FRANKLINWH

Reliable Thermal Stability Across Freezing Winters

Applicable to aPower 2 & aPower S

September 4, 2026

Executive Summary

The FranklinWH System provides comprehensive home energy management designed to seamlessly integrate multiple power sources, including PV, battery energy storage systems (BESS), electric vehicles, grid, and generators. The FranklinWH **aPower 2** and **aPower S** units deliver robust performance and flexible energy storage capabilities, enabling homeowners to achieve greater energy independence. This advanced system empowers households to better manage their energy needs, enhance resilience, and reduce reliance on the grid.

Cold temperatures are often considered a challenge for lithium-based batteries due to their impact on overall device performance. Low temperatures may reduce battery capacity, slow charge rates, increase internal resistance, and affect overall thermal efficiency. One of the primary causes of this degraded performance is the slowing of intercalation, the process by which lithium ions move into the graphite layers of the anode at colder temperatures.

To ensure thermal stability in cold weather, FranklinWH utilizes a proven method for BESS pack heating, commonly referred to as a heating blanket. Combined with the thermal mass of the system, this approach helps maintain strong thermal stability and system reliability. Each aPower 2 and aPower S battery pack is equipped with an optimized built-in heating blanket designed to support operation across a wide temperature range from –4° F (-20° C) to 122° F (50° C), enabling reliable outdoor installations even in harsh environments without compromising efficiency. With an IP67 weatherproof rating (wiring compartment rated to IP56), the systems are fully sealed against dust and protected from short-term water immersion, ensuring dependable performance in demanding climates. Both aPower 2 and aPower S units are designed for indoor and outdoor installations. Please refer to the installation guide for additional information regarding installation location guidance and best practices.

This white paper validates the exceptional thermal stability of FranklinWH aPower 2 and aPower S units through Winter 2025-2026 (November 2025 – March 2026). Key takeaways include:

- Across all monitored deployments, 99.92% of aPower units maintained cell temperatures within the designed operating range throughout the winter despite severe winter conditions across North America. In the instances where ambient conditions caused cell temperatures to fall below the operating threshold, the system behaved as designed by automatically pausing battery operations to protect battery health and ensure safe, reliable operation.

- While indoor BESS installations remain common, this study highlights a growing share of outdoor deployments driven by factors such as local fire code requirements, site and spatial constraints, ease of install and the incremental cost of conditioned indoor installation. The FranklinWH System continues to reliably support both indoor and outdoor configurations, enabling flexible deployment options for both installers and homeowners without compromising performance in cold-climate environments.

- Based on fleet analysis, the average daily heating blanket energy consumption per aPower unit remained approximately 1 kWh. This represents a minimal energy footprint that was seamlessly supplied either by grid power or available solar generation, depending on system operating mode and time of day.

- For outdoor installations exposed to high wind conditions, increased convective heat loss resulted in higher demand on the heating system. Daily heating energy consumption exceeded 1.5 kWh per unit, as sustained wind-driven cooling extended heater runtime and required additional energy to maintain cell temperatures within the operating range. Even under these more severe conditions, the system continued to operate as designed, maintaining safe and controlled thermal behavior.

- Both aPower 2 and aPower S are engineered around high-performance battery cells with integrated heating blankets, enabling reliable low-temperature charging and maintaining stable thermal performance across the full range of cold-weather operating conditions encountered in the field.

Heating Blanket Information

Part	Description			Remarks
	aPower X	aPower 2	aPower S	
Film material	Silicone rubber pad	Silicone rubber pad		Note that aPower 2 & aPower S have the same heating blanket
Controlled by	EMS/BMS	EMS/BMS		
Installation	Both cell pack sides	On one side of cell pack		
Heating rate	~ 14.4° F/hour (8° C/hour)	~ 14.4° F/hour (8° C/hour)		

Table 1. Heating blanket information

Heating Logic

Operation of the integrated heating blanket depends on several factors, including but not limited to cell temperature, battery state of charge (SOC), system operating mode, battery status (normal operation or fault conditions), battery connectivity and the availability of a charging request. Cold weather can impact battery performance, particularly by reducing charging capability and temporarily lowering available capacity. However, the integrated heating blanket significantly mitigates these effects by maintaining the battery within its optimal operating temperature range, allowing the system to perform at or near its rated capacity even in extreme cold conditions.

For systems operating in Time of Use (TOU) or Self Consumption modes, heating is enabled only between sunrise and sunset to leverage available solar to run the heating blankets. The heating blanket activates when the battery cell temperature falls below 50°F (10°C) and turns off once the cell temperature rises above 55.4°F (13°C). Its operation is optimized to maintain battery thermal reliability while minimizing unnecessary energy consumption.

