

How to Design a Data-Center Substrate That Replaces the UPS and DC Bus

Data-center operators pour a concrete shell, then bolt a UPS battery room, a low-voltage distribution plane, a facility network, and a cooling loop onto it as four separate systems. This guide teaches an architectural alternative in which the structural concrete itself carries ride-through storage, the DC bus, the internal network, and liquid-cooling heat rejection as credentialed properties of the material. It describes an architecture disclosed in U.S. Provisional Application No. 64/050,895, not a shipping library. The home inventive step is the Credentialed Surfaces inventive step.

What You Are Building

You are designing a data-center facility in which the structural concrete does four jobs at once. The foundation, the lower wall sections, the raised-floor structural panels, and the inter-rack structural elements are poured as a credentialed cementitious-graphene composite that simultaneously carries a structural rating, an energy-storage capability sized to the facility's ride-through requirement, a low-voltage DC distribution capability, an internal data-network capability, and a liquid-cooling heat-rejection interface for direct-to-chip equipment.

The goal is to collapse the separate uninterruptible-power-supply battery rooms, the dedicated cooling distribution units, the raised-floor electrical distribution, and the structural foundation into a single substrate whose energy, distribution, network, and thermal functions are declared properties of concrete you were going to pour anyway. This is the "data center substrate deployment" class of the filed disclosure.

The audience is facility architects, data-center electrical and mechanical engineers, and materials teams who already know why a battery room, a DC plane, and a cooling loop exist, and who want to understand how one credentialed material could carry all of them. What follows is an architecture you would implement, not a product you install.

Why the Obvious Approaches Fall Short

The conventional approach treats each function as a dedicated device installed into a passive building. That is not a flaw in any one product; it is the organizing assumption of the whole stack. Batteries, the UPS, the distribution plane, and the cooling loop are engineered as discrete equipment whose job is that one function, and the building is a host enclosure for them.

Two consequences follow. First, the capital cost of ride-through storage scales with installed battery-room capacity, on top of the structural mass you already paid to pour for load reasons. There is no path in the conventional stack for storage to be a property of that structural mass rather than a separate device. Second, each function needs its own distribution and interface infrastructure: battery-to-panel wiring, a separate low-voltage plane, a separate facility network, and a separate cooling distribution network, each independently routed, powered, and maintained.

Structural-battery research narrows the first gap but keeps the device framing: it embeds a battery into a host material, so the storage device is still the architectural primary and the concrete is its shell. It also treats each cell or pack as a discrete connected device needing per-device power electronics, and it does not contemplate

composing storage with thermal, distribution, network, or fire-performance behavior as independently governed peers of the same material. The structural gap that remains is architectural: nothing in the conventional or structural-battery approach treats the built substrate as one material carrying several independently credentialed but composed functional surfaces, aggregated by the building's own systems.

The Architecture

The disclosed approach inverts the framing. Energy storage, distribution, networking, and thermal coupling become credentialed properties of the structural material, and the facility's own management system aggregates them. Every mechanism below traces to the filed specification.

The material. The structural element is a cementitious composite loaded with biomass-derived carbonaceous material that has hierarchical porosity: a macroscale fibrillar architecture that carries continuous structural load paths, plus mesoscale and nanoscale porosity that provides electrochemical surface area, in the same physical material. The spec's primary preferred production route is flash Joule heating, a sub-second capacitive-discharge electrothermal pulse that converts a carbonaceous feedstock to turbostratic graphene; three other routes are disclosed, including carbonizing inside a host material's existing manufacturing thermal cycle. The underlying materials science here is prior art; the disclosed novelty is composing these properties into one credentialed structural category, not any newly discovered physical effect.

The UPS surface. In the data-center class, the storage capability of the concrete operates as uninterruptible-power-supply substrate, with capacity attestations sized to the facility's declared ride-through requirement. Storage lives in the foundation, lower walls, raised-floor panels, and inter-rack elements rather than in a battery room. The spec discloses several electrolyte-coupling classes for the storage: a passive native-pore-resolution class with no cavity or refill hardware, and an engineered closed-cell cavity-

bath class with sealed cavities, a fill-and-drain manifold, defense-in-depth edge containment, and refillable electrolyte whose calendar life is decoupled from the chemistry.

