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Zero-Carbon Heat for Industry

David Bierman, Co-Founder and Chief Product Officer

2022-09-21

Wind and solar represent the lowest cost sources of industrial energy

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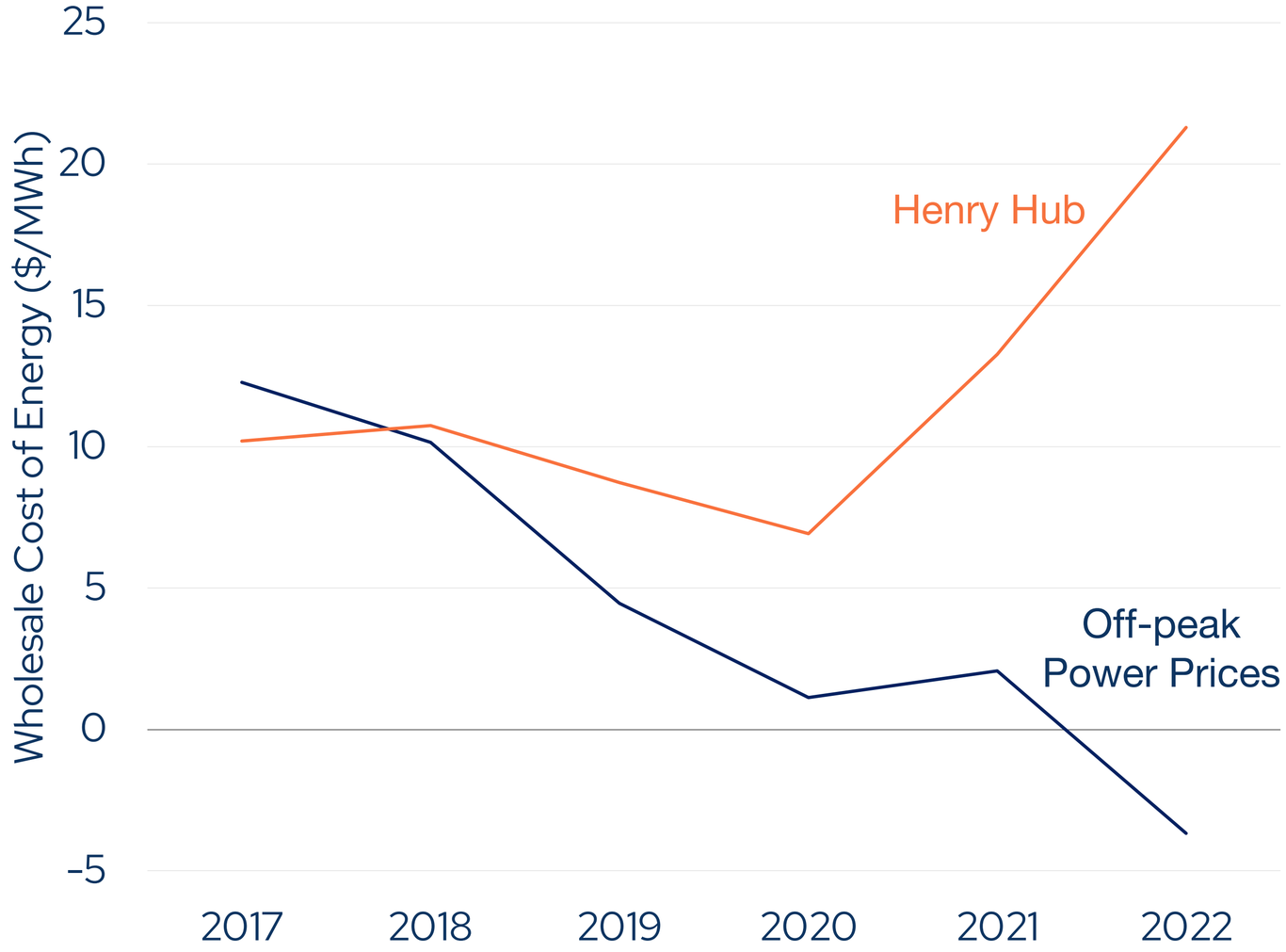
Renewables deployment unlocks opportunity to electrify Industrial Heat



