ELECTRIFIED THERMAL SOLUTIONS

Electrifiedthermal.com

Decarbonizing Industry with Electrified Heat

The Market Pain Point:

There is no affordable zero-carbon heat option for industry

Zero-carbon electricity is cheap…

but firming it is expensive

and Industries need heat.

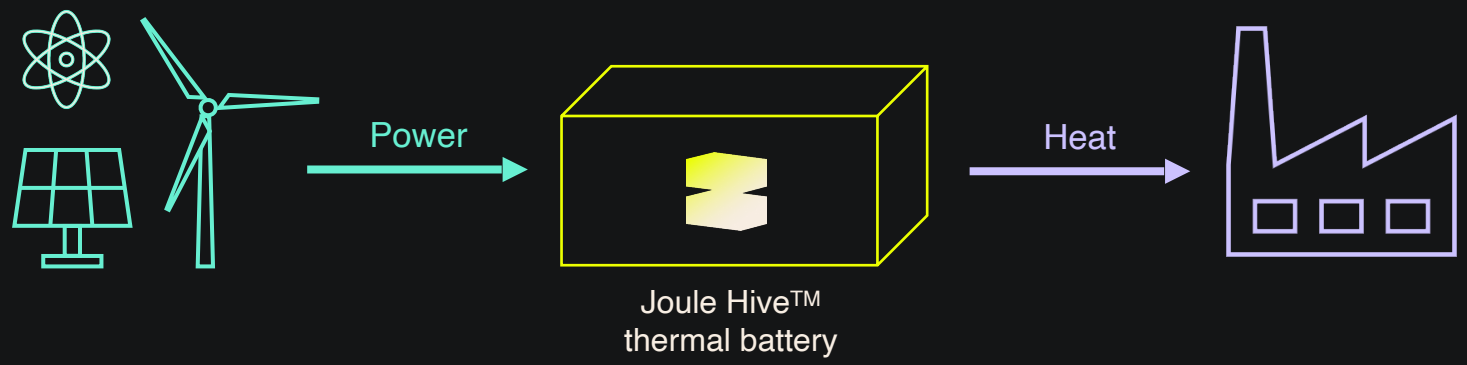
Joule Hive™ thermal battery turns zero-carbon electricity into firm industrial heat.

The Technology

Hot
1,800°C (3,270°F) deliverable temperatures

Affordable
3x cheaper than green hydrogen

Retrofittable
Plugs into existing processes



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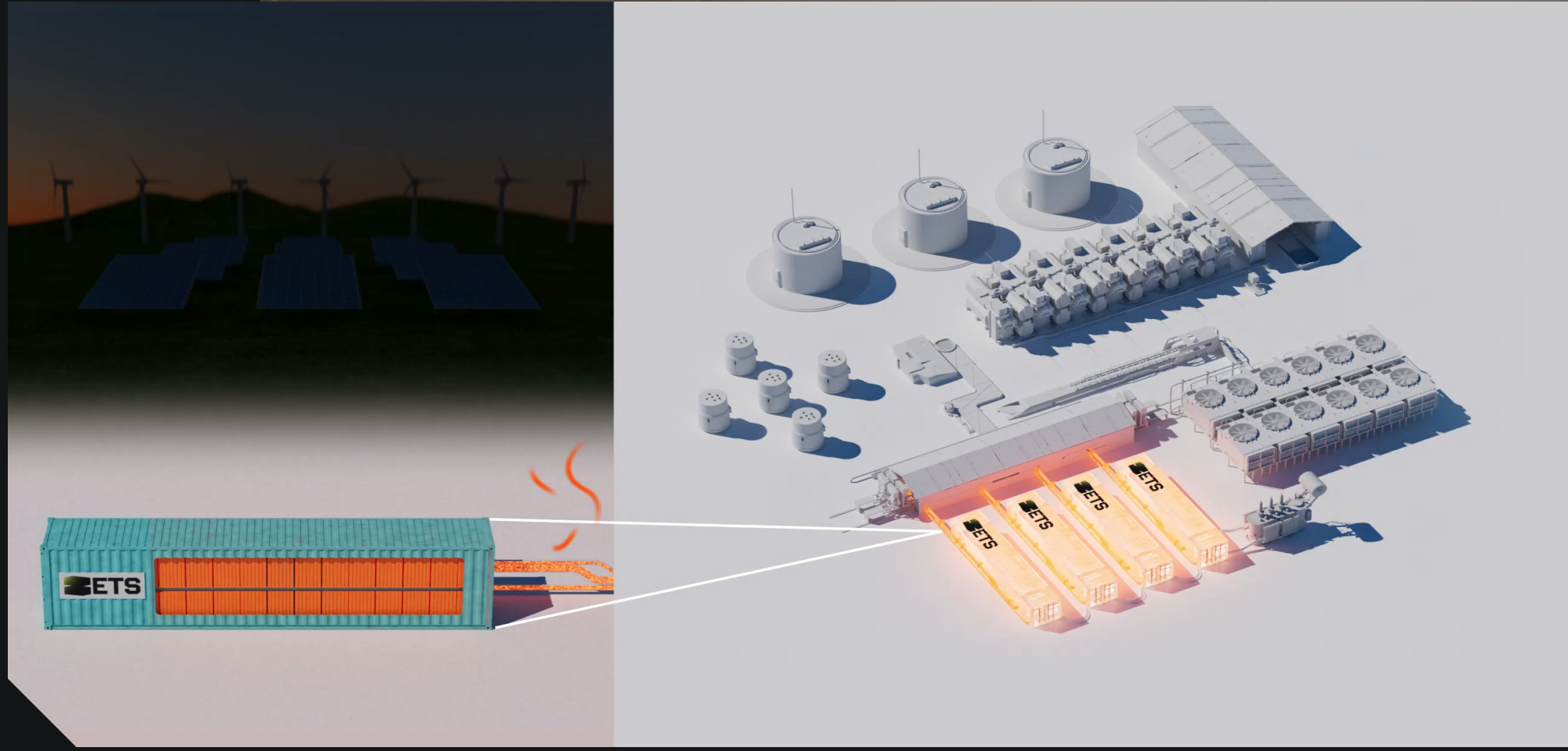