The DC-bus surface. The distribution capability operates as a low-voltage DC bus. The structural-to-electrical interface is declared in the material's credentialed profile and can use an embedded electrode network of distributed current collectors, surface electrode terminations, or a per-zone power-electronics topology in which each zone has a converter, a state-of-health monitor, and fault isolation feeding a building low-voltage DC bus into a master inverter at the point of common coupling. Operating voltages typically below 60 volts DC place the substrate in the Class 2 / Class 3 wiring regime under NFPA 70 Article 725. A panel can also act as a distribution substrate whose surface admits credentialed device attachment.

The network surface. The data-network capability operates as the facility-internal network. Panels carry a data-network admissibility surface and act as credentialed network nodes, running panel-resident electronics per the referenced Protocol and Execution applications. Signaling is carried by power-line modulation on the distribution layer, by dedicated data layers, by time-multiplexed operation, or by panel antennas. The network surface itself declares data classification, per-source and per-destination rate ceilings, permitted routing destinations, and retention, so what the network admits is governed rather than open.

The thermal surface. The thermal capability operates as a direct-to-substrate liquid-cooling heat-rejection interface for liquid-cooled or direct-to-chip IT equipment. In the cavity-bath storage class, the same fill-and-drain fluidic network can serve simultaneously as the electrolyte distribution medium and as a thermal hydronic loop, coupling to heat-pump, geothermal, ambient-radiator, or Joule-loss-recovery subsystems.

Composition and aggregation. Each surface is credentialed independently by an authority with declared scope, and the surfaces compose through signed, versioned composition rules held in a registry. A fire-event rule, for instance, reduces storage admissibility to zero when the fire-performance surface reports a fire event. A building energy management system discovers the distributed elements, characterizes and attests their state of health, aggregates them into one coherent resource, evaluates access against the composite profile, and dispatches energy, all recorded in a lineage chain. That aggregation-by-the-building-system, rather than per-device power electronics, is the load-bearing architectural move.

How to Approach the Build

You are implementing this yourself. Treat the following as an ordered design method, not a package to install.

1. **Size the surfaces to the facility spec.** Translate your ride-through requirement into a storage-capacity target, your rack density into a heat-rejection target, and your IT power into a DC-bus current and voltage class. These become the declared parameters of each admissibility surface. The spec ties UPS-substrate capacity attestations directly to the declared facility ride-through requirement, so make that number explicit first.
2. **Choose the electrolyte-coupling class per element.** Decide, element by element, between the passive native-pore-solution class and the engineered cavity-bath class. Foundations and lower walls that need serviceable, refillable, freeze-tolerant storage point toward the cavity-bath class; the spec ties electrolyte selection to the deployment climate's design-low temperature. Elements needing only modest reserve can stay passive.
3. **Pick the structural-to-electrical topology.** Select embedded electrode network, surface termination, per-zone power electronics, or a hybrid for each element, and design the DC bus to aggregate zone converters into the master inverter at the point

of common coupling. Hold operating voltage in the regime that keeps you in the low-voltage wiring class you intend to certify against.

4. **Lay out the fluidic network once, for two jobs.** If you use the cavity-bath class, route the fill-and-drain manifold so it also serves as the liquid-cooling loop reaching your racks, and select its heat-sink coupling (ground loop, ambient radiator, heat-pump, or Joule-loss recovery) from the disclosed thermal compositions.
5. **Make each panel a network node.** Deploy panel-resident electronics and choose a physical layer for signaling (power-line modulation, dedicated data layer, time-multiplex, or RF), then declare the data-classification, rate, destination, and retention parameters of the network surface.
6. **Write the credentials and composition rules.** For each element, assemble a composite admissibility profile with structural, storage, distribution, network, and thermal surfaces, each signed by an authority of appropriate scope. Register the composition rules you depend on, at minimum the fire-event storage-cutoff rule and a thermal-runaway-constrained dispatch rule.
7. **Stand up the management system.** Implement discovery, characterization, state-of-health attestation, aggregation, access evaluation, and dispatch so the facility system treats the whole substrate as one governed resource and records events in a lineage chain.