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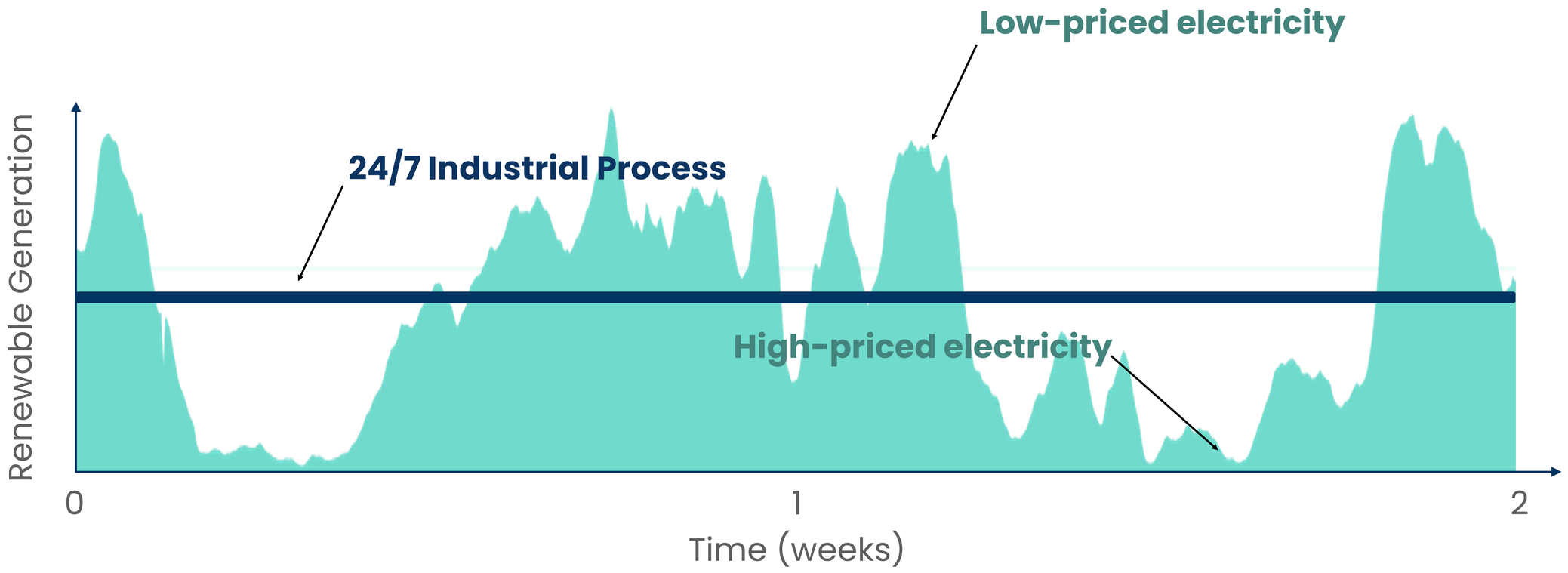
But intermittency in renewable power is incompatible with industrial processes



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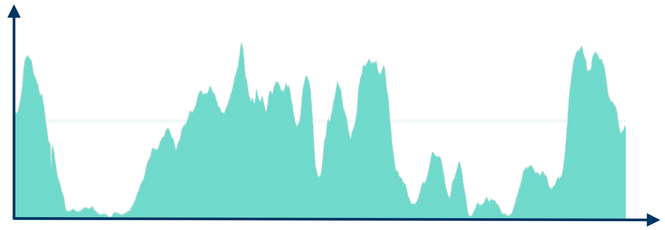
Antora converts intermittent renewables to on-demand heat

Product designed to deliver around-the-clock energy, 24/7/365

Input:

Cheap, clean intermittent renewables



Output:

