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Stationary Backup and UPS Reserve Power for Data Centers, Hospitals, and Telecom

Critical facilities (data centers, hospitals, and telecom central offices) depend on reserve energy that sits idle for months yet must deliver full power the instant utility feed fails, and conventional chemistries lose charge at rest and carry a thermal-runaway fire risk that complicates indoor siting. The Hydrogen-Aluminum Energy Cell, disclosed in U.S. Provisional Application No. 64/055,649, is an architecture whose bulk-equipotential charge retention holds energy with no internal self-discharge driving force, whose reversible thermal stall replaces runaway with a recoverable stall, and whose field-serviceable gel medium extends usable service life. This application draws on the same disclosure's mechanochemical self-healing and dual-domain proton-conducting gel to serve stationary reserve duty.

What This Application Specifies

This application describes how the Hydrogen-Aluminum Energy Cell, an architecture disclosed in U.S. Provisional Application No. 64/055,649, would be configured as stationary reserve energy for critical facilities: the battery plant behind a data center uninterruptible power supply (UPS), the emergency power source feeding a hospital's life-safety branch, and the DC plant that keeps a telecom central office or cell site alive through a utility outage.

The disclosed cell is a sealed unit with two carbon current collectors, a bulk volume of dual-domain proton-conducting carbon gel that fills the interior with no internal separator, and a population of metal nanoflakes (aluminum in the preferred embodiment) dispersed through that gel. Energy is stored as electron-stabilized metal-hydrogen surface bonds on the nanoflakes, formed during charging by proton-coupled electron transfer and reversed during discharge when an external load withdraws the bonding electron. Because the gel is itself both electronically and ionically conductive, every flake in a charged cell sits at the same electrochemical potential, and the spec frames this bulk-equipotential condition as the reason the cell holds charge: there is no internal potential gradient to drive self-discharge, so the cell discharges only as fast as a closed external circuit admits.

For stationary duty, the relevant single-cell voltage is bounded (the spec recites roughly 2.5 to 3.0 volts per cell before carbon-framework oxidation onsets), so facility-scale DC bus voltages are reached by series stacking, exactly as recited in Section 9.10, with per-cell monitoring and remanufacturing. The underlying materials science here (metal-hydrogen surface chemisorption, proton-conducting sulfonated carbon gels, boron-doped turbostratic graphene, mechanochemical repair at strained sites) is established prior art. What this application configures into a stationary reserve product is the disclosed combination and architecture, not any newly discovered material or effect.

Why It Matters

Reserve power for critical facilities has a duty cycle unlike almost any other storage application: the asset spends nearly all of its life fully charged and idle, then must deliver rated power within milliseconds and sustain it for a defined ride-through window until generators start or the utility returns. Two properties dominate the economics and the siting decision.

The first is rest behavior. Conventional rechargeable chemistries lose roughly 1 to 5 percent of capacity per year to spontaneous internal degradation that proceeds whether or not the cell is cycled, and they require continuous float charging to stay topped up, which itself ages the cell. The disclosed architecture attacks this at its root: the spec recites that the gel is a passive medium that does not undergo internal degradation in the absence of bias, that the metal-hydrogen bond is a kinetically trapped state stable without continuous external bias, and that the bulk-equipotential condition removes the internal driving force for self-discharge. On those mechanisms the disclosure projects calendar self-discharge well below 1 percent per year. A reserve asset that holds its charge at rest, rather than bleeding it into a float charger, changes the maintenance and total-cost picture for a facility that may go years between real outages.

The second is failure behavior. Indoor battery rooms in hospitals and data centers are governed by fire and life-safety requirements precisely because conventional lithium-ion plant can enter irreversible thermal runaway. The disclosed cell is engineered with a different failure character: a reversible heat-triggered discharge stall, and a mechanical-breach response that oxidizes stored energy into non-flammable products. A reserve technology whose dominant failure modes are recoverable or benign is directly relevant to where, and how densely, a facility can site it.

How It Composes With the Domain

A stationary reserve deployment maps onto the disclosed architecture as an enabling implementation, not as new technology dressed up as a use case.

Idle hold through bulk-equipotential retention. The UPS or DC-plant string sits charged between outages. Per Chapter 2, with no external circuit closed, the flakes are equipotential and no internal current path exists. The spec's long-term storage mode (Section 9.4) is the exact operating profile of a reserve asset: charged to a target state and held without load for extended periods, with projected self-discharge well below

one percent per year. State of charge can be read directly from open-circuit voltage because the discharge curve is smooth (Section 9.2), which suits the periodic readiness checks that critical-facility codes require.