For systems operating in Emergency Backup mode, battery heating is enabled 24 hours a day as required to maintain cell temperature. Upon receiving a charging request from the Energy Management System (EMS) in the aGate or the MAC, the integrated heating blanket operates as needed to maintain battery readiness and support reliable charging under low-temperature conditions.

Reliable Thermal Performance, Winter 2025-2026

Study Overview

By the end of Q1 2026, large-scale field thermal performance data was collected from 25,000 aPower 2 units and 200 aPower S units. These systems are deployed across installation sites covering all of North America. Supported by a comprehensive dataset of 1.4 million daily operational records, this study systematically validates the cold weather reliability and thermal stability of the FranklinWH System during the 2025-2026 winter season.

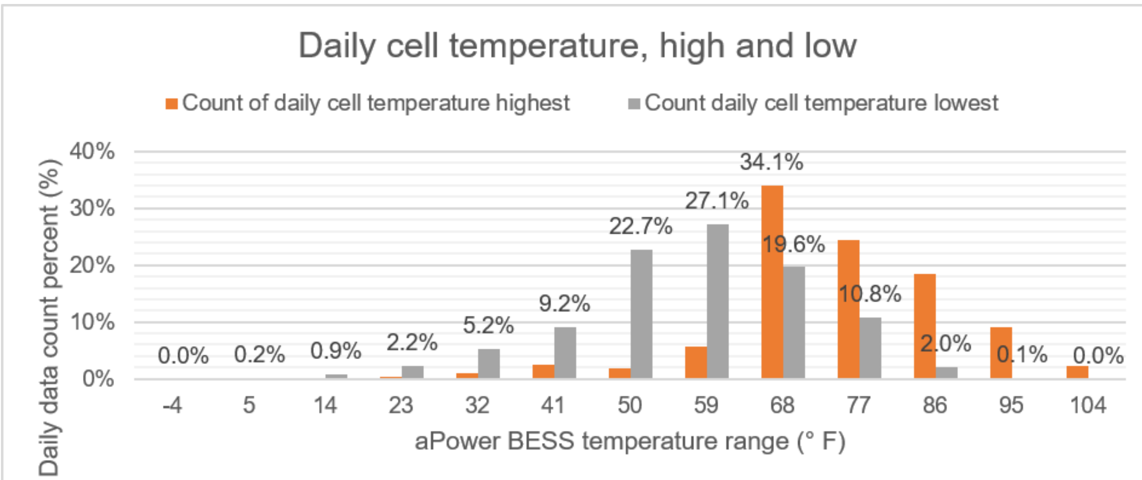


Figure 1. Daily cell temperature, high and low

Charging Stability: Daily Maximum Cell Temperature Analysis

FranklinWH's proprietary thermal management architecture maintained optimal battery charge temperature conditions consistently in low-temperature environments. Key statistics for daily maximum cell temperatures are summarized below:

- 96% of daily maximum cell temperatures remain at or above 50° F. The remaining 4% typically occur when the system is operating in Emergency Backup mode or when Storm Hedge is active, limiting opportunities for battery heating and charging.
- 94.5% of daily maximum cell temperatures reach at least 59° F.
- 89% of daily maximum cell temperatures reach at least 68° F.
- Instances where the daily maximum cell temperature remains below 32° F are extremely rare, even when ambient temperatures fall to as low as -4° F.

Discharging Stability: Daily Minimum Cell Temperature Distribution

The FranklinWH Systems similarly maintained consistent discharge capability in cold environments, with daily minimum cell temperatures distribution as follows:

- 96.7% of daily minimum cell temperatures remain at or above 32° F. The remaining 3.3% typically occur when Storm Hedge is active, the system is operating in Emergency Backup mode, or during periods of extreme morning cold.
- 91.5% of daily minimum cell temperatures remain at or above 41° F.
- 82.4% of daily minimum cell temperatures remain at or above 50° F.
- Only 3.3% of daily minimum cell temperatures fell below 32° F, with no significant impact on overall system performance.

Case Studies: Winter 2025-2026

While a lot of aPower 2 and aPower S systems deployed in colder regions of North America are installed indoors, a significant share of installations are sited outdoors due to evolving factors like local fire code requirements, location and spatial constraints, electrical infrastructure considerations, and the cost differential associated with conditioned indoor installations. In our fleet analysis, both locations have demonstrated uninterrupted operations and consistent system reliability across a range of operating modes including off-grid.