Cheap, reliable process heat

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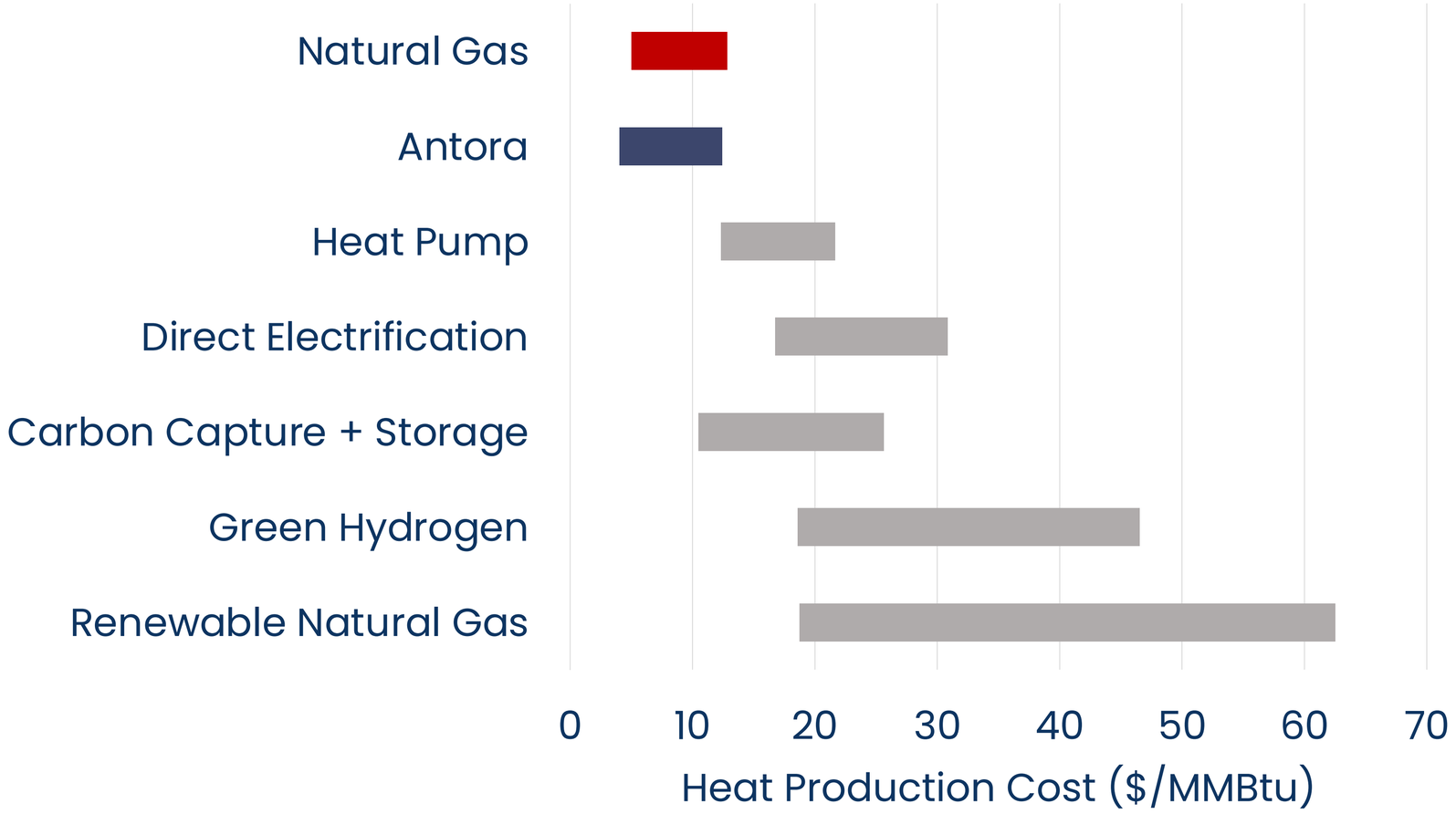
Low-cost renewables + storage unlocks the lowest-cost decarbonization pathway



NG: 2022 HH and TTF prices; Heat Pump / Dir. Elec: Baseload power assumed to be between $55 and $100/MWh for industrial sites; CCS: 2022 IEA avg for post-combustion; Green H2 between $2-4/kg delivered to site; RNG: MI ICF Study 2022

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Resistive heating of a low-cost material

Clean electricity generated with wind or solar is used to charge the system. The charging occurs selectively, only when the energy has minimal value elsewhere.

The clean electricity resistively heats carbon blocks to high temperatures, where the energy is stored as sensible heat in the material.

Thermal energy can be continuously extracted from the system to generate heat for a wide range of industrial processes on-demand.

Process steam up to 100 bar

HTF oil to 400 °C

Power

Antora's Thermal Energy Storage product is a simple industrial furnace, built with the same principles of an industrial graphitization furnace – a >100-year-old technology.