Instant, high-rate delivery on transfer. When the utility feed drops and the static transfer switch closes the load onto the battery, the cell must source current immediately. The disclosed high-rate discharge mode (Section 9.3) supports sustained currents the spec characterizes as 10C to 100C for short windows, enabled by the absence of separator impedance, the bulk-equipotential architecture that lets charge be drawn from any region rather than a localized electrode, and surface-bond chemistry without diffusion-limited intercalation. For a UPS bridging to a generator start, or a telecom plant absorbing a load step, this is the relevant behavior. The same fast-response capability the spec ties to grid-frequency response applies to UPS ride-through and to grid-services revenue when a facility's reserve doubles as a demand-response resource.

Thermal stall instead of runaway. Section 9.9 recites that above roughly 60 to 90 degrees Celsius the rate of controlled carbon-framework breakage exceeds the healing rate, internal resistance climbs, and the cell enters a high-resistance stalled state where discharge current falls to negligible levels regardless of load. Crucially, the spec recites this as reversible: on cooling, the auxiliary carbon reservoir reforms the conductive paths and capacity returns. For an indoor battery room, an over-temperature, over-current, or external-fire condition drives the affected cells toward a recoverable stall rather than a propagating runaway.

Benign breach products. Section 9.12 recites that on puncture or crush, oxygen ingress oxidizes the stored energy into water vapor, aluminum oxide particulate, and carbon dioxide, on a fast timescale, converting the breached-cell hazard away from electrocution and yielding non-flammable products in contrast to the flammable solvent vapors of lithium-ion runaway. This matters for seismic, vehicle-impact, and maintenance-accident scenarios in occupied buildings.

Field-serviceable gel and full remanufacturing. The disclosure recites two distinct service architectures. In the field-serviceable variant, the consumable gel medium is replaced while the durable metal nanoflake population is retained, which the spec frames as extending operational life by an order of magnitude or more relative to single-fill operation. In the fully hermetic variant (Section 1.9), the cell is sealed for life and material is recovered by centralized remanufacturing (Chapter 8), which rebuilds cells to the same or improved specification. A facility operator can choose the variant whose service model fits its maintenance regime, and per-cell state-of-health monitoring (Section 9.8) supports predictive rather than reactive replacement scheduling.

What This Enables

Configured for stationary reserve duty, the disclosed architecture admits a range of embodiments:

- **Data center UPS plant** sized for the bridge-to-generator window, where the value is holding charge across long idle intervals without float-charge aging and delivering high-rate current on transfer.
- **Hospital essential and life-safety power**, where a recoverable thermal-stall and non-flammable breach response bear directly on indoor siting alongside occupied spaces, and where multi-year charge retention reduces the testing-and-replacement burden on facilities staff.
- **Telecom central-office and cell-site DC plant**, where remote and unstaffed sites benefit from minimal at-rest maintenance and from a failure character that does not propagate, and where per-cell monitoring supports scheduled rather than emergency truck rolls.
- **Dual-use reserve assets** that idle as backup but participate in grid-frequency response or peak-shaving between outages, exploiting the same high-rate capability and use-positive aging (the disclosed mechanochemical healing of Chapter 7,

projected to let cumulative cycling stabilize rather than monotonically erode capacity).

- **High-voltage strings** assembled by series stacking standardized cells (Section 9.10) with inter-cell isolation, thermal management, and individual monitoring, so a single cell design spans facility bus voltages from telecom DC plant to large UPS systems.
- **Capacity and chemistry variants** chosen per site: aluminum-based flakes for cost and abundance, low-loading high-cycle-life formulations for cycling-heavy dual-use plant, and higher-loading formulations where volumetric reserve density dominates.

Boundary Conditions

The honest limits matter here. U.S. Provisional Application No. 64/055,649 is a provisional disclosure of an architecture. It has not been built, validated, or benchmarked, and the spec itself flags its central reserve-relevant properties as projected from disclosed mechanisms and to be determined empirically: the sub-1-percent-per-year self-discharge, the use-positive aging profile, and the long-term storage performance are all recited as projections pending prototype and long-duration testing. No energy-density, cycle-life, efficiency, or cost figure should be read from this article as a product specification, and none is asserted here.

