TECHNICAL ANALYSIS | DATA CENTER INFRASTRUCTURE

The HVAC Shock No One Priced In: "No Chillers" Doesn't Mean "No Cooling"

A comprehensive technical analysis of chiller-free cooling for data centers, with tropical climate implementation guide, fault scenario analysis, and operational considerations.

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Executive Summary

- **Nvidia's Rubin claim:** Warm-water DLC with ~45°C supply temperature eliminates need for chillers in suitable climates.
- **Capex rotation:** Chiller plant shrinks, but CDUs, pumps, and controls grow. Total cooling capex redistributes, not disappears.
- **Climate dependency:** "No chillers" viable in cool climates (Nordic: 95% of year). In tropics, hybrid approach with 40-50% backup required.
- **Operational shift:** Liquid cooling fails faster (30-45 seconds vs 8-15 minutes) but recovers faster. Enhanced monitoring essential.
- **Implementation verdict:** Score ranges from 9.5/10 (Stockholm) to 6.8/10 (Singapore) based on climate conditions.

1. The Market Moment

At CES 2026, Jensen Huang declared that "no water chillers are necessary for data centres" when describing Nvidia's Vera Rubin platform. Within hours, HVAC stocks tumbled: Johnson Controls -7.5%, Trane Technologies -5.3%, Carrier Global -1.1%. The market's linear assumption that "AI buildout = more chiller demand" was suddenly questioned.

But Barclays analysts were right to urge caution. The statement requires nuance: "necessary" is not the same as "no cooling." Heat rejection remains unavoidable; only the method changes.

2. Understanding the Paradigm Shift

2.1 From Cold Water to Warm Water

Traditional data center cooling relies on chillers producing 6-12°C water to feed CRAH/CRAC units. This decouples indoor temperature from outdoor conditions but consumes significant energy (0.5-0.7 kW per ton of cooling).

Nvidia's approach accepts 45°C supply water temperature. At this temperature, dry coolers can reject heat to ambient air whenever outdoor conditions permit. The higher the acceptable supply temperature, the more hours per year free cooling is viable.

The Physics of Free Cooling

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Free Cooling Viability:
T_supply > T_ambient + Approach_Temperature

Traditional (7°C supply):
  Free cooling when: T_ambient < 2°C
  Hours/year (Jakarta): ~0 hours (0%)
  Hours/year (Frankfurt): ~1,500 hours (17%)

Warm-Water DLC (45°C supply):
  Free cooling when: T_ambient < 40°C
  Hours/year (Jakarta): ~600 hours (7%)
  Hours/year (Frankfurt): ~5,200 hours (59%)
  Hours/year (Stockholm): ~7,500 hours (86%)
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2.2 The Cooling Stack Transformation

Component	Traditional	Warm-Water DLC	Trend
Chillers	Primary cooling	Backup only	Shrinking
Cooling Towers	Heat rejection	Reduced/eliminated	Shrinking
CDUs	N/A	Per-rack coolant distribution	Growing
Dry Coolers	Optional	Primary heat rejection	Growing
Controls/Sensors	Basic	Advanced (flow, leak, temp)	Growing
Commissioning	Standard	Complex (flushing, leak-test)	Growing

3. The Tropical Challenge

A warm and humid climate like Singapore or Jakarta represents the worst-case scenario for free cooling. The combination of high ambient temperature AND high humidity eliminates both primary free cooling mechanisms.

Challenge 1: High Ambient Temperature

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Dry Cooler Physics: Heat Transfer = U × A × LMTD

Temperate Climate (Frankfurt):        Tropical Climate (Jakarta):
  Design Ambient: 30°C                  Design Ambient: 35°C
  Approach Temp:  5°C                   Approach Temp:  5°C
  Achievable Fluid Out: 35°C            Achievable Fluid Out: 40°C
  45°C supply → 10°C margin ✓           45°C supply → 5°C margin ⚠

Peak Conditions (Heat Wave):
  Frankfurt: 35°C → 5°C margin (manageable)
  Jakarta:   40°C → 0°C margin (FAILS)
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Challenge 2: High Humidity Limits Evaporative Cooling

