

885-0138 AES CAB Reliable Thermal Performance in Extreme Temperatures



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1 INTRODUCTION

Discover Energy System's family of high-voltage cabinet energy storage systems (AES 210HV, CAB-106, CAB-160, CAB-210, CAB-266, CAB-373, CAB-418) is engineered for resilient operation in climates ranging from -30°C to $+55^{\circ}\text{C}$ (-22°F to 131°F).

All cabinet models share a common integrated liquid Thermal Management System (TMS) that actively regulates battery pack temperature for consistent performance, safety, and long-term durability under extreme environmental conditions.

2 THERMAL MANAGEMENT MATTERS

The Lithium Iron Phosphate (LiFePO_4) chemistry is highly stable, but both high and low temperatures affect system performance and longevity.

- High heat ($>40^\circ\text{C}$ / 104°F) accelerates degradation and reduces cycle life.
- Cold ($<0^\circ\text{C}$ / 32°F) impairs charge acceptance and risks lithium plating.

Unregulated systems often derate or fail under extreme ambient conditions.

Discover's battery cabinets overcome these challenges through a standardized liquid-cooling and heating architecture, validated by UL testing at the cell, module, and cabinet levels.



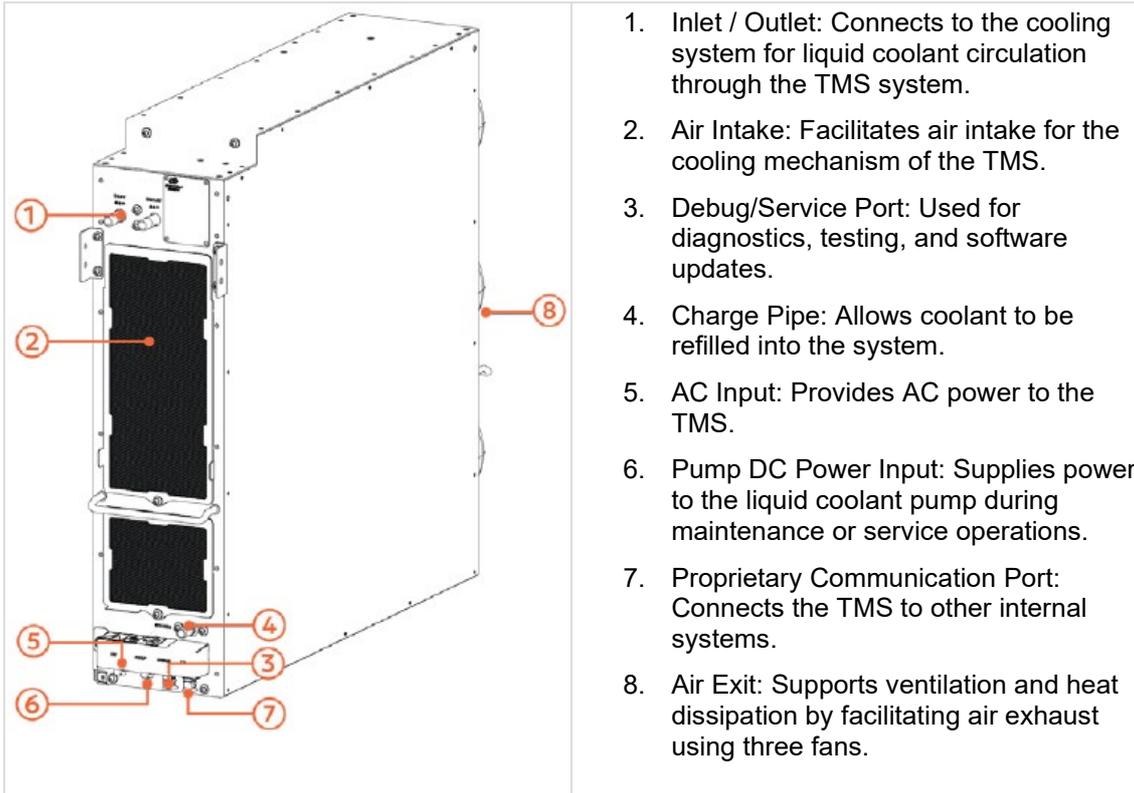
AES Cabinets installed outdoors on concrete foundation

3 THERMAL MANAGEMENT SYSTEM ARCHITECTURE

The Thermal Management System (TMS) regulates the temperature of battery cells in the AES Cabinet.