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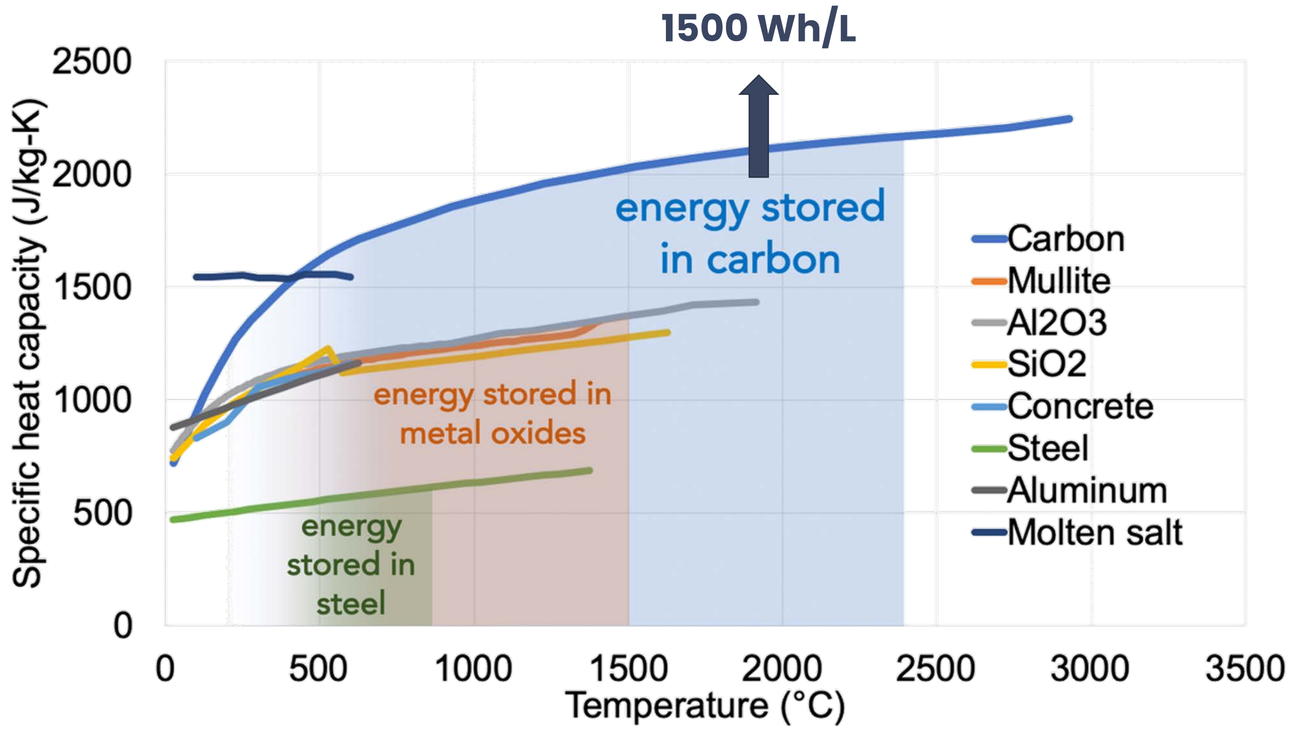
Why carbon? Low cost, highly scalable, excellent properties

- Ultra low cost ($1/kWh$_{th}$)
- Existing supply chain
- High thermal conductivity
- Access to high temps (high-energy density)
- High specific heat



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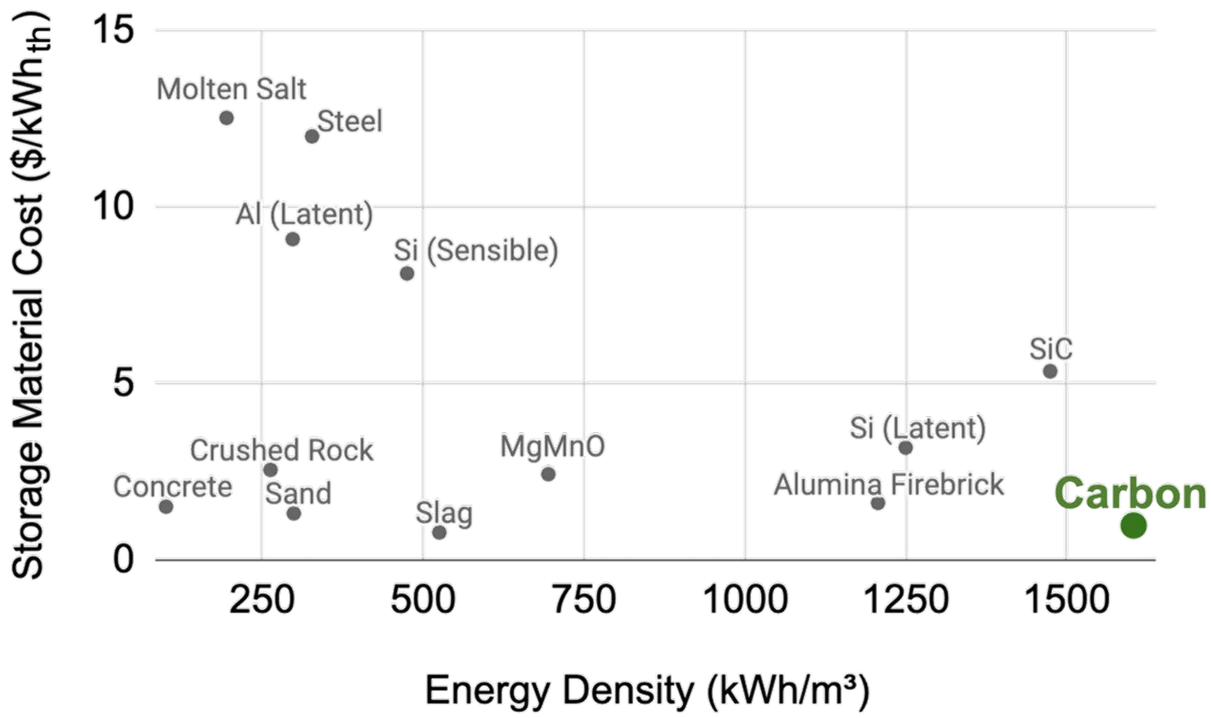