The Solution:
Joule Hive™
Thermal Battery

By Electrified Thermal Solutions

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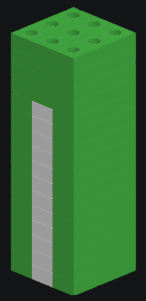
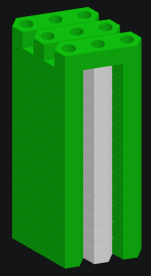
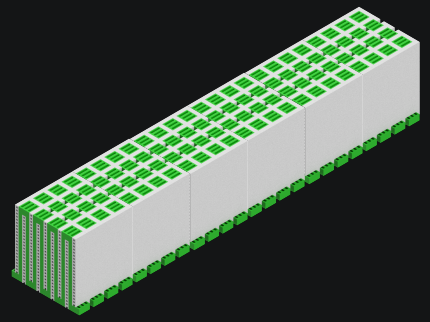
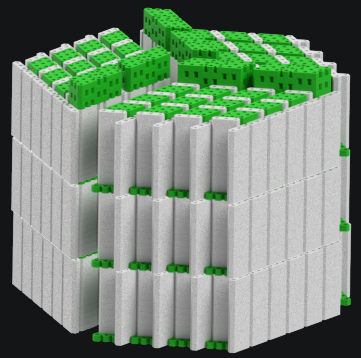
The building block of industrial decarbonization: Electrically conductive “E-bricks”