The underlying materials science is prior art. Surface-bonded hydrogen, proton-conducting carbon gels, boron-doped graphene, and mechanochemical healing are each established in published research; the novelty asserted in the disclosure is the combination, architecture, governance, and resulting cell category, not any constituent material or physical effect. The spec also discloses real engineering limits relevant to stationary use: a single-cell voltage bound that mandates series stacking, a round-trip efficiency in the range of roughly 70 to 90 percent that the disclosure itself calls lower than conventional intercalation cells but acceptable for stationary applications, a long-timescale aluminum-leakage degradation mode (with disclosed mitigations), and an

eventual gel-exhaustion failure mode that the service or remanufacturing architecture is designed to address. The thermal-stall behavior, while a safety feature, can read as an availability constraint in under-sized installations, which the spec explicitly frames as a system-design signal to add cells or cooling.

Finally, deploying reserve power in hospitals, data centers, and telecom facilities is governed by fire codes, life-safety standards, and electrical codes administered by the relevant authorities having jurisdiction. Those requirements are external context. Whether a given implementation of this architecture satisfies them is an engineering and certification question outside the scope of the disclosure.

Disclosure Scope

The technology described here is the Hydrogen-Aluminum Energy Cell as disclosed in U.S. Provisional Application No. 64/055,649. All statements about what the cell does (bulk-equipotential charge retention, surface-bonded hydrogen storage, reversible thermal-stall behavior, mechanical-breach oxidation to benign products, mechanochemical self-healing, high-rate discharge, field-serviceable gel replacement, and centralized remanufacturing) trace to that disclosure and are presented as disclosed and, where the specification so states, as projected pending empirical validation. The data center, hospital, telecom, and grid-services framing, including duty cycles, siting considerations, and any reference to fire, life-safety, or electrical codes and the authorities that administer them, is external domain context provided to show an enabling application of the disclosed architecture. That domain and regulatory framing is not part of the patent claims, and nothing in this article should be read as a representation that the architecture has been built, certified, or shown to meet any standard or performance figure.

Hydrogen-Aluminum Energy Cell (/h-al-battery)

All 40 steps → (/inventive-steps)

Sealed electrochemical cell storing energy as reversible covalent hydrogen bonds on carbon electrodes.

Provisional application

PRIMARY TECHNICAL DISCLOSURE

- A Hydrogen-Aluminum Surface-Bond Storage Cell with Bulk-Equipotential Charge Retention (/articles/a-hydrogen-aluminum-surface-bond-storage-cell-with-bulk-equipotential-charge-retention)

SECONDARY TECHNICAL

- Charge Retention by Bulk-Equipotential Saturation Without an Internal Separator (/articles/h-al-battery/bulk-equipotential-charge-retention)
- Storing Energy as Electron-Stabilized Metal-Hydrogen Surface Bonds Formed by Proton-Coupled Electron Transfer (/articles/h-al-battery/hydrogen-metal-surface-bond-storage)
- Electron-Mediated Bond Stability: The Kinetically Trapped Idle State Behind Indefinite Calendar Life (/articles/h-al-battery/electron-mediated-bond-stability)
- Hot-Proton Charging Versus Cold-Proton Discharge: The Bias-Gated Asymmetry That Blocks Self-Charge and Self-Discharge (/articles/h-al-battery/hot-cold-proton-asymmetry)
- Asymmetric Dual-Domain Proton Paths: Separate Ingress and Egress Routes in a Hydrogen-Aluminum Storage Gel (/articles/h-al-battery/asymmetric-dual-domain-paths)
- Hydrophobic Gating: Rejecting Neutral and Molecular Hydrogen While Admitting Only Biased Protons (/articles/h-al-battery/hydrophobic-gating)
- The Storage Gel as a Polarized Electrochemical Switch: Coherent Alignment, Equipotential Locking, and Load-Proportional Discharge (/articles/h-al-battery/gel-polarized-switch)
- Flake-Flake Electrostatic Isolation: DLVO Repulsion as a Self-Discharge Barrier in a Separator-Free Hydrogen-Aluminum Cell (/articles/h-al-battery/flake-electrostatic-isolation)
- Dynamic Flake Expansion: Carbon-Intercalation Wedging to Expose Buried Metal Surface Under Bias (/articles/h-al-battery/dynamic-flake-expansion)
- Hydrogen-Locked Expanded State: Surface-Energy Inversion as a Positive-Feedback Capacity Mechanism (/articles/h-al-battery/hydrogen-locked-expanded-state)
- Secondary Carbon-Hydrogen Storage on Transmuted Intercalated Carbon (/articles/h-al-battery/secondary-carbon-hydrogen-storage)