This section presents an analysis of temperature profiles, heating system operation (on/off status), and heating energy consumption across a range of indoor and outdoor aPower installations in cold-climate regions during the 2025-2026 winter season. The portfolio includes indoor and outdoor installations, systems with and without solar, and sites spanning controlled indoor environments to unshielded outdoor exposure encompassing a range of operating modes including Emergency Backup, Off Grid, Self-Consumption and Time of Use. This diverse set of installations demonstrate the thermal reliability of both aPower 2 and aPower S across a wide range of real-world conditions, regardless of whether the system is installed indoors or outdoors.

Massachusetts Outdoor Case Study

This outdoor residential energy storage installation demonstrated exceptional cell thermal stability during self-consumption operation.

Throughout daily operational cycles, cell temperatures were dynamically regulated within the optimal thermal range of 50° F to 57° F via the integrated thermal management system (TMS). Over the full monitoring period, total heating energy consumption reached 118 kWh/winter, with a daily average of 1.0 kWh/winter day, demonstrating the TMS's high energy utilization efficiency.

Even under extreme sub-zero ambient conditions (overnight ambient temperature dropping to -4° F) associated with Storm Hedge activation, the battery pack sustained a minimum cell temperature of 7° F. This validates the system's robust low-ambient operating performance and superior thermal retention capability.