E-bricks → Unit Cell → Full-Scale Joule Hive™ → Form Factor









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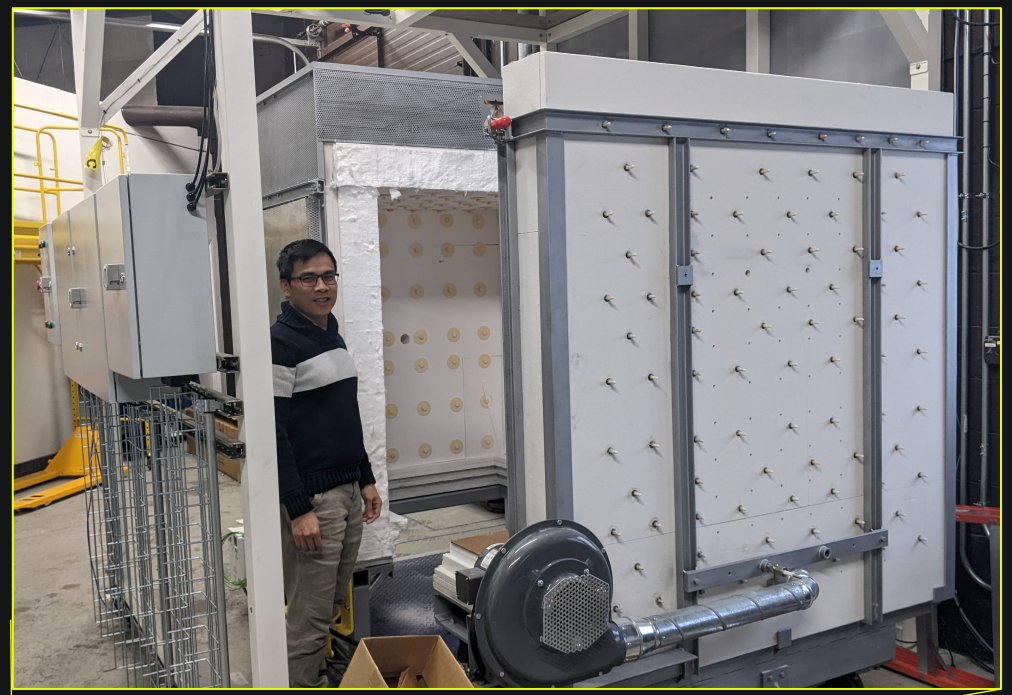
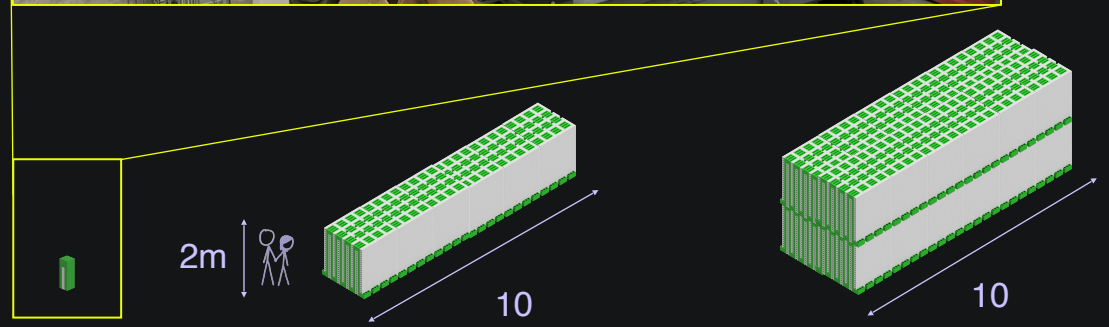
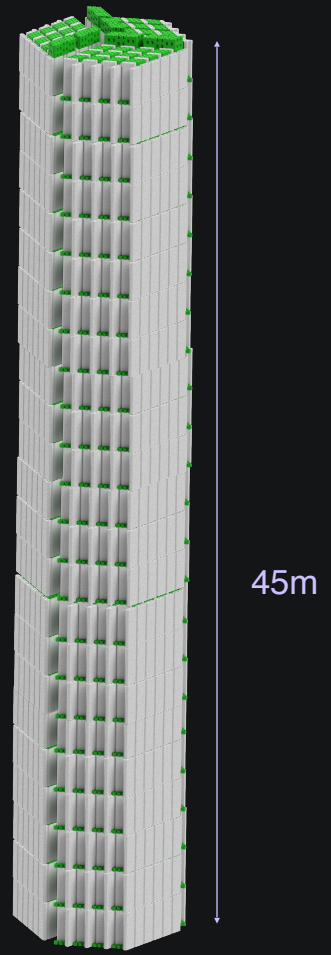
We will scale to the largest, hottest industrial needs







Joule Hives for larger systems, industrial heating, cement, steel, glass, chemicals

0.1 MWh , 60 kW

25 MWh, 5 MW

1,000 MWh, 200 MW

3,000 MWh, 600 MW

Pilot → First Product → Single / Multi-unit Sales → Gigawatt-hour Scale → Multi-Gigawatt-hour plant

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Product Roadmap: 2023 Pilot, 2024 Demo, 2025 Customer sites

