WK WHITE PAPERS

IMMERSION COOLING BATTERY STORAGE

AN EFFECTIVE TECHNOLOGY FOR AIRPORTs AND ANSPs SECURITY

Executive Summary

Immersion cooling, where battery cells are fully submerged in a non-conductive dielectric fluid, is a transformative technology for BESS. For airports and ANSPs, whose operations are defined by uninterruptible safety, critical reliability, and massive energy demands, immersion BESS offers a superior solution compared to traditional air-cooled or chilled-water systems. It directly addresses key challenges like safety, thermal runaway prevention, energy efficiency, and space constraints.

1. What is Immersion Cooling for BESS?

In an immersion-cooled BESS, the standard battery modules are placed in a sealed tank filled with a specialized coolant (e.g., synthetic or mineral oil). This fluid has two primary functions:

- Cooling: It efficiently draws heat away from the cells during charging and discharging cycles.
- Fire Suppression: It eliminates oxygen from the cell environment, making thermal runaway propagation virtually impossible.

This technology is a significant step up from traditional methods, offering more stable temperatures, longer battery life, and drastically improved safety.

2. Key Drivers for Adoption in Airports & ANSPs

· Safety First (The Paramount Concern): The absolute worst-case scenario for an airport or ANSP is a fire. Traditional BESS can pose a fire risk. Immersion cooling effectively negates the risk of catastrophic battery fires, making it the only viable choice for installing large-scale BESS in safety-critical infrastructure.

· Uninterruptible Power: ANSPs (managing radar, navigation aids, control towers) and key airport functions (e.g., runway lights, boarding bridges) require 100% uptime. Immersion BESS provides highly reliable backup power with minimal maintenance and degradation.

· Sustainability & Decarbonization: Airports are major energy consumers with ambitious net-zero targets. BESS is a key enabler for integrating solar PV, managing peak demand, and reducing reliance on fossil-fuel-based backup generators.

· Energy Cost Reduction: Electricity demand charges (based on peak usage) constitute a significant portion of an airport's utility bill. A BESS can discharge during short peak periods to "shave" these peaks, leading to substantial cost savings.

· Grid Stability and Revenue: Large airports can act as grid assets. They can participate in demand response programs, providing frequency regulation services to the local utility and generating new revenue streams.

3. Specific Applications and Use Cases

- For Air Navigation Service Providers (ANSPs)

ANSPs are responsible for the safe and orderly flow of air traffic. Their infrastructure is often remote and absolutely critical.

· Backup Power for Remote Sites: Navigation aids (VOR, DME, ILS), radar stations, and communication sites are often located on hilltops or remote areas with less stable grid connections. An immersion BESS can provide seamless backup power during outages, ensuring continuous operation without the delay of a diesel generator starting.

· Uninterruptible Power Supply (UPS) Replacement: Traditional UPS systems (e.g., lead-acid or flywheel) for control centers have short durations and high maintenance. An immersion BESS can provide longer-duration backup for critical systems, bridging the gap until generators take over or allowing for a safe shut-down procedure.

· Microgrids for Critical Infrastructure: ANSPs can create resilient microgrids for their most critical sites, combining solar PV, a diesel generator, and an immersion BESS. The BESS manages the microgrid, ensuring smooth transitions between power sources and maximizing solar consumption.

- For Airports

Airports are like small cities with complex and diverse energy needs.

· Peak Shaving and Demand Charge Management: The simultaneous operation of HVAC systems, baggage handling, retail, and aircraft ground power (GPU) and preconditioned air (PCA) units creates massive, short-term demand spikes. An immersion BESS is discharged during these peaks to flatten the load profile, reducing demand charges by 20-30%.

· Backup for Critical Systems: Provides reliable backup power for:

- ✓ Air Traffic Control (ATC) towers
- ✓ Emergency systems
- ✓ Runway and taxiway lighting systems
- ✓ Passenger boarding bridges

· Electric Ground Support Equipment (eGSE) Charging: As airports electrify their vehicle fleets (baggage tugs, belt loaders, pushback tractors), the charging infrastructure places a huge strain on the electrical network. BESS can be used to support high-power charging stations, preventing the need for costly grid upgrades.

· Renewable Energy Integration: Many airports have large-scale solar arrays on terminal roofs, over parking lots or land available next to the airport. An immersion BESS stores excess solar energy generated during the day for use at night, maximizing self-consumption and reducing carbon footprint.

· Grid Services: Large airport BESS installations can be aggregated to provide frequency regulation and voltage support to the local utility grid, turning a cost center into a potential revenue center.

4. Advantages of Immersion Cooling Specifically for Airports/ANSPs

Enhanced Safety #1 Priority: Eliminates fire risk, allowing safe installation near terminals, hangars, and other critical infrastructure. Meets stringent regulatory and insurance requirements.

Higher Efficiency & Longer Life: The superior thermal management reduces battery degradation, extending system life beyond 10-15 years. This improves the return on investment (ROI) for long-term infrastructure projects.

Reduced Footprint: Immersion systems can be more energy-dense. This is crucial for space-constrained airports/ANSPs where real estate is extremely valuable.

Lower Operational Costs (OPEX): Eliminates complex air conditioning, refrigerant, and ducting systems. The cooling system uses less energy, and the maintenance is simplified, reducing total cost of ownership.

Operational Resilience: Performs consistently well in extreme ambient temperatures, whether in hot desert climates or cold regions, ensuring reliability year-round.

5. Challenges and Considerations

· Initial Capital Cost (CAPEX): Immersion-cooled BESS typically could have a slight higher upfront cost than air-cooled systems. However, this must be evaluated against the Total Cost of Ownership (TCO), which includes longer life, lower OPEX, and avoided risk.

· New Technology Perception: While rapidly maturing, it is still newer than traditional methods. This requires thorough due diligence and education of stakeholders, regulators, and insurers.

· Coolant Handling and Disposal: Procedures for handling, filtering, and eventually disposing of or recycling the dielectric fluid need to be established, though suppliers offering managed and qualified services for this.

· Regulatory and Standards Compliance: The immersion BESS manufacturers and providers must comply and adopt specific local regulations and recommendations.

6. Conclusion

For airports and ANSPs, the transition to immersion BESS is not just an upgrade. ***It's a strategic necessity.***

The unparalleled safety profile of immersion cooling is the key that unlocks the door to deploying BESS at scale within critical aviation infrastructure. By providing resilient, efficient, and sustainable power, immersion BESS becomes a foundational technology for modernizing airport energy systems, reducing operational costs, and supporting the aviation industry's journey toward a net-zero future.

The initial investment is justified by the profound benefits in risk mitigation, reliability, and long-term operational savings.

By Wahb KERMADI

Aviation Expert

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