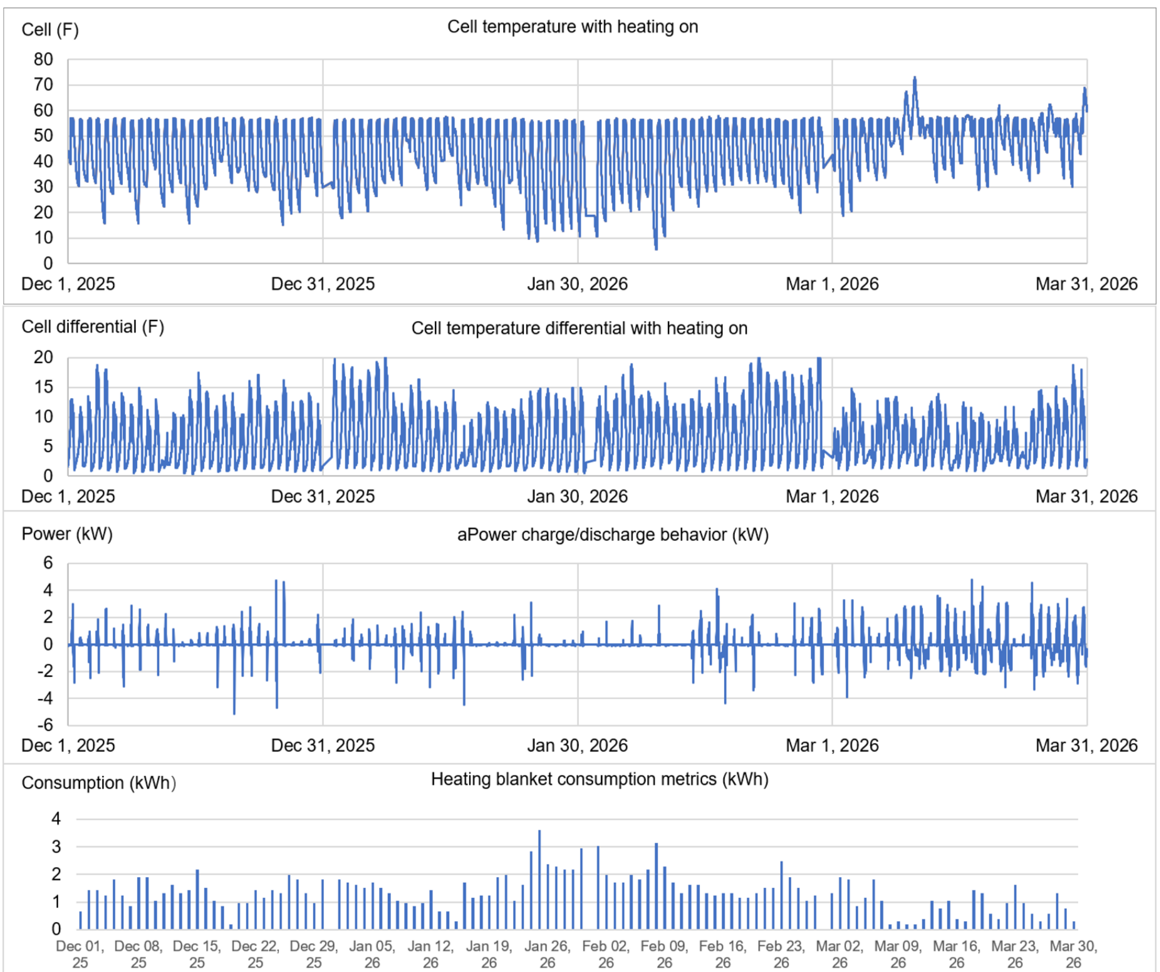


Figure 2. Massachusetts case study

Michigan Outdoor Case Study

This outdoor residential energy storage installation demonstrated exceptional **cell thermal stability** during self-consumption operation, similar to the Massachusetts case study. With Storm Hedge enabled, the system frequently **switched operating modes between** Self-Consumption and Emergency Backup in response to storm alerts, ensuring uninterrupted power supply amid winter grid outages.

Throughout daily operational cycles, cell temperatures were dynamically regulated within the optimal thermal range of 50° F to 57° F via the integrated TMS. Over the full winter monitoring period, total heating energy consumption reached 110 kWh, with a daily average of 0.95 kWh, demonstrating the TMS's high energy utilization efficiency.