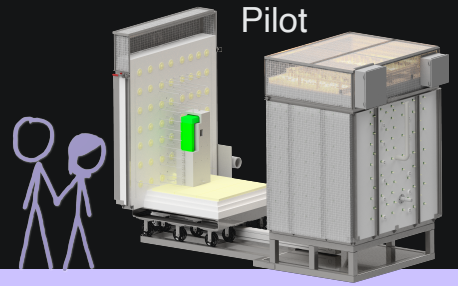
2022 — 2023 — 2024 — 2025 — 2030

Brick Development

PRE-SEED

Activate arpa·e

MASSVENTURES



Pilot

SEED: $4.5M

CLEAN ENERGY VENTURES

STARLIGHT VENTURES

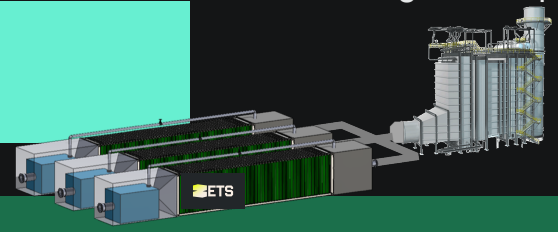
Commercial demonstration
25 MWh, 5 MW

PRE-A: $10-15M

SERIES A: $30-50M

2 GW deployed heat

- Customer integrations
- Manufacturing scale-up



SERIES B

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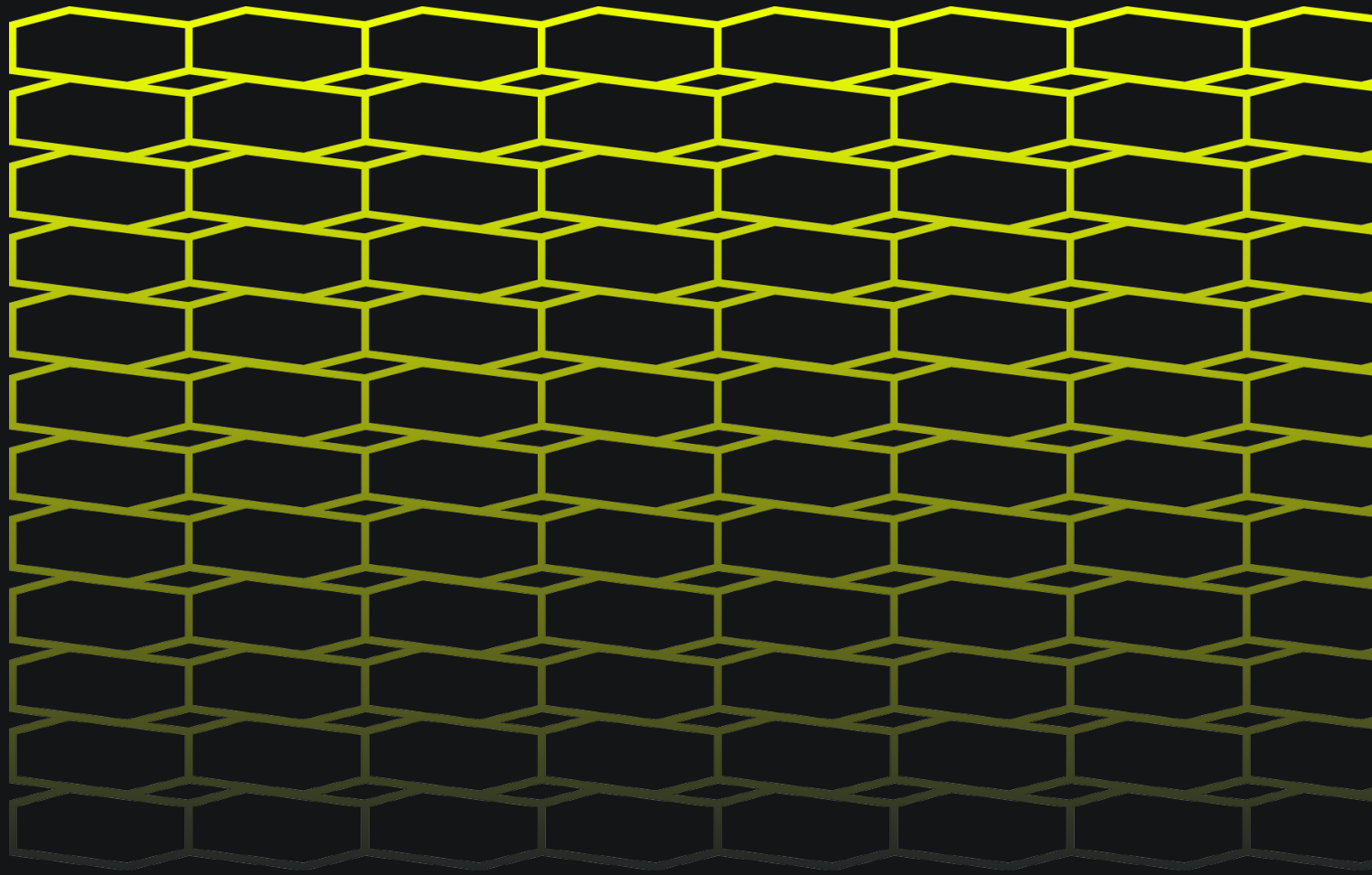

Contact

phillip.stephenson@electrifiedthermal.com

Thank You!

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The Competition:
Joule Hive is hotter, cheaper, and more scalable

	ETS
Heating Technology	Patented oxide technology
Temperature Delivered	1,800°C (3,270°F)
Scalability	High
Cost	$

The Competition:
Joule Hive is hotter, cheaper, and more scalable

	ETS	Competitors			
Heating Technology	Patented oxide technology	Traditional metallic	Traditional ceramic	Graphite	Hydrogen
Temperature Delivered	1,800°C (3,270°F)	1,200°C (2,190°F)	1,700°C (3,090°F)	1,000°C (1,830°F)	1,800°C (3,270°F)
Scalability	High	High	Low	High	High
Cost	$	$$$	$$$	$$	$$$$$

First product: Container-style Joule Hive™ thermal battery

"Let's start with a few megawatts."—cement, chemicals, glass, steel co's

- 25 MWh_t nominal heat capacity
- 0-5 MW_e input, 0-5 MW_t (0-17 MMBtu/hr) controllable heat output
- 200-1500°C (390-2730°F) controllable hot gas output. (Up to 1800°C peak output)
- Simultaneous charge and discharge (including steady state "heater" mode)
- Can still switch to combustion heat source

Windy mid-west US wholesale (case study)

- 50% of the year $ electricity < $ gas
- 80% reduction in carbon emissions
- < 5 yr payback