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Based on >100 years of proven industry operation

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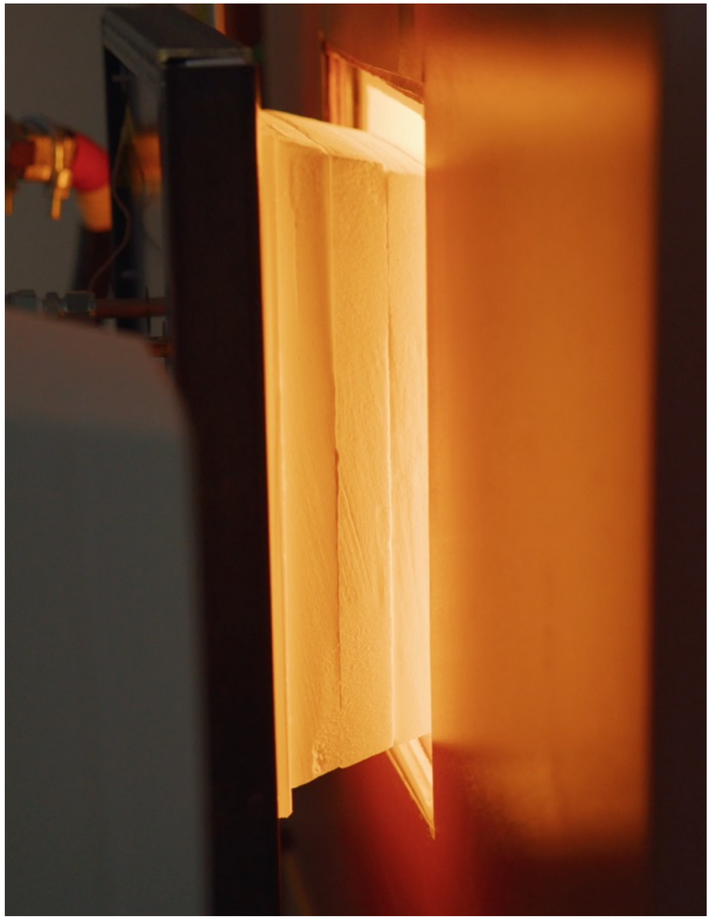
Why radiation? Using light to move heat drives cost, simplicity, and reliability

Cheap renewables opens design space

- Charging with electricity → high exergy
- Previous TES designed for CSP and limited to "low" temps
- Patented design is highly differentiated from other solutions

Using light eliminates complexity

- Moving heat without a fluid inside the storage unit drives down costs and increases reliability