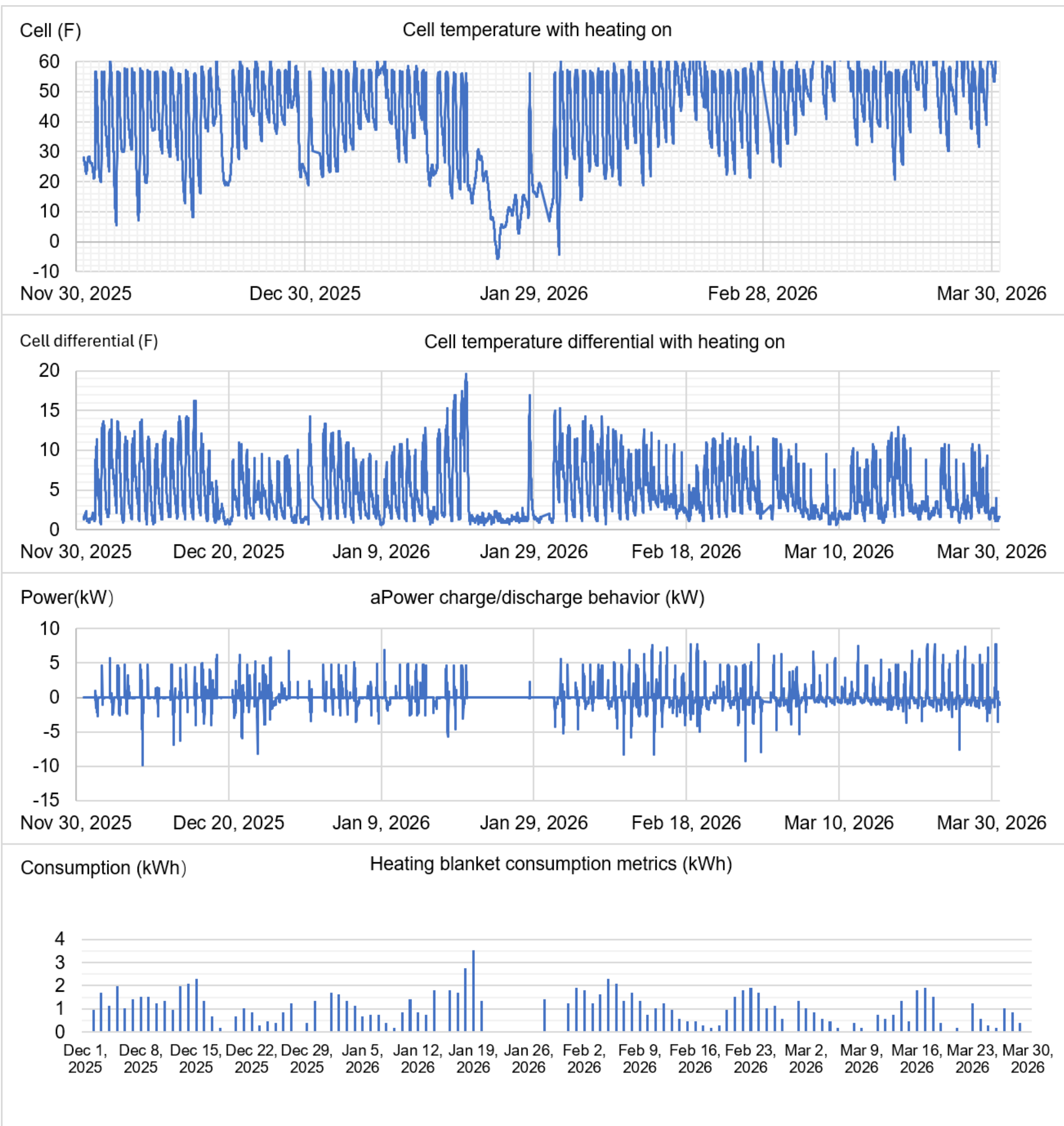


Figure 3. Michigan case study

Vermont Indoor Case Study

A significant portion of the Vermont fleet operates in Emergency Backup mode due to the frequency of power outages during severe weather events. In these regions, homeowners often prioritize resiliency and backup power availability over energy optimization, resulting in more systems being configured to maintain higher backup reserves.

This case represents an indoor installation in a climate controlled environment where ambient room temperatures were maintained between 60° F and 75° F. As a result, the integrated heating system did not operate much during the winter. Throughout this period, the aPower unit continued to charge and discharge