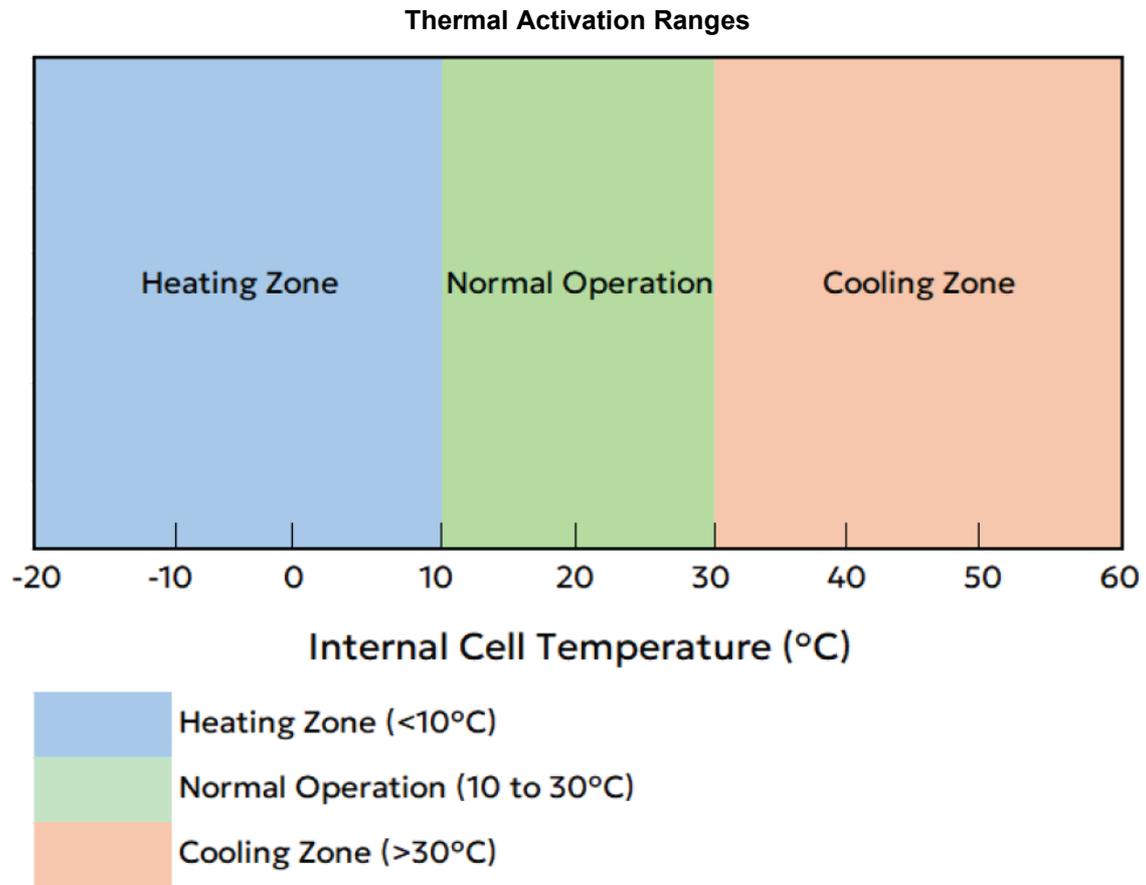
Thermal Management System (TMS)



3.1 TMS System Design

- Liquid Cooling Loop: Closed-loop glycol-water mix (50:50) with variable-speed pump.
- Refrigeration Circuit: R-513A refrigerant compressor that provides ≥ 8 kW cooling capacity at 45°C (113°F) ambient temperatures.
- Heating Elements: PTC resistive heaters (≥ 2.5 kW) for cold-weather operation.
- Integrated Controls: Each cabinet uses a Battery Control Unit (BCU) and Battery Monitoring Units (BMUs) for real-time regulation.
- Sensors: Multiple NTC thermistors at pack and cell level.