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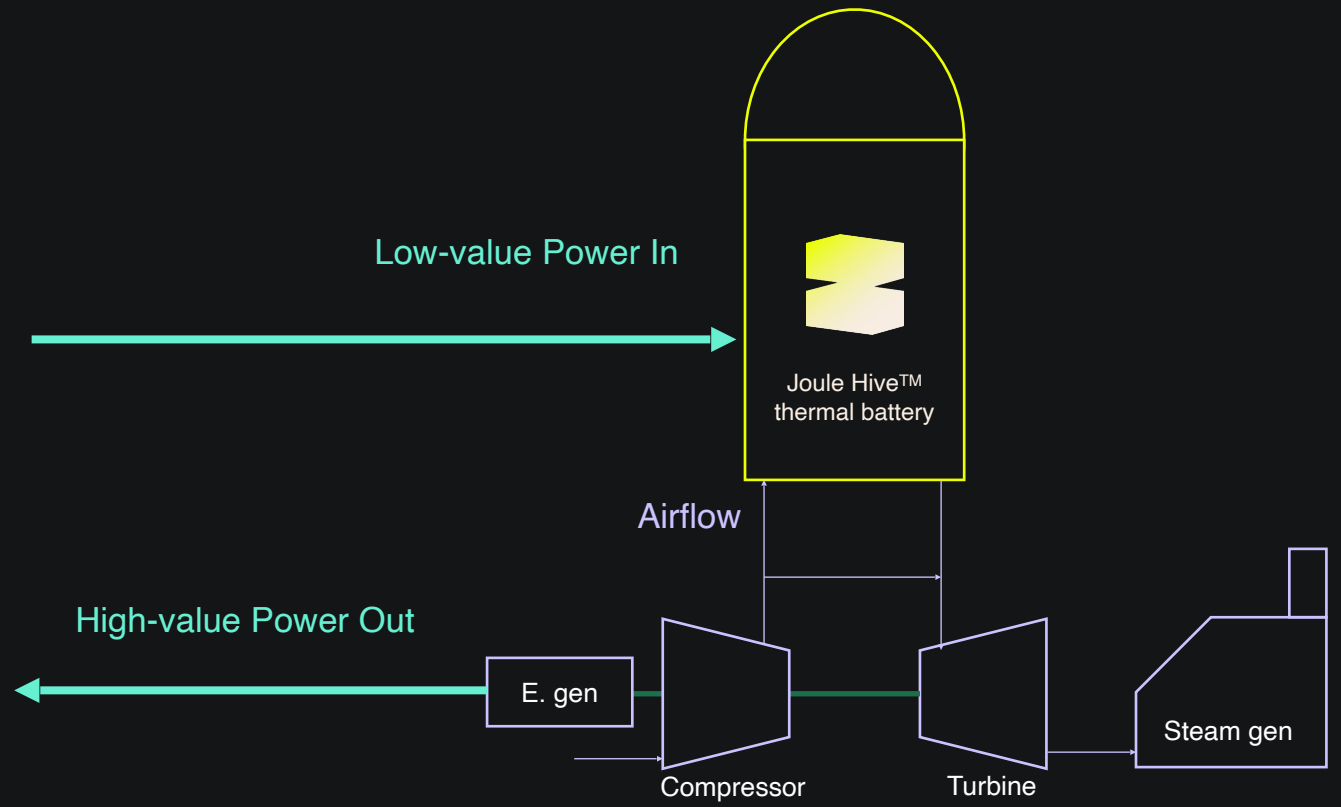
Joule Hive™ can hook up to power plants to save money, cut emissions, and give new life to assets as grid LDES *Long duration Energy Storage

- Attaches to gas turbine, steam turbine, s-CO2, at combustion step.
- When prices are low: Charge Joule Hive
- When prices are high: Discharge Joule Hive to run turbine.
- If Joule Hive is empty, use fuel source instead (H_2, gas)

- From plant perspective: Joule Hive is a Fuel Option
- From grid perspective: plant + Joule Hive is a Battery