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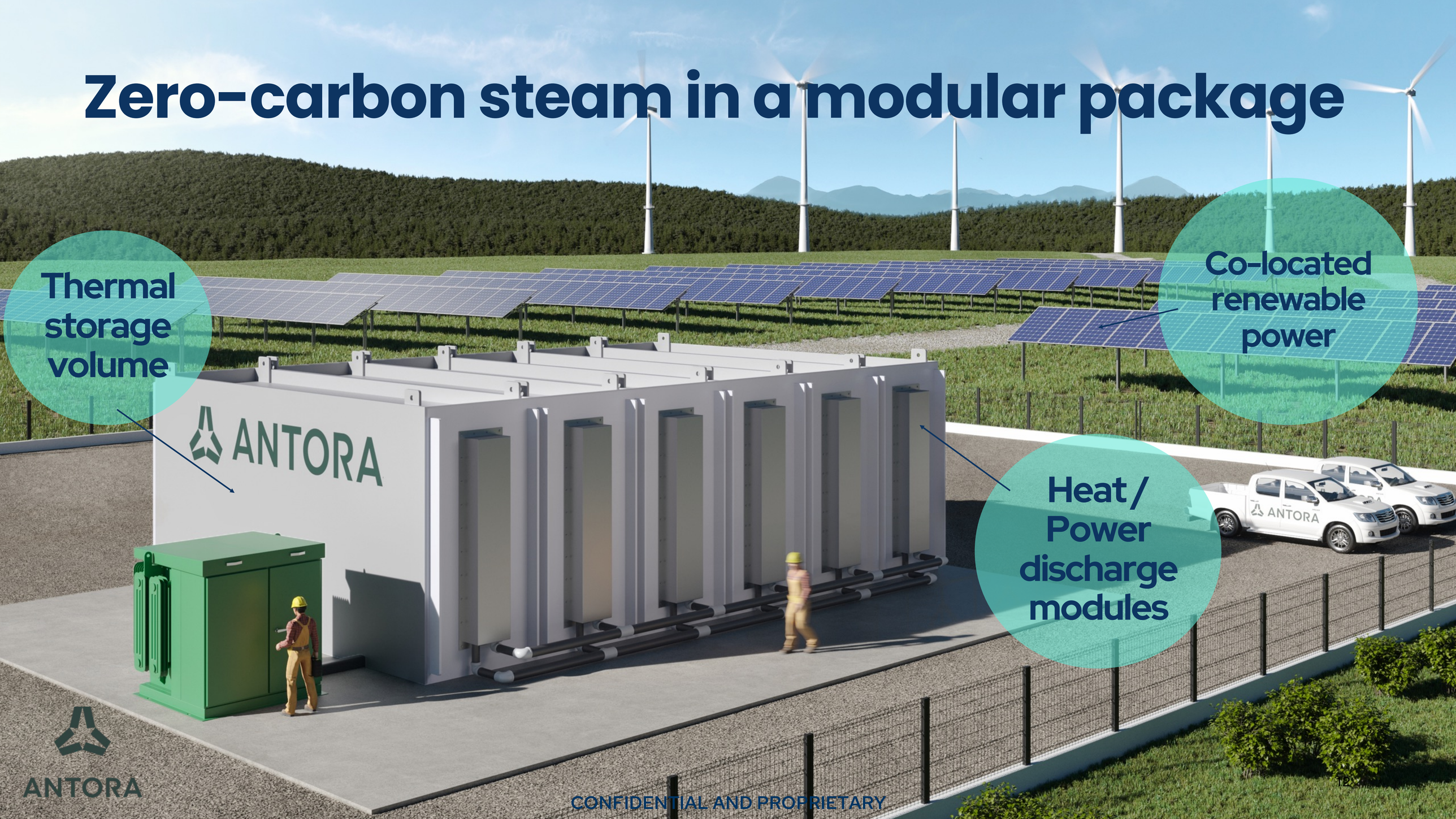
Zero-carbon steam in a modular package



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Designed for seamless integration in an industrial setting