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Adiabatic Cooling Effectiveness by Relative Humidity:

RH 30% (Desert):      ΔT = 10-12°C  - Excellent
RH 50% (Mediterranean): ΔT = 6-8°C    - Good
RH 70% (Subtropical):  ΔT = 3-4°C    - Limited
RH 85% (Tropical):     ΔT = 1-2°C    - Minimal

Jakarta Average RH: 75-85%
Singapore Average RH: 80-90%

Result: Evaporative pre-cooling provides minimal benefit in tropical climates.
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3.1 Regional Implementation Scores

Stockholm	Ireland	Frankfurt	Virginia
9.5	9.2	9.0	8.5
UAE	**India**	**Indonesia**	**Singapore**
7.8	7.5	7.2	6.8

4. Fault Scenario Analysis

Critical Understanding: Liquid cooling systems fail FASTER but recover FASTER than traditional systems. This fundamentally changes the operational paradigm.

4.1 Thermal Runaway Comparison

Time	Air Cooling (No AC)	Liquid Cooling (No Flow)
T+0	25°C - Normal	70°C - Normal
T+30s	28°C - Rising	98°C - CRITICAL
T+1min	32°C - Warning	SHUTDOWN
T+5min	45°C - Critical	-
T+8min	60°C - Throttling	-
T+15min	85°C - Shutdown	-

Key Insight: You have ~30-45 seconds to respond to liquid cooling failure vs 8-15 minutes for air cooling. This demands 2N redundancy and sub-second detection.

4.2 CDU Failure Modes

Failure Mode	Severity	Detection	MTTR
Primary Pump Failure	High	Flow sensors, pressure drop	2-4 hrs
Seal/Gasket Leak	High	Leak detection cables	1-3 hrs
VFD/Motor Controller	Medium	Electrical monitoring	1-2 hrs
Control System Failure	Medium	BMS communication loss	0.5-2 hrs

5. Pros and Cons Analysis

5.1 Short-Term (0-3 Years)

PROS

- 30-60% cooling energy reduction
- ESG compliance and carbon credits
- 30-40% water conservation
- Fewer mechanical components
- Avoid HFC phase-out regulations

CONS

- $500-2,000/kW initial CAPEX
- Limited vendor ecosystem
- Staff retraining required
- Server compatibility issues
- Supply chain constraints

5.2 Long-Term (3-10 Years)

PROS

- Ready for 100+ kW/rack AI densities
- Ahead of regulations
- Heat reuse revenue ($20-50/MWh)
- Premium pricing opportunity
- 30-40% lower TCO

CONS

- Stranded chiller assets
- Vendor lock-in risk
- Climate change impact
- Fluid lifecycle management
- Unknown failure modes

6. Implementation Recommendations

6.1 For Tropical Climates (Indonesia, Singapore, Thailand)

1. **Hybrid approach essential:** Target 60-70% chiller-free with 30-40% backup capacity
2. **Design for worst-case:** Use 38-40°C ambient, not average conditions
3. **Enhanced monitoring:** Sub-second detection for liquid cooling faults
4. **2N redundancy:** Minimum for critical systems, not N+1
5. **Dehumidification:** Required for condensation management
6. **STDCT alignment:** Follow Singapore's tropical DC research findings

6.2 For Temperate Climates (Europe, Northern USA)

1. **Full free cooling viable:** 60-90% of annual hours

2. **Seasonal backup:** 15-30% chiller capacity for summer peaks
3. **Heat reuse:** Explore district heating partnerships
4. **Water optimization:** Consider zero-water designs

7. Conclusion

The market panic-sold HVAC stocks after one line about "no chillers". But Rubin doesn't kill cooling; it reprices the cooling stack. Heat still flows; investors and operators just need to follow it into pumps, CDUs, and control loops.

> *"The edge is knowing where the new bottleneck sits — inside the plant room, not on a silicon slide."*

For operations professionals: understand the physics, plan for your climate, invest in monitoring, train your teams, and design for 2050 conditions. The transition to liquid cooling is inevitable for AI/HPC workloads. The question is not whether, but how to implement it for your specific context.

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