An illustrative, spec-faithful sketch of the composite profile an element would carry, for orientation only, not runnable code:

```
element_profile:
  structural: { rating, signed_by: structural_authority }
  storage:    { capacity_kWh, ride_through_target, electrolyte_class,
               signed_by: utility_or_code_authority }
  distribution: { voltage_class, topology, per_zone_current_limit,
                signed_by: electrical_authority }
  network:     { data_classification, rate_ceilings, destinations, retentio
  thermal:     { heat_rejection_interface, hydronic_loop, coupling }
  composition_rules: [ fire_event_storage_cutoff, thermal_runaway_dispatch_l
```

What This Does Not Give You

This is an architecture, not a drop-in library, and not a product you can buy or download. There is no SDK, no package, and no benchmarked implementation behind this guide. You would engineer, pour, instrument, credential, and certify each element yourself.

Nothing here is built, validated, or benchmarked. The energy-density, conductivity, yield, voltage, copper-reduction, and temperature figures in the filed disclosure are disclosed or projected ranges, not measured results from a deployed facility, and this guide invents no numbers beyond them. The materials science is pre-existing prior art; only the combination into a credentialed multi-surface structural category is presented as the novel contribution.

Realizing it is real engineering with real failure modes. Passive native-pore-solution storage is limited to low-power reserve and to warmer climates by its freezing point. Cavity-bath storage introduces sealed electrolyte, containment, and manifold serviceability that must satisfy leakage and pressure requirements near occupied space. The electrical interface must satisfy grounding, bonding, arc-flash, fault-isolation, and fire-coordination code requirements independent of the management system. Where a pour geometry or mix cannot meet the in-situ graphenization constraints, the

disclosure itself directs you to the pre-process route instead. And a data center's storage-chemistry cycle life will generally be shorter than its structural life, which is why the disclosure leans on continuous re-credentialing and refillable electrolyte rather than assuming one composition lasts the life of the building. If your facility does not want storage, a DC bus, an internal network, and cooling to share one material and one governance system, this architecture is not the right fit.

Disclosure Scope

The approach described in this guide is disclosed in U.S. Provisional Application No. 64/050,895. This guide is educational: it teaches an architectural design method grounded in that filing so a skilled engineer can understand how to approach the build. It is not a warranty, a performance guarantee, or an offer of software, and it does not represent that any product, benchmark, or deployment exists. Any third-party technologies, standards, or codes referenced above are described for context only and belong to their respective owners.

Credentialed Surfaces (</credentialed-materials>) [All 40 steps → \(/inventive-steps\)](/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 \(/articles/credentialed-building-materials-cryptographic-admissibility-for-structural-surfaces\)](/articles/credentialed-building-materials-cryptographic-admissibility-for-structural-surfaces)

SECONDARY TECHNICAL

- [Carbon-Sequestration Admissibility Surface \(/articles/credentialed-materials/carbon-sequestration-property-surface\)](/articles/credentialed-materials/carbon-sequestration-property-surface)