at power levels of up to 8 kW and 10 kW respectively. While this homeowner chose an indoor installation, both the aPower 2 and aPower S are designed and certified for outdoor installations as well, providing reliable performance and peace of mind across a wide range of environmental conditions.

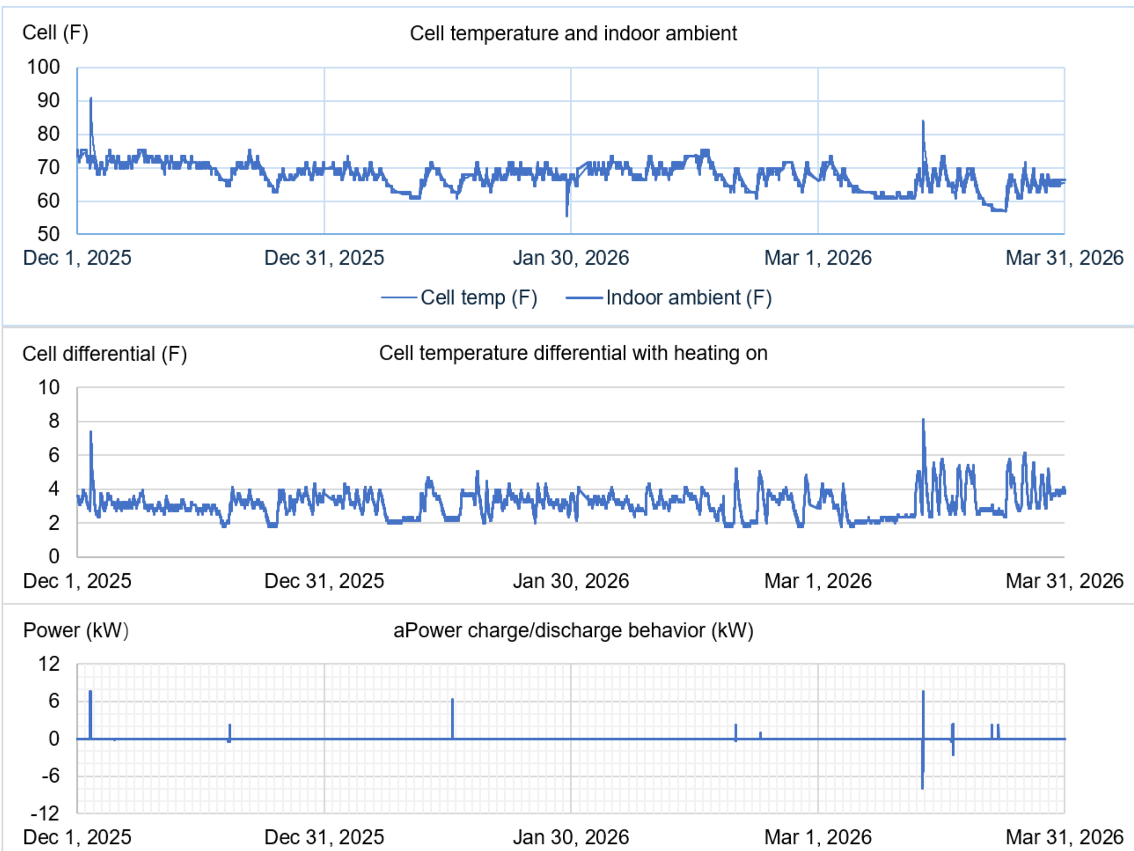


Figure 4. Vermont case study

Colorado Indoor Case Study

This is another indoor installation with TOU mode located in Colorado where homeowner preference was indoor installation. The integrated heating system remained off for nearly the entire Winter 2025-2026 season. Throughout the period, aPower cell were maintained between 55° F and 95° F, with cell-to-cell temperature variation generally within 10° F.