Safe No fire hazard or reactive materials

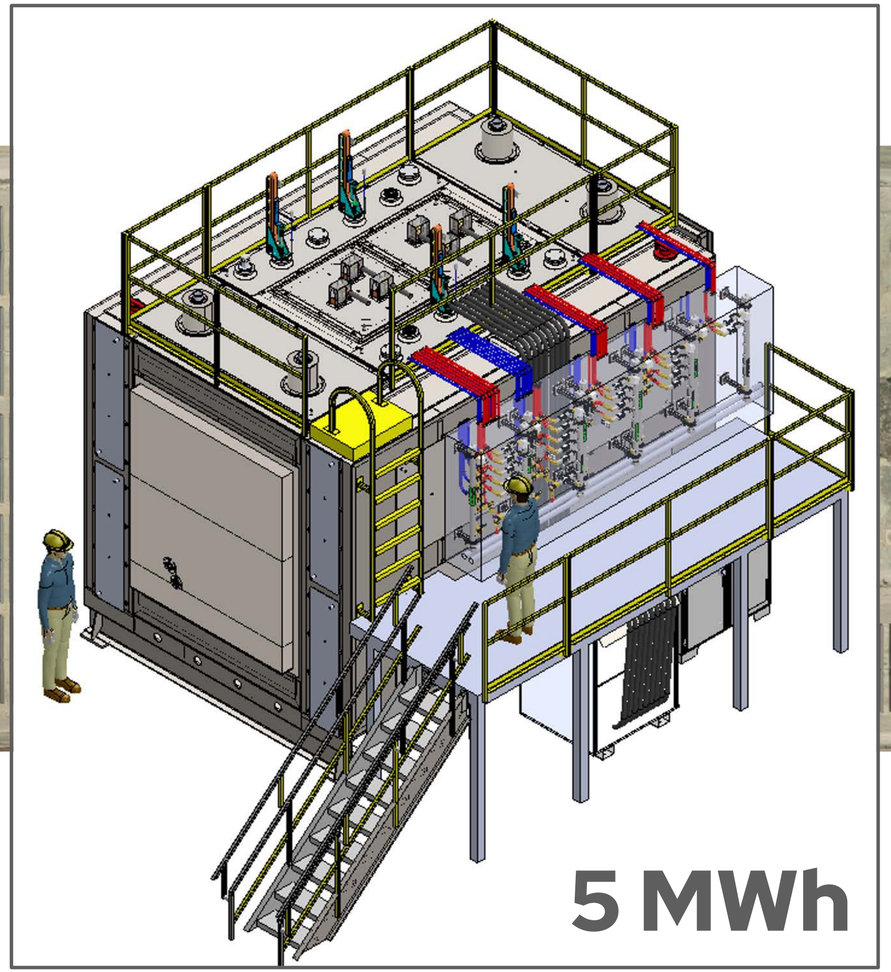
Reliable >30 year lifetime, no degradation

Flexible Quick startup and high turndown

Compact Small system footprint, easily siteable

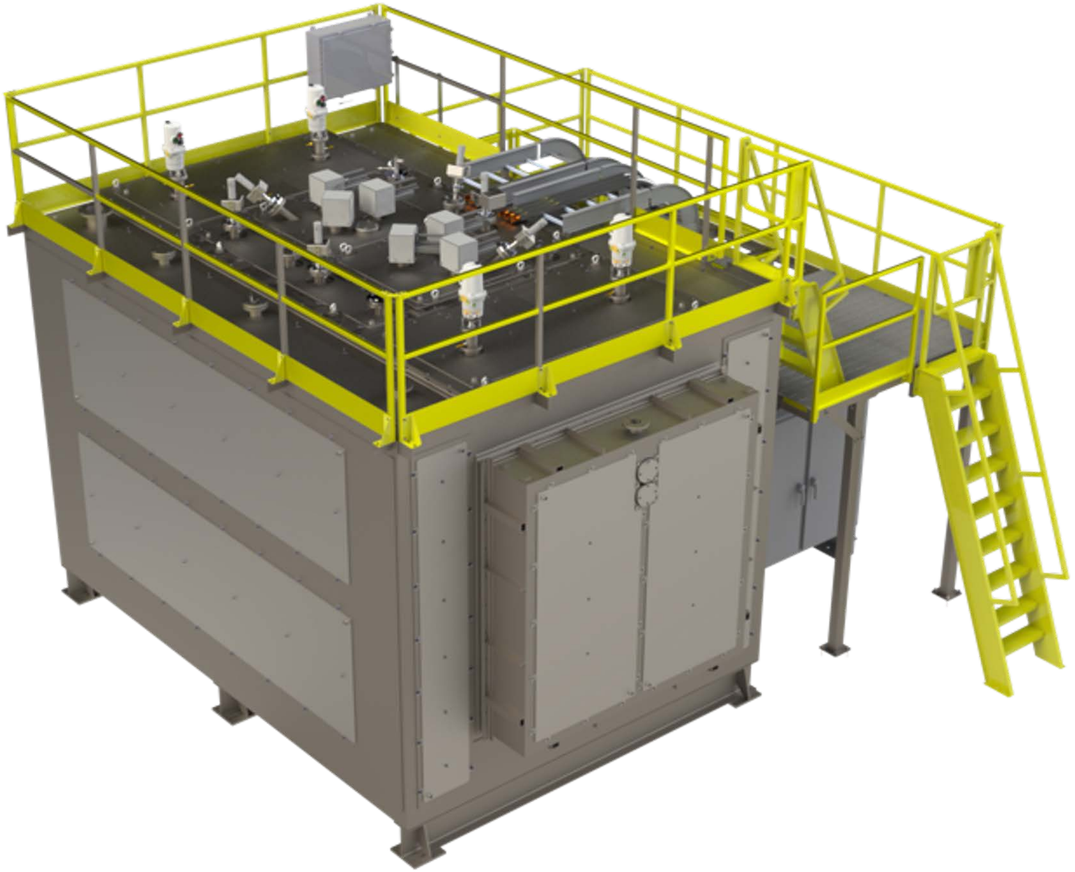
Modular Stack building blocks to meet any load

