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Energy and Grid-Coupled Surfaces: Crediting Stationary Storage in Structural Mass Without Trusting the Cell

Stationary storage on the grid is dispatched on numbers nobody can independently check: a battery room reports its state of charge, its capacity, and its availability, and the utility, the building, and the market operator are asked to trust those figures. When storage capacity stops living in a dedicated device and starts living in the structural mass of a building, that trust problem multiplies across every wall, slab, and foundation that now carries charge. This article shows how an energy-storage property-surface, built on the Credentialed Surfaces, disclosed in U.S. Provisional Application No. 64/050,895, composes a structure with stationary storage as a credentialed attestation layer, so that distributed storage participates in building energy management and in grid services on signed, authority-attested values rather than on asserted ones. It draws on sibling portfolio inventions for its identity, settlement, and governance primitives.

What This Application Specifies

This document specifies how the energy-storage property-surface applies to energy and grid-coupled deployments: stationary storage that participates in a building's electrical system and in grid services. The surface is a credentialed attestation layer. It is the

signed, authority-attested boundary by which a structural element's storage capability is admitted to aggregation, dispatch, and settlement. It is not a claim to the internal chemistry of the storage cell, and nothing here asserts a particular energy density, cycle life, efficiency, or cost.

The home inventive step is the Credentialed Surfaces, disclosed in U.S. Provisional Application No. 64/050,895. That disclosure inverts energy storage from a property of dedicated devices to a credentialed property of structural building materials, with the building's electrical system, rather than per-device power electronics, as the aggregation primitive. A credentialed structural element carries an admissibility profile composed of independently credentialed property surfaces (structural, thermal, energy storage, fire-performance, carbon-sequestration, distribution, network, water-coupled, and others), each signed by an authority with declared scope and composed through signed, versioned composition rules. The energy-storage admissibility surface is one such surface. It declares storage capacity, power capacity, cycle count, calendar age, round-trip efficiency, fault history, and degradation indicators, and the disclosure names a utility or building-code authority as its signer.

The application to the energy domain is straightforward to state and load-bearing in practice: every value a grid operator would otherwise have to take on faith from a storage asset is instead carried on a signed surface, bound to a specific physical element, weighted by current state-of-health, and recorded in a lineage chain that preserves prior values for audit. The underlying storage behaviors, electric-double-layer capacitance, Faradaic redox, air-cathode chemistry, are established science treated here as attested values; the novelty is the credentialing and admissibility architecture wrapped around them.

Why It Matters

Grid-coupled stationary storage is governed by trust in self-reported numbers. A storage resource that bids capacity into a frequency-regulation or capacity-reserve market is committing to deliver kilowatt-hours over time, and the market operator's settlement, the utility's dispatch planning, and the building owner's revenue all depend on whether the committed figure is real. Today that figure is asserted by the asset's own controller. When the asset is a single battery room, the trust surface is at least concentrated in one place. The disclosed architecture deliberately distributes storage across structural mass that would otherwise be poured for structural reasons, so the trust surface fragments across walls, slabs, foundations, and precast blocks throughout a building or a federation of buildings. Without a credentialing layer, that fragmentation would make distributed structural storage uninspectable.

The energy-storage property-surface exists to make the fragmented resource governable. Because realized storage capacity degrades with cycling, calendar age, carbonation, freeze-thaw exposure, and mechanical fatigue, a static nameplate figure would be wrong almost immediately. The surface is therefore not a nameplate; it is updated through state-of-health attestations signed by the building energy management system's attestation module and recorded in the lineage chain. A utility evaluating a virtual-power-plant participant, a balancing authority settling a dispatch, an insurer underwriting a facility, or a building-code authority reviewing an installation can each evaluate the same composed admissibility profile and reach the same answer about what the storage can actually do at a given moment. The matter at stake is whether distributed storage can be admitted to the grid on evidence rather than on assertion.