The system was configured to discharge during peak-rate periods between 4:00 PM and 9:00 PM. Charging, including grid charging, was enabled from 9:00 PM through the following day until 4:00 PM, allowing the battery to recharge during off-peak hours and optimize energy savings. The battery discharge during peak-rate hours helped increase cell temperatures without requiring the heating blankets to activate for the most part. This is an important point that homeowners often overlook that batteries naturally generate heat during charging and discharging, which can contribute to maintaining operating temperatures in colder conditions.

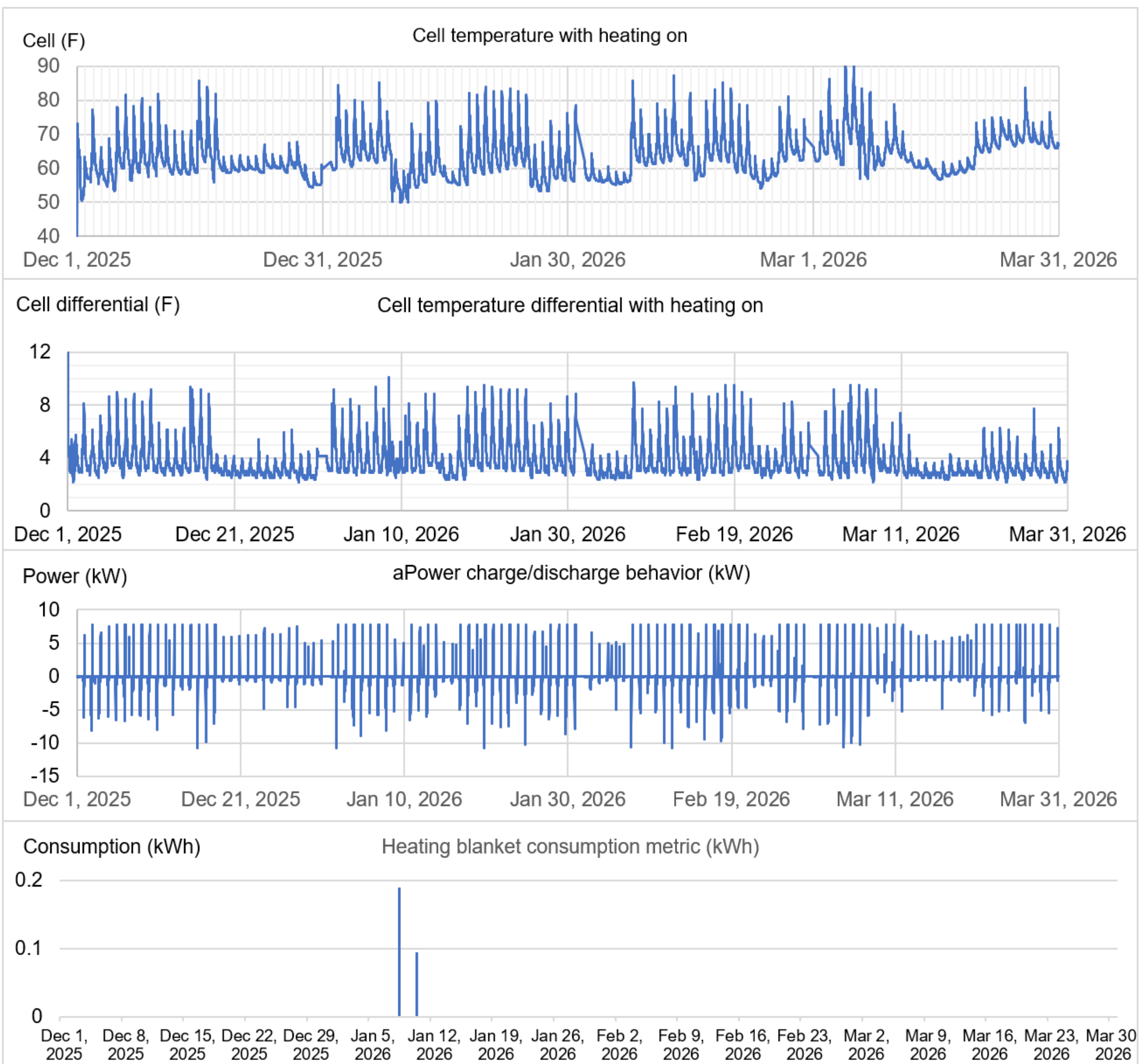


Figure 5. Colorado case study

Canada Indoor Case Study

This site in Ontario, Canada, is another indoor installation with a 9.6 kW solar system and two aPower 2 units operating in TOU mode. This is a common configuration in this region, where homeowners are interested in FranklinWH Systems not only for resiliency but also for TOU arbitrage and avoiding peak electricity rates. This case differs from the indoor installations analyzed above, as it shows measurable heating blanket energy consumption due to more severe winter conditions in the place.

The aPower heating energy consumption was approximately 30 kWh over the winter, averaging 0.25 kWh per day. Cell temperatures remained between 50° F and 60° F, while indoor ambient temperatures ranged from 30° F to 60° F.

The system supported discharge levels between 4 kW and 8 kW, with charging rates between 3 kW and 4 kW. Solar generation peaked between 6 kW and 7 kW, with an assumed ~70% effective generation rate relative to nameplate PV capacity throughout the winter.

