

Can a movable iron energy carrier actually work?

Scientific feasibility. Economic model. Competitive landscape.
Patent and FTO risk. The kill criteria.

Fairlight is developing a standardized physical energy carrier: a reusable, serviceable object designed to hold stored renewable electricity and move through a compatible network. This paper asks the uncomfortable questions early. It includes findings that weaken parts of the original concept. Credibility is the point.

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No measured Fairlight performance is claimed anywhere in this document. All performance figures cited are either published third-party evidence or explicit development targets.

1. The carrier thesis

Fairlight is not a stamped iron plate seasonal battery for homes, and it is not a smaller utility-scale iron-air system. The development object is a standardized physical energy carrier platform: the carrier is the invariant physical object, while the active electrode technology inside it can evolve through revisions.

The hierarchy is deliberate. Fairlight is physical energy infrastructure. The FEC carrier is the standardized reusable object. Rechargeable iron electrochemistry is the first implementation technology. Home seasonal storage is one application. Exchange is a core platform capability.

The earlier framing assumed that the full mass of a smooth stamped mild-steel plate could be treated as electrochemically active iron. The current scientific evidence does not support that assumption, and this paper corrects it.

2. Scientific feasibility

Theoretical iron capacity is not the same thing as usable electrode capacity. A thick iron plate does not react uniformly through its mass. Published iron-air research shows flat iron sheets have limited practical reversible capacity; high-performance electrodes rely on increased active surface area and engineered microstructure.

Iron-air performance depends strongly on:

- Electrochemically accessible surface area

- Grain structure and porosity
- Oxide formation and passivation
- Parasitic hydrogen evolution
- Electrolyte access and management

The development program therefore separates two problems. Macro geometry: handling, current collection, fluid distribution, drainage, preservation. Microstructure: electrochemical activity, iron utilization, hydrogen suppression, cycle life. The formed DrainPlate geometry remains valuable as the mechanical substrate; it is not the energy store.

Published iron-air system evidence sits at roughly 40-45% round-trip efficiency. The development objective is to improve the complete system including auxiliaries, not just one electrode step. No efficiency above that range is implied, and no Fairlight system efficiency has been measured.

Preservation is treated as a measurable endpoint, not a timer and not a claim of completely dry storage or zero self-discharge. The proposed cycle - process, drain, optional rinse, vibrate, verify, preserve - must demonstrate that it materially improves 90- and 180-day retention before it becomes a claim.

3. Economic model

Cheap materials are not enough. A carrier that cycles only once each year is difficult to justify economically: poor capital utilization makes a seasonal-only battery hard to finance. The carrier is therefore being developed for long dormancy AND useful operation throughout the year, at roughly 10-20 cycles per year across multi-day, resilience and exchange jobs.

Moving energy only makes sense when the value at the destination exceeds the energy loss, handling and transport combined. Stored electricity has mass. Fairlight Exchange is therefore being developed primarily for local and regional exchange, not for replacing transmission lines with trucks. As an economic development hypothesis, 0-50 km is the strongest early exchange zone, 50-100 km is use-case dependent, and long distance is reserved for high-value applications.

Best early applications:

- Curtailed commercial solar and negative-price energy
- Remote diesel displacement and weak-grid supply
- Capacity, resilience and emergency reserve
- Grid-constrained sites and local exchange

Weak initial use case: pure one-cycle-per-year household arbitrage. This finding is stated openly because it shapes the whole architecture: reusable energy inventory, not a single-purpose household appliance.

4. Competitive landscape

Fixed utility-scale 100-hour iron-air storage - Form Energy is the most visible example - is external evidence that the underlying chemistry can work as a system. It is a different architecture and timescale: fixed installations versus standardized, removable, serviceable physical energy inventory.

Fairlight's differentiation is the carrier and preservation/network architecture. If mobility, serviceability and cross-site compatibility do not create enough value to exceed their logistics cost, the concept loses to fixed systems. That is an acceptable outcome and this paper exists to find out early.

5. Patent and freedom-to-operate risk

The metal-air and iron-air patent landscape is active. A Fairlight patent application does not guarantee freedom to operate. The architecture must be buildable through design-around or licensing without infringing active third-party patents; FTO analysis is a running workstream with explicit kill authority, not a conclusion.

6. The kill criteria

- 01 Iron utilization: can a manufacturable carrier reach ≥ 0.20 Ah/g active Fe repeatedly?
- 02 Carrier density: can the complete carrier exceed ~ 100 Wh/kg?
- 03 Round-trip efficiency: can the complete system reach or exceed $\sim 40\%$ including auxiliaries?
- 04 Hydrogen: can parasitic hydrogen be controlled?
- 05 Preservation: does the preserve cycle materially improve 90/180-day retention?
- 06 Cost: is there a credible path toward ≤ 10 -15 currency/kWh carrier-system capacity at scale?
- 07 Logistics: can target regional use cases remain economically sensible after handling and transport?
- 08 Freedom to operate: can the architecture be built through design-around or licensing?

7. Current status

- Concept architecture: defined
- FEC-1 envelope: in development
- Electrode: in research
- Preservation: in research
- Full-cycle prototype: not yet validated
- Commercial certification: not yet started

Build the standard only if the physics earns it.

Fairlight / Switzerland / fairlight.energy / Research, manufacturing, energy-system and investment conversations are open.