How It Composes With the Domain

In an energy and grid deployment, the storage surface is consumed by the building energy management system, which is the aggregation primitive the disclosure places at the center of the architecture. The system discovers structural-storage capacity

distributed across structural elements, characterizes each element's admissibility, aggregates the distributed capacity into a coherent storage resource, evaluates credentialed access through composite admissibility evaluation, and dispatches energy to credentialed loads through governed actuator execution. The aggregation module computes the coherent resource as the sum of constituent element capacities weighted by current state-of-health, adjusted for constraints arising from multi-element coordination. The dispatch module operates individual elements consistent with the access-evaluation determination and records each dispatch event in the lineage chain. This is how a wall, a floor, and a foundation are admitted as credentialed structural-storage elements and operated as one resource, as the disclosure describes for the substrate-mode building.

The storage surface never operates alone. It composes with the element's other surfaces through signed, versioned composition rules held in a composition-rule registry that the building energy management system consumes at admissibility-evaluation time. The disclosure enumerates representative rules directly relevant to grid coupling: a fire-event rule reducing storage admissibility to zero when the fire-performance surface declares fire-event detection; a thermal-runaway prevention rule constraining dispatch during high thermal-surface readings; a structural-load-versus-storage-cycle rule reducing storage admissibility when the structural surface reports fatigue above a declared threshold; a wet-environment storage rule requiring current water-coupled attestations before admitting storage operations near wet surfaces; and freeze-thaw-derated and carbonation-tracked capacity rules. A grid dispatch is thus admitted only when the composite profile, not the storage surface in isolation, permits it.

For grid participation specifically, the building energy management system issues duration-attested commitments to grid-service authorities. These declare kilowatt-hour-over-time profiles with declared reliability, signed by the system's credentialed identity, and matched-pair-settled per the matched-pair settlement primitive of the sibling Spatial Mesh Application. The disclosure distinguishes a duration-attested commitment from amperage-rated capacity participation: the offer to the grid is

provable kilowatt-hour-over-time rather than instantaneous power, with the substrate's chemistry class governing the available duration profile (capacitive supporting sub-minute duration, Faradaic supporting minutes-to-hours, air-cathode supporting multi-hour duration). Settlement can run pair-settled and direct, between a building energy management system and a balancing authority and market operator through their credentialed identities and a temporal proximity window, without an intermediary aggregator or platform operator, as distinguished in the disclosure from aggregator-mediated topologies.

The grid-coupled embodiments scale through federation. The disclosure contemplates a peer-to-peer mesh of building energy management systems, a neighborhood-pool topology with declared shared dispatch authority, a utility-territory aggregation operating as a virtual power plant under utility-authority-declared scope, and cross-jurisdictional federation under multi-authority-declared scope, each coordinated by a federation orchestrator operating under credentialed scope declared by the participating systems rather than as a hierarchical control authority. At a single property, the storage surface composes across substrate classes (a building, a paved surface, a rooftop photovoltaic generation substrate, a vehicle when present, and the grid connection) federated as credentialed mesh nodes. At grid scale, the same primitive aggregates distributed structural storage into utility-territory, regional, and international long-duration storage resources.

The energy-domain composition leans on several sibling portfolio inventions named in the disclosure. The Identity Application's keyless-identity-through-continuity primitive supplies the signature scheme that binds elements, authorities, and profiles. The Spatial Mesh Application supplies matched-pair settlement for grid-services settlement. The Cognition Application's governance chain provides the evidential weighting and governed actuator execution under which the building energy management system operates. The Protocol and Execution Applications provide the panel-resident network and persistent-agent primitives by which credentialed panels operate as discoverable nodes.

What This Enables

Treating storage as a credentialed attestation layer enables several deployment patterns in the energy domain. A virtual power plant can admit distributed structural storage as a participant on the same evidentiary footing as a dedicated battery, because each contributing element carries a signed storage surface and a state-of-health history rather than an unverifiable controller report. Long-duration energy storage can be assembled from structural mass aggregated through federation, with the disclosure noting that the substrate's marginal cost approaches the marginal cost of the additive applied to composite that would have been poured anyway, distinct from installations whose capital cost is dominated by dedicated battery infrastructure.

The attestation layer also enables honest derating across the asset's life. Because the surface is updated through state-of-health attestations and governed by capacity rules tied to the structural and environmental surfaces, a federation's offer to the grid tracks realized capability as it declines, rather than overcommitting against a stale nameplate. End-of-storage-life is itself a credentialed transition: when realized capacity degrades below a declared threshold, the storage surface is updated to zero or reduced capacity while the structural surface continues to support the element's load-bearing function, and continuous re-credentialing across material flows can refresh or augment the storage substrate without demolishing the structure. For grid planners, that means a storage resource whose decommissioning and refresh events are auditable transitions in a lineage chain rather than opaque retirements.