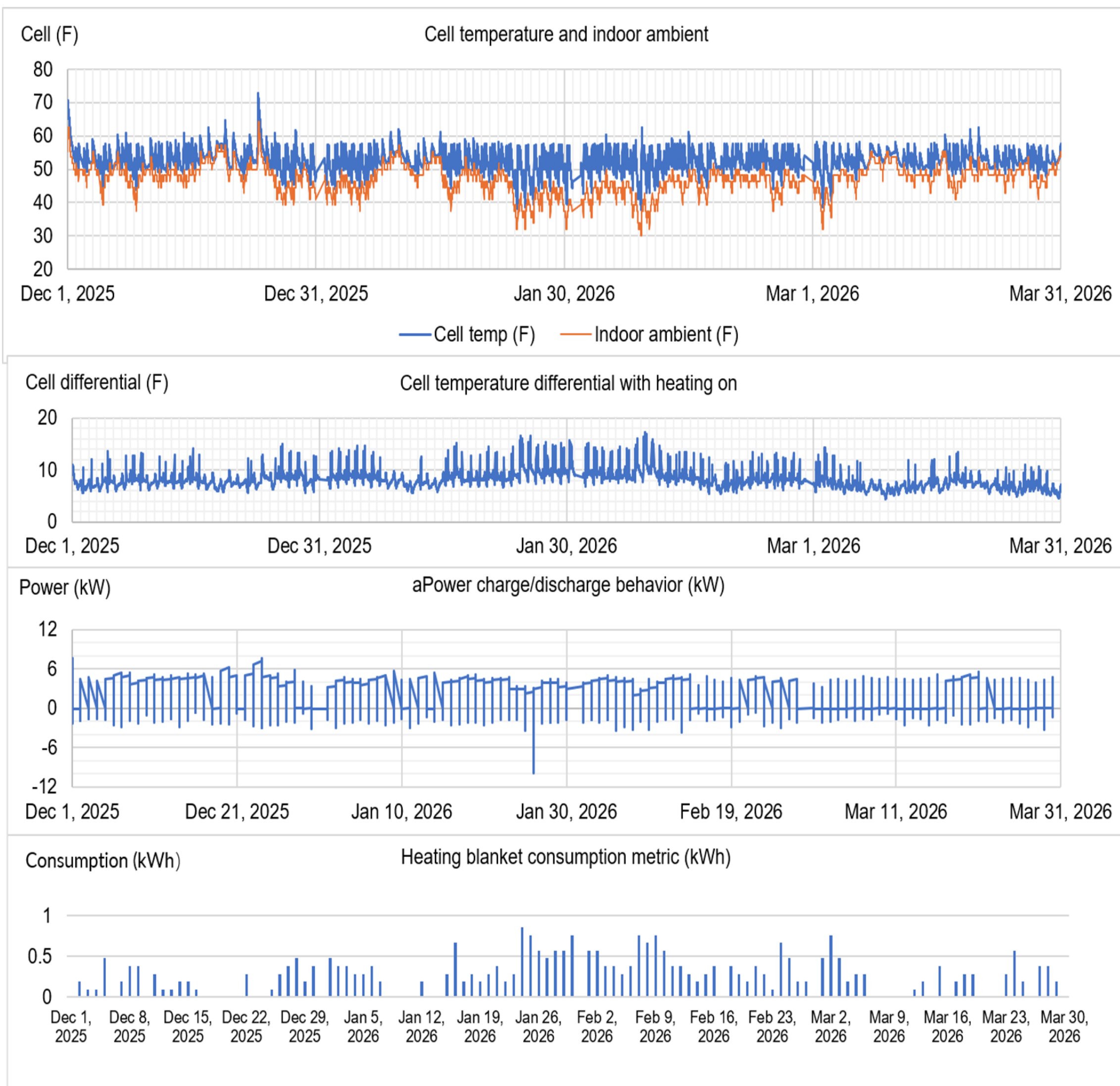


Figure 6. Canada case study

Looking Forward

The fleet data presented and analyzed in this white paper confirms that FranklinWH aPower batteries deliver consistent thermal reliability across a wide range of cold climate operating conditions for both indoor and outdoor installations. The 2025-2026 winter season provided a rigorous real-world test of that reliability, and the results validate the core thermal design while also informing the next generation of cold weather improvements. During the most severe record breaking winter weather events, with temperatures outside the operational temperature range, some aPower units experienced temporary charging deration, reduced storage capacity or increased standby losses. These behaviors are expected characteristics of lithium based batteries at very low temperatures and are reliably managed by the TMS to protect battery health, maintain safety, and ensure long term reliability. At the fleet level, 99.92% of the fleet maintained cell temperatures within the designed operating range throughout the season, affirming the thermal reliability of the aPower platform under real world conditions.

FranklinWH continues to heavily invest in R&D across hardware, firmware, system software, and installer and customer experience to further advance cold weather performance and reliability. Active areas of development include optimizing heating blanket operation, evaluating advanced thermal insulation materials, refining heating control logic, reducing system standby losses and exploring passive thermal management approaches that reduce energy consumption without compromising cell health.

These efforts reflect a long-term commitment to ensuring that the FranklinWH System remains dependable and trusted solution in the harshest operating environments our customers face. These advancements are planned across product releases throughout late 2026 and into 2027 as we continue to further improve cold weather performance and system reliability.

FAQs

What happens if the ambient temperature drops below –4° F?

If the ambient temperature falls below -4° F while the battery cell temperature remains above this threshold, the aPower will continue to discharge normally and apply charge-rate derating based on cell temperature. If the cell temperature approaches -4° F, the system will begin limiting discharge output to protect the battery until the cell temperature rises above -4° F. Should the cell temperature continue to decrease below the protection threshold, the system will enter a protective shutdown mode. Normal operation will automatically resume once the cell temperature increases above -4° F.

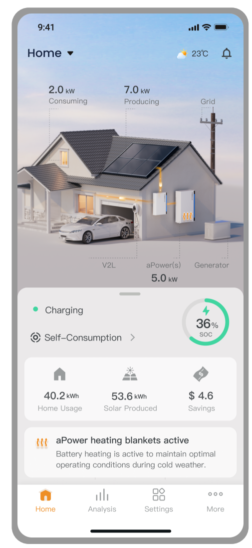
How much power does the heating system consume?

The aPower 2 and aPower S are equipped with two 220 W rated heating pads, delivering a total rated heating power of 440 W. Actual energy consumption depends on heating runtime and mode of operation of the battery, which is intelligently optimized to balance system performance and operational stability.

The heating blanket prioritizes PV power supply first before drawing electricity from the grid when aPower(s) are charging, and aPower(s) energy supply while they discharge.

Can I check the heating blanket status on the FranklinWH App?

Yes, installers and homeowners can monitor heating blanket activity directly through the FranklinWH App.



What are some recommendations to optimize system performance in freezing weather?

The FranklinWH System is designed to deliver reliable performance in cold-weather conditions. To maximize performance and system availability during winter operation, consider the following best practices:

- In regions that experience prolonged periods of extreme cold, indoor installation in a temperature-controlled environment is recommended whenever possible.
- Avoid leaving the battery idle for extended periods during winter. Occasional charge and discharge activity helps generate internal heat, maintain optimal cell temperatures, and improve overall system performance.
- Enable battery pre-conditioning to improve charging efficiency in cold weather. Configuring a Time-of-Use (TOU) or self-consumption schedule can help warm the battery prior to charging, reducing the likelihood of charge-rate deration and improving overall energy availability.

Can the aPower batteries be installed outdoors?

Yes, both aPower 2 and aPower S support indoor and outdoor installations. For regions with long-lasting severe freezing weather, indoor installation is recommended.

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