- [Composition Rules Governing Surface Interactions \(/articles/credentialed-materials/composition-rules\)](/articles/credentialed-materials/composition-rules).
- [Decommissioning And Re-Credentialing Attestation \(/articles/credentialed-materials/decommissioning-and-recredentialing\)](/articles/credentialed-materials/decommissioning-and-recredentialing).
- [Electrical-Distribution Admissibility Surface \(/articles/credentialed-materials/distribution-property-surface\)](/articles/credentialed-materials/distribution-property-surface).
- [End-Of-Storage-Life Attestation \(/articles/credentialed-materials/end-of-storage-life-attestation\)](/articles/credentialed-materials/end-of-storage-life-attestation).
- [Energy-Storage Admissibility Surface \(/articles/credentialed-materials/energy-storage-property-surface\)](/articles/credentialed-materials/energy-storage-property-surface).
- [Lineage Chain Across Material Lifecycle \(/articles/credentialed-materials/lineage-chain-across-lifecycle\)](/articles/credentialed-materials/lineage-chain-across-lifecycle).
- [Authority Signatures Block Binding Property Surfaces To Material Identity \(/articles/credentialed-materials/master-credential-binding\)](/articles/credentialed-materials/master-credential-binding).
- [Multi-Authority Signature Block \(/articles/credentialed-materials/multi-authority-signature-block\)](/articles/credentialed-materials/multi-authority-signature-block).
- [Data Network Admissibility Surface \(/articles/credentialed-materials/network-property-surface\)](/articles/credentialed-materials/network-property-surface).
- [Profile Versioning Continuity \(/articles/credentialed-materials/profile-versioning-continuity\)](/articles/credentialed-materials/profile-versioning-continuity).
- [Structural Admissibility Surface \(/articles/credentialed-materials/structural-property-surface\)](/articles/credentialed-materials/structural-property-surface).
- [Thermal-Property Admissibility Surface \(/articles/credentialed-materials/thermal-property-surface\)](/articles/credentialed-materials/thermal-property-surface).
- [Versioned Admissibility Profiles With Lineage Chain \(/articles/credentialed-materials/versioned-profiles-with-lineage\)](/articles/credentialed-materials/versioned-profiles-with-lineage).
- [Water-Coupled Admissibility Surface \(/articles/credentialed-materials/water-coupled-property-surface\)](/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 \(/articles/credentialed-materials/construction-and-infrastructure\)](/articles/credentialed-materials/construction-and-infrastructure).
- [Carbon-Credit-Bearing Building Materials: Sequestration Attestations That Survive Incorporation, Transfer, and Decommissioning \(/articles/credentialed-materials/carbon-credit-materials\)](/articles/credentialed-materials/carbon-credit-materials).
- [Building-Product Compliance and Code Approval: Property-Surface Profiles as Machine-Evaluatable Admissibility Evidence \(/articles/credentialed-materials/building-product-compliance\)](/articles/credentialed-materials/building-product-compliance).
- [Credentialed Building Materials for Real Estate Valuation, Insurance, and Disclosure: A Property History That Binds to the Asset \(/articles/credentialed-materials/real-estate-and-asset-lifecycle\)](/articles/credentialed-materials/real-estate-and-asset-lifecycle).
- [Recredentialing Recovered Materials: Verifiable Lineage for Reuse and Decommissioning in the Circular Economy \(/articles/credentialed-materials/circular-economy-and-decommissioning\)](/articles/credentialed-materials/circular-economy-and-decommissioning).

- [Energy and Grid-Coupled Surfaces: Crediting Stationary Storage in Structural Mass Without Trusting the Cell \(/articles/credentialed-materials/energy-and-grid-surfaces\)](/articles/credentialed-materials/energy-and-grid-surfaces).
- [Credentialed Surfaces for Water and Environmental Infrastructure: Signed Performance and Compliance Attestations on Water-Coupled Concrete \(/articles/credentialed-materials/water-and-environmental-infrastructure\)](/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 \(/articles/credentialed-materials/data-center-infrastructure\)](/articles/credentialed-materials/data-center-infrastructure).
- [Turning EV-Charging Sites Into Structure: Credentialed Substrate That Stores, Distributes, and Settles Power in the Slab \(/articles/credentialed-materials/ev-charging-infrastructure\)](/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 \(/articles/credentialed-materials/circularise\)](/articles/credentialed-materials/circularise).
- [EC3 \(Embodied Carbon in Construction Calculator\) by Building Transparency vs a credentialed carbon-sequestration surface bound to the material \(/articles/credentialed-materials/ec3-building-transparency\)](/articles/credentialed-materials/ec3-building-transparency).
- [CarbonCure Technologies, which injects and mineralizes CO2 into concrete during mixing vs a credentialed carbon-sequestration attestation architecture \(/articles/credentialed-materials/carboncure\)](/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 \(/articles/credentialed-materials/sublime-systems\)](/articles/credentialed-materials/sublime-systems).
- [Brimstone carbon-negative portland cement vs credentialed material attestations: process decarbonization or per-element carbon accounting? \(/articles/credentialed-materials/brimstone\)](/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 \(/articles/credentialed-materials/eu-digital-product-passport\)](/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 \(/articles/credentialed-materials/one-click-lca\)](/articles/credentialed-materials/one-click-lca).
- [Concrete.ai vs credentialed carbon-sequestration surfaces on structural materials \(/articles/credentialed-materials/concrete-ai\)](/articles/credentialed-materials/concrete-ai).
- [Madaster alternative: material passports as a building registry vs credentialed surfaces bound to the physical material \(/articles/credentialed-materials/madaster\)](/articles/credentialed-materials/madaster).