Embodiments span the deployment spectrum the disclosure enumerates: passive cementitious slabs and coatings as low-power capacity reserve; engineered cavity-bath elements for higher-performance daily cycling; data center foundations and structural panels operating simultaneously as uninterruptible-power-supply substrate, distribution bus, and liquid-cooling interface; and marine and hydraulic works coupled to ambient water as long-life storage. In every case the storage surface is the credential, and the cell behind it is treated as attested, not as a novel claim.

Boundary Conditions

The boundary of this application is the attestation layer. The energy-storage property-surface credentials what a storage element claims to do; it does not claim the internal cell chemistry, and the underlying electrochemistry (electric-double-layer storage, Faradaic redox, air-cathode reactions, turbostratic-graphene electrodes) is established science, not a discovery of this disclosure. Nothing here asserts that any device has been built, validated, benchmarked, or that it achieves a specific energy density, cycle life, round-trip efficiency, or cost. The disclosure is a provisional disclosure of a credentialing and admissibility architecture; performance values are authority-attested fields on a surface, declared per element, not performance claims made by this article.

The attested values are only as good as the authorities that sign them and the state-of-health observations that update them. The architecture provides the structure for honest derating, lineage-preserved audit, and composition-rule-governed dispatch, but it presumes competent credentialing authorities operating in declared scope and an honest attestation module observing realized state. The grid-services framing here (frequency regulation, capacity reserve, demand response, virtual-power-plant participation, settlement with balancing authorities and market operators) is a faithful description of where the surface would compose; it is not a representation that any particular market rule, interconnection standard, or regulatory approval has been obtained for a structural-storage participant.

Disclosure Scope

This material is supported by U.S. Provisional Application No. 64/050,895. The disclosure contemplates an energy-storage admissibility surface declaring storage capacity, power capacity, cycle count, calendar age, round-trip efficiency, fault history, and degradation indicators for a credentialed structural element, signed by a utility or building-code authority and bound to the element through the authority signatures block and the lineage chain; aggregation and dispatch of distributed structural storage

by a building energy management system through composite admissibility evaluation; composition of the storage surface with the structural, thermal, fire-performance, and water-coupled surfaces under signed, versioned composition rules; duration-attested grid-commitment participation settled through pair-settled direct settlement per the matched-pair settlement primitive; and federation of credentialed substrates into neighborhood-pool, virtual-power-plant, and grid-scale long-duration storage resources. The energy-domain application, the grid-services, virtual-power-plant, and market-settlement framing, and any reference to electrical, utility, or interconnection standards are external domain context provided to show an enabling implementation, and are not patent claims. The surface is credentialed by a utility or building-code authority and is not limited to a particular storage chemistry or form factor; the internal chemistry of the storage cell is outside the scope of what the surface credentials.

Credentialed Surfaces (/credentialed-materials)

All 40 steps → (/inventive-steps)

Building surfaces as credentialed agents that participate in the structure's networking and electrical systems.

Provisional application

PRIMARY TECHNICAL DISCLOSURE

- Credentialed Building Materials: Cryptographic Admissibility for Structural Surfaces (/articles/credentialed-building-materials-cryptographic-admissibility-for-structural-surfaces)

SECONDARY TECHNICAL

- Carbon-Sequestration Admissibility Surface (/articles/credentialed-materials/carbon-sequestration-property-surface)
- Composition Rules Governing Surface Interactions (/articles/credentialed-materials/composition-rules)
- Decommissioning And Re-Credentialing Attestation (/articles/credentialed-materials/decommissioning-and-recredentialing)