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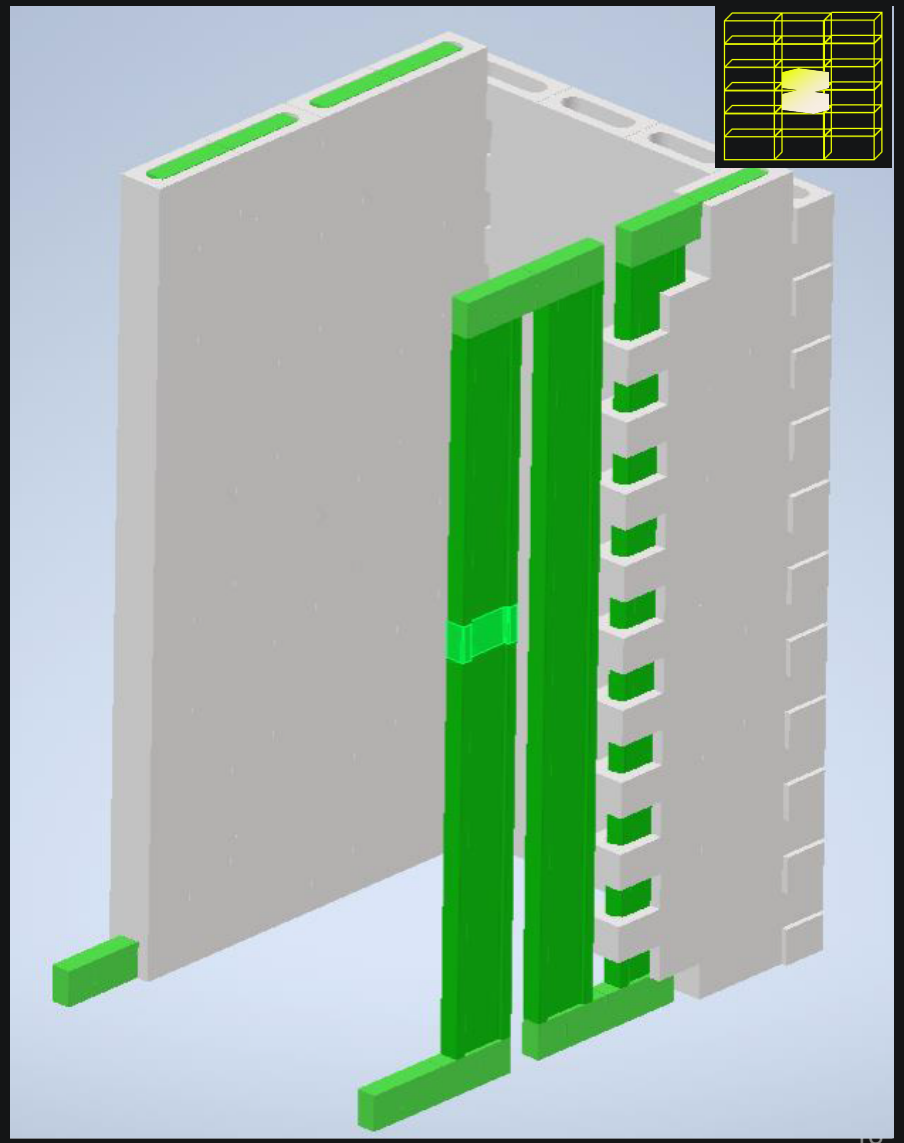
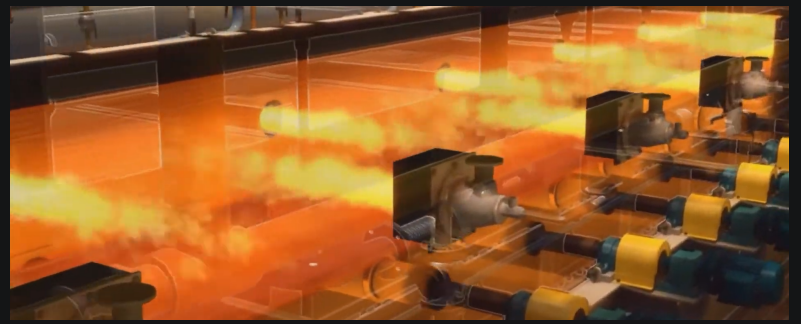
Alternative: Joule Hive™ “heating walls”, floors, and ceilings

- Brick patterns staggered for steady state wall heating to build all-electric furnace chambers
- DISADVANTAGE – You may pay substantially more for heat
  - no storage means no price hunting (always at mercy of grid)
  - not inherently synergistic with renewables/non-load following nuclear or hydro
- ADVANTAGES – Preferred over Joule Hive™ thermal battery when:
  - Electricity is already low-carbon and non-fluctuating in pricing
  - Space constraint for thermal storage footprint or ductwork
  - Application requires numerous heat injection points
    - (ex: piping a hot gas to 100 nozzles is harder than piping a fuel)
- Example applications:
  - Reverb furnaces, pusher furnaces, walking beam furnaces, annealing furnaces, round-top melters, ethane cracking furnaces, reforming furnaces, glass furnaces





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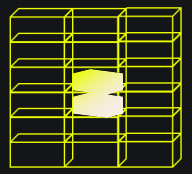
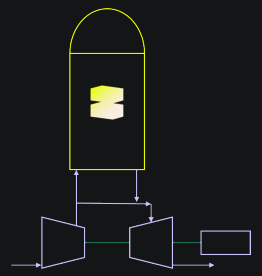
Competitive Products for Every Industry



