a Preliminary Cooling Review

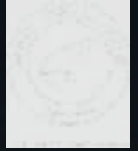
A 30-minute review of your concept, constraints, and architecture options.

Scott.Timms@irco.com

G&D Chillers

130 East 1st Avenue, Junction City, Oregon 97448

800.555.0973 · gdchillers.com



— COMMITTED TO COLD.

PRECISION LIQUID COOLING FOR MISSION-CRITICAL FACILITIES

Precision temperature control isn't approximate — it's exact, repeatable, and engineered. Field-proven platforms, refined over decades, for continuous-duty operation.

G&D Chillers

130 East 1st Avenue, Junction City, Oregon 97448
800.555.0973 · gdchillers.com · info@gdchillers.com

AN INGERSOLL RAND
BUSINESS · EST. 1993