- Electrical-Distribution Admissibility Surface (/articles/credentialed-materials/distribution-property-surface)
- End-Of-Storage-Life Attestation (/articles/credentialed-materials/end-of-storage-life-attestation)
- Energy-Storage Admissibility Surface (/articles/credentialed-materials/energy-storage-property-surface)
- Lineage Chain Across Material Lifecycle (/articles/credentialed-materials/lineage-chain-across-lifecycle)
- Authority Signatures Block Binding Property Surfaces To Material Identity (/articles/credentialed-materials/master-credential-binding)
- Multi-Authority Signature Block (/articles/credentialed-materials/multi-authority-signature-block)
- Data Network Admissibility Surface (/articles/credentialed-materials/network-property-surface)
- Profile Versioning Continuity (/articles/credentialed-materials/profile-versioning-continuity)
- Structural Admissibility Surface (/articles/credentialed-materials/structural-property-surface)
- Thermal-Property Admissibility Surface (/articles/credentialed-materials/thermal-property-surface)
- Versioned Admissibility Profiles With Lineage Chain (/articles/credentialed-materials/versioned-profiles-with-lineage)
- Water-Coupled Admissibility Surface (/articles/credentialed-materials/water-coupled-property-surface)

APPLICATIONS · GENERAL

- Credentialed Structural Materials for Construction and Civil Infrastructure: Carrying Strength, Mix, and Provenance as Multi-Authority Attestations (/articles/credentialed-materials/construction-and-infrastructure)
- Carbon-Credit-Bearing Building Materials: Sequestration Attestations That Survive Incorporation, Transfer, and Decommissioning (/articles/credentialed-materials/carbon-credit-materials)
- Building-Product Compliance and Code Approval: Property-Surface Profiles as Machine-Evaluable Admissibility Evidence (/articles/credentialed-materials/building-product-compliance)
- Credentialed Building Materials for Real Estate Valuation, Insurance, and Disclosure: A Property History That Binds to the Asset (/articles/credentialed-materials/real-estate-and-asset-lifecycle)
- Recredentialing Recovered Materials: Verifiable Lineage for Reuse and Decommissioning in the Circular Economy (/articles/credentialed-materials/circular-economy-and-decommissioning)
- **Energy and Grid-Coupled Surfaces: Crediting Stationary Storage in Structural Mass Without Trusting the Cell (/articles/credentialed-materials/energy-and-grid-surfaces)**

- Credentialed Surfaces for Water and Environmental Infrastructure: Signed Performance and Compliance Attestations on Water-Coupled Concrete (/articles/credentialed-materials/water-and-environmental-infrastructure)
- Data-Center Infrastructure Substrate: Collapsing UPS Rooms, Cooling Distribution, and Raised-Floor Wiring Into One Credentialed Structural Surface (/articles/credentialed-materials/data-center-infrastructure)
- Turning EV-Charging Sites Into Structure: Credentialed Substrate That Stores, Distributes, and Settles Power in the Slab (/articles/credentialed-materials/ev-charging-infrastructure)

APPLICATIONS · SPECIFIC

- Circularise, a blockchain-based supply-chain traceability and digital-product-passport platform for materials vs credentialed material surfaces: attestations bound to the physical material (/articles/credentialed-materials/circularise)
- EC3 (Embodied Carbon in Construction Calculator) by Building Transparency vs a credentialed carbon-sequestration surface bound to the material (/articles/credentialed-materials/ec3-building-transparency)
- CarbonCure Technologies, which injects and mineralizes CO2 into concrete during mixing vs a credentialed carbon-sequestration attestation architecture (/articles/credentialed-materials/carboncure)
- Sublime Systems, maker of low-carbon cement via an electrochemical (ambient) process vs a credentialed carbon-sequestration surface bound to the material (/articles/credentialed-materials/sublime-systems)
- Brimstone carbon-negative portland cement vs credentialed material attestations: process decarbonization or per-element carbon accounting? (/articles/credentialed-materials/brimstone)
- The EU Digital Product Passport (DPP) under the Ecodesign for Sustainable Products Regulation (ESPR) vs credentialed surfaces: a data-carrier standard next to a material-bound attestation architecture (/articles/credentialed-materials/eu-digital-product-passport)
- One Click LCA, a life-cycle-assessment and EPD software platform for construction vs a credentialed carbon-sequestration property surface bound to the material (/articles/credentialed-materials/one-click-lca)
- Concrete.ai vs credentialed carbon-sequestration surfaces on structural materials (/articles/credentialed-materials/concrete-ai)
- Madaster alternative: material passports as a building registry vs credentialed surfaces bound to the physical material (/articles/credentialed-materials/madaster)

Credentialed Surfaces overview → (/credentialed-materials)