- Mechanochemical Strain Self-Healing and Use-Positive Aging in a Bulk-Equipotential Hydrogen-Aluminum Cell (/articles/h-al-battery/mechanochemical-self-healing)
- Boron Doping of the Carbon Framework as a Multi-Function Precision Multiplier (/articles/h-al-battery/boron-doping-precision-multiplier)
- The Floating Aluminum Equipotential Extension Layer: A Multifunctional Inner Case for the Bulk-Equipotential Cell (/articles/h-al-battery/aluminum-equipotential-extension-layer)

APPLICATIONS · GENERAL

- Grid-Scale and Renewable-Firming Storage with the Hydrogen-Aluminum Energy Cell (/articles/h-al-battery/grid-scale-storage)
- Building-Integrated and Behind-the-Meter Storage: Putting Energy Cells Inside the Structure With the Hydrogen-Aluminum Energy Cell (/articles/h-al-battery/building-integrated-storage)
- **Stationary Backup and UPS Reserve Power for Data Centers, Hospitals, and Telecom (/articles/h-al-battery/backup-and-ups)**
- Storage for Microgrids, Islands, and Off-Grid Sites: A Stationary Cell Built From Abundant Materials (/articles/h-al-battery/microgrid-and-off-grid)
- Electric Mobility and Transport: How a Hydrogen-Aluminum Cell Architecture Maps to Vehicle Constraints, and Where It Does Not (/articles/h-al-battery/ev-and-mobility)
- Marine and Rail Energy Storage: A Bulk-Equipotential Hydrogen-Aluminum Cell for Mass-Tolerant Heavy Transport (/articles/h-al-battery/marine-and-rail)
- Supply-Chain-Resilient Field Power: An Abundant-Material Energy Cell for Defense and Expeditionary Operations (/articles/h-al-battery/defense-and-field-power)
- Fast-Response Frequency Regulation and Power Quality Without a Separate Power Bank (/articles/h-al-battery/frequency-regulation-power-quality)

APPLICATIONS · SPECIFIC

- CATL (Contemporary Amperex Technology Co. Limited) alternative: a hydrogen-aluminum cell architecture vs LFP, NMC, and sodium-ion at the chemistry-category and materials-sourcing level (/articles/h-al-battery/catl)
- LG Energy Solution NCM/NCMA lithium-ion cells vs the Hydrogen-Aluminum Energy Cell: an architectural comparison (/articles/h-al-battery/lg-energy-solution)
- Form Energy iron-air multi-day grid storage vs a sealed bulk-equipotential hydrogen-aluminum cell: an architectural comparison (/articles/h-al-battery/form-energy)
- ESS Inc, maker of long-duration iron flow batteries vs a sealed solid-state cell: comparing the flow architecture to the Hydrogen-Aluminum Energy Cell (/articles/h-al-battery/ess-inc)
- Ambri liquid-metal battery vs a solid-state hydrogen-aluminum energy cell: architectural comparison for stationary storage (/articles/h-al-battery/ambri)

- QuantumScape solid-state lithium-metal battery vs a bulk-equipotential hydrogen-aluminum surface-bond cell: an architecture comparison (/articles/h-al-battery/quantumscape)
- Natron Energy sodium-ion (Prussian-blue-electrode) batteries vs a hydrogen-aluminum surface-bond cell: an abundant-materials architecture comparison (/articles/h-al-battery/natron-energy)
- Eos Energy Enterprises Znyth zinc long-duration storage vs a hydrogen-aluminum equipotential cell: an abundant-materials architecture comparison (/articles/h-al-battery/eos-energy)
- EnerVenue nickel-hydrogen stationary cells vs a hydrogen-aluminum equipotential cell: two ways to store hydrogen in a battery (/articles/h-al-battery/enervenue)
- Skeleton Technologies supercapacitors vs the Hydrogen-Aluminum Energy Cell: pairing high power with bulk energy storage (/articles/h-al-battery/skeleton-technologies)

Hydrogen-Aluminum Energy Cell overview → (/h-al-battery)