Pilot system: construction underway at customer site



Wellhead Electric

Beta pilot system: construction underway at customer site



- 5 MWh storage test facility, outputs HTF at ~315C
- All failure modes to be tested during commissioning
- Demonstrates and validates key system components (throttle, fast and variable discharge, continuous discharge, extended duration, etc.)
- Construction underway, scheduled installation by end of 2022

Antora team and partners

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Intersect Power

ANACAPA ENGINEERING AND DESIGN, INC.

PCL

Breakthrough Energy

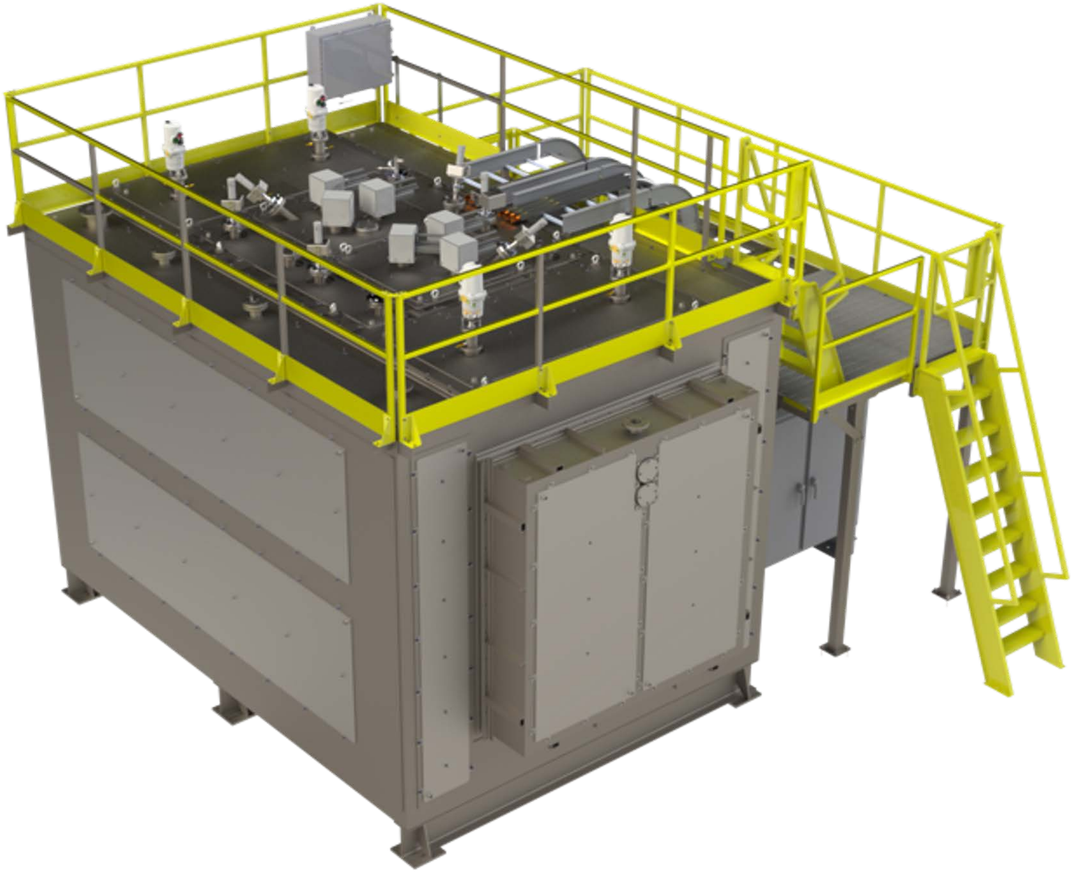
LOWERCARBON CAPITAL

BHP