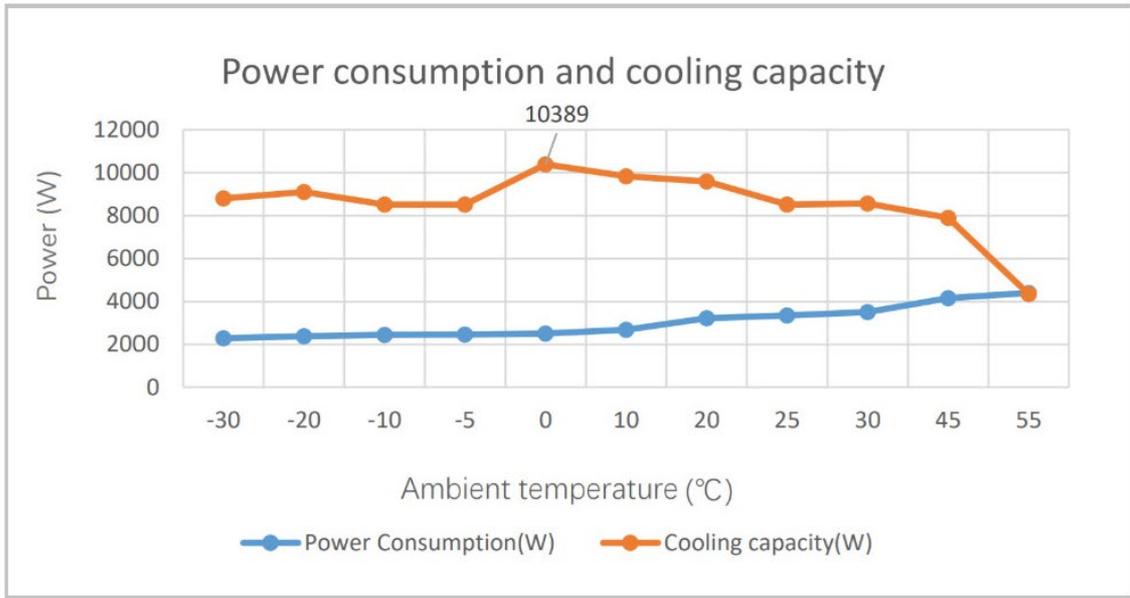
4 OPERATING MODES



- **Cooling:** Engages when the average battery pack temperature exceeds 30°C (86°F) or a single pack exceeds 32°C (89.6°F). Cooling stops when the average pack temperature drops to 28°C (82.4°F), and all packs are below 30°C (86°F). For more information, see [Cooling Mode](#).
- **Heating**
 - Engages during charge when the average battery pack temperature is less than 10°C (50°F) or the temperature of any individual battery pack is 5°C (41°F) or less. The heating turns off when the average pack temperature reaches 25°C (77°F), and all individual packs are 20°C (68°F) or warmer.
 - Engages during discharge when the average battery pack temperature is less than -5°C (23°F) or the temperature of any individual battery pack is -10°C (14°F) or less. The heating turns off when the average pack temperature reaches 25°C (77°F), and all individual packs are 20°C (68°F) or warmer. For more information, see [Heating Mode](#).
- **Self-Circulation:** Equalizes temperature when it diverges between the battery packs.
- **Standby:** Active monitoring with no heating or cooling when all packs are in a safe range.

This standardized system is used across all Discover cabinet sizes, ensuring consistent field behavior.

4.1 Cooling Mode



When cabinet pack temperatures exceed preset thresholds, the TMS automatically initiates a cooling cycle:

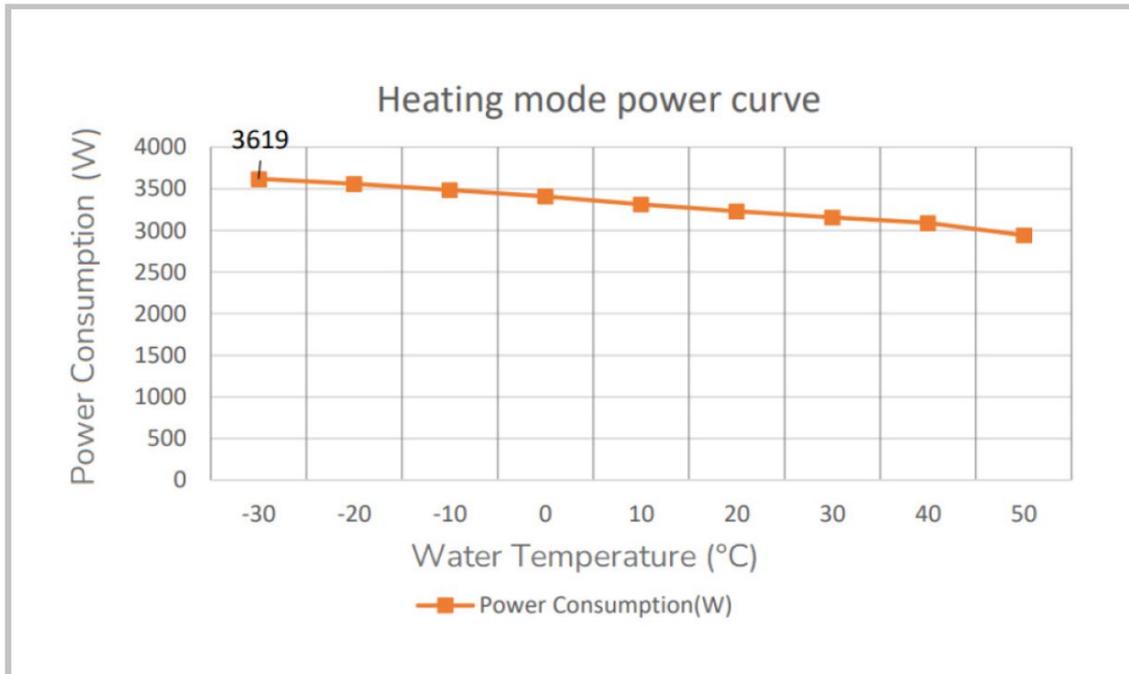
- **Activation thresholds:** Cooling begins when the system average reaches 30°C (86°F) or when any individual pack exceeds 32°C (89.6°F).
- **Deactivation thresholds:** Cooling continues until the system average drops to 28°C (82.4°F) and all packs fall below 30°C (86°F).
- **Process:** Within 20 seconds, the coolant pump begins circulating a 50/50 glycol-water mixture through each pack’s cooling plates. After 30 seconds, the compressor engages, transferring heat from the liquid coolant into a refrigerant loop. Heat is then expelled via three high-efficiency fans at the rear of the cabinet.
- **Target coolant temperature:** 20°C (±1°C) / 68°F (±1.8°F).
- **Control logic:** Cooling takes priority over all other modes. If both heating and cooling thresholds are triggered, the system enters self-circulation mode to equalize pack temperatures without overcorrection.