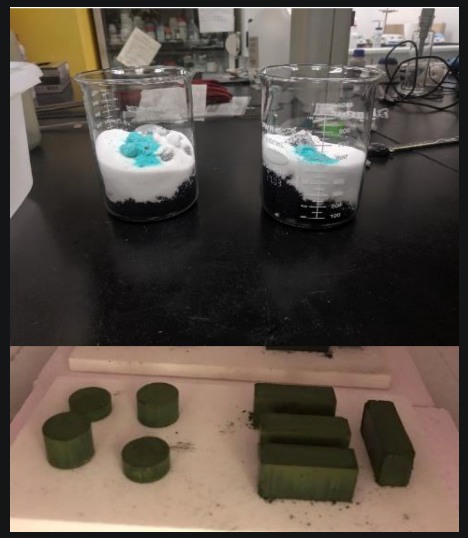


Product	Capacity Specs (Charge, Store, Discharge)	Application	Customer Industries
JHTB Box	5MW_e, 25MWh, 5MW_{th}	Small scale steam generation, drying, etc.	❑ Specialty Chemicals ❑ Hazardous Waste Incineration ❑ Minerals ❑ Metals ❑ Food
JHTB Tower	200MW_e, 1,000MWh, 200MW_{th}	Large scale high heat furnace, kiln, oven.	❑ Basic Chemicals ❑ Cement ❑ Steel ❑ Large District Heating
JHTB Hot Walls	TBD MW_e, 0 MWh, TBD MW_{th}	Furnaces and kilns built of "E-brick" walls, floors and ceilings.	❑ Basic Chemicals ❑ Glass ❑ Cement ❑ Steel
JHTB + Power Turbine	200MW_e, 1,000MWh, 200W_{th}	Energy Storage to Power Generation, combined heat and power.	❑ Electric Utilities ❑ IPPs ❑ Municipal Campus ❑ Industrial Campus

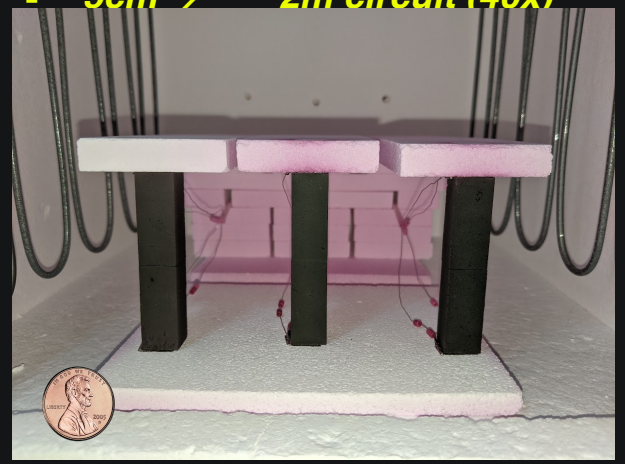
Today's technical progress

- ETS has driven technology from ***TRL 1 -> 5*** in 2 years and rapidly approaching ***TRL 6***
- Materials
  - Scaled lab grade material to commercial ready production: ***1 lb → 1000 lbs (1000x)***
  - Multi-ton batches planned this year
- Pilot
  - Coupon characterization to full-scale heated brick circuit: ***600W → 60kW (100x)***
  - ***5cm → 2m circuit (40x)***

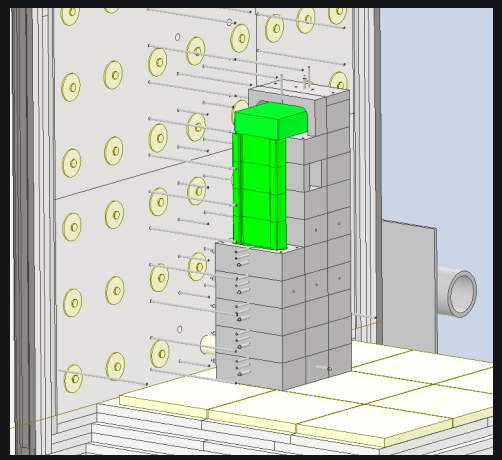
Then:
Material Synthesis

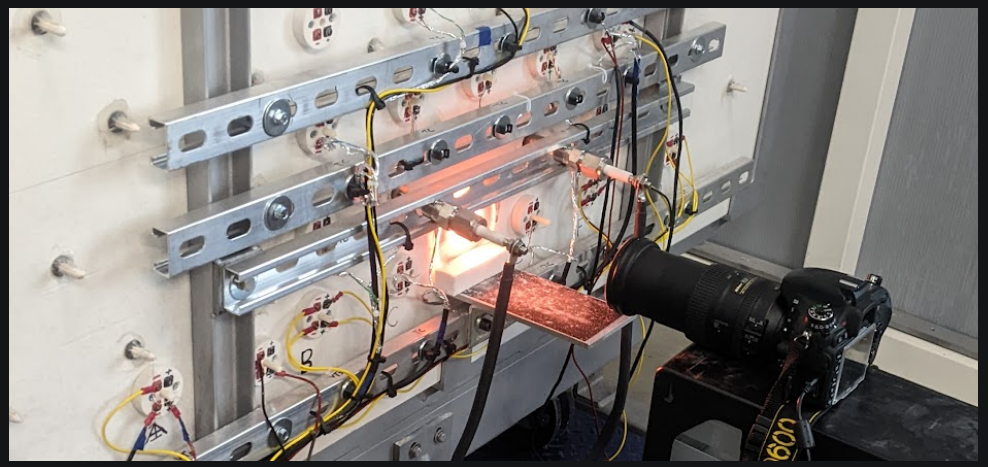


Now:
Commercial brick production



Then:
Coupon testing





Now:
Elevator sized pilot running heated brick circuit to 1700C and 70kW/m2

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Market Entry: Volatile price regions