This design ensures that internal cell temperature remains below 32°C (89.6°F), even during extreme heat waves with ambient temperatures greater than 40°C (104°F).

4.1.1 Hot Environment Performance

- Cabinets maintain rated continuous power up to 55°C (131°F) ambient.
- Cooling prevents accelerated degradation and derating during extended heat waves.
- Suitable for extreme-heat regions such as the Middle East, the Southwestern U.S., and Australia.

4.2 Heating Mode



In cold conditions, the TMS activates a heating cycle to prevent lithium plating and ensure safe charging:

- **Activation thresholds**
 - During discharge: If system average $\leq -5^{\circ}\text{C}$ (23°F) or any battery pack $\leq -10^{\circ}\text{C}$ (14°F).
 - During charge: If the system average $\leq 10^{\circ}\text{C}$ (50°F) or any battery pack $\leq 5^{\circ}\text{C}$ (41°F).
- **Deactivation thresholds:** Heating disengages once the system average reaches 25°C (77°F) and all packs are $\geq 20^{\circ}\text{C}$ (68°F).
- **Process:** Coolant is routed through PTC ceramic heaters, which warm the fluid before circulating through pack plates. This raises the pack temperature uniformly until all cells are in the safe operating range.
- **Target coolant temperature:** 30°C (86°F).
- **Control logic:** While heaters are active, charging and discharging are restricted or derated until safe thresholds are met; once those thresholds are met, full performance is restored.

This ensures that cabinets remain fully chargeable even when ambient temperatures drop to -30°C (-22°F), even in cold climates where unmanaged batteries would remain offline.

4.2.1 Cold Environment Performance

- Safe charging down to -30°C (-22°F) ambient temperatures, with pre-heating to $\geq 20^{\circ}\text{C}$ (68°F) before current acceptance.
- Eliminates lithium plating risk.
- Suitable for extreme-cold regions such as Canada, Scandinavia, and Alaska.

Example cold-environment deployment:

- [Northern Manitoba \(St. Theresa Point\)](#)

5 INTEGRATED SAFETY FEATURES

Discover cabinets combine thermal management with multi-layered fire safety and protection systems:

- Detection: Heat and smoke sensors.
- Suppression: Pack-level and cabinet-level aerosol extinguishers.
- Pressure Relief: Passive deflagration vents.
- Control Logic: Automatic derating and shutdown in case of thermal events.
- Certification: All cabinet platforms have undergone UL 9540A propagation testing at cell, module, and unit levels.

6 DEPLOYMENT ADVANTAGES

- Outdoor-Ready: IP55/NEMA 3R enclosures, no climate shelter needed.
- Cost Savings: Lower balance-of-system costs by eliminating HVAC structures.
- Scalability: From 210 kWh to 5 MWh with consistent performance.
- Warranty Confidence: 10 to 20-year pathways with throughput-based coverage.

7 COMPARISON WITH AIR-COOLED SYSTEMS

Feature	Air-cooled competitors	Discover AES Cabinet
Ambient Range	Typically 0 to 40 °C (32 to 104°F)	-30 to 55 °C (-22 to 131°F)
Cooling	Fans only	8 kW liquid cooling
Cold Charging	Limited or disabled below 0°C (32°F)	Safe charging with heaters
Deployment	Requires HVAC shelter	Outdoor ready IP55 (NEMA 3R)
Lifetime	Higher degradation in heat	Maintains performance across extremes