Windy mid-west US wholesale (case study)

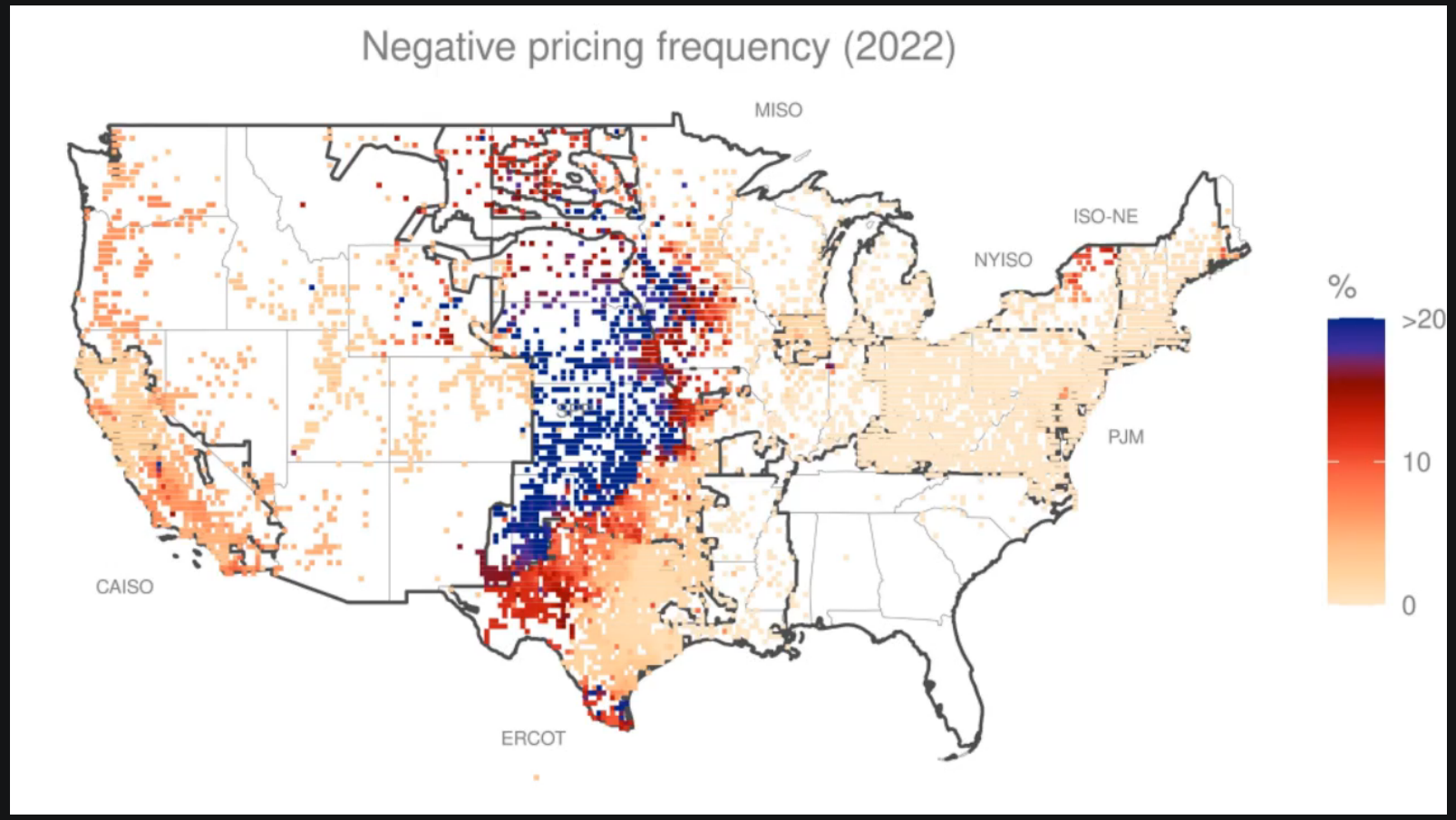
- 50% of the year $ electricity < $ gas
- 80% reduction in carbon emissions
- < 5 yr payback

California will follow

- Negative prices are driven by wind PTC (production tax credit)
- PV will soon have PTC as part of IRA

Not shown: favorable southeast rates

- Regulated utilities feel challenge of new loads
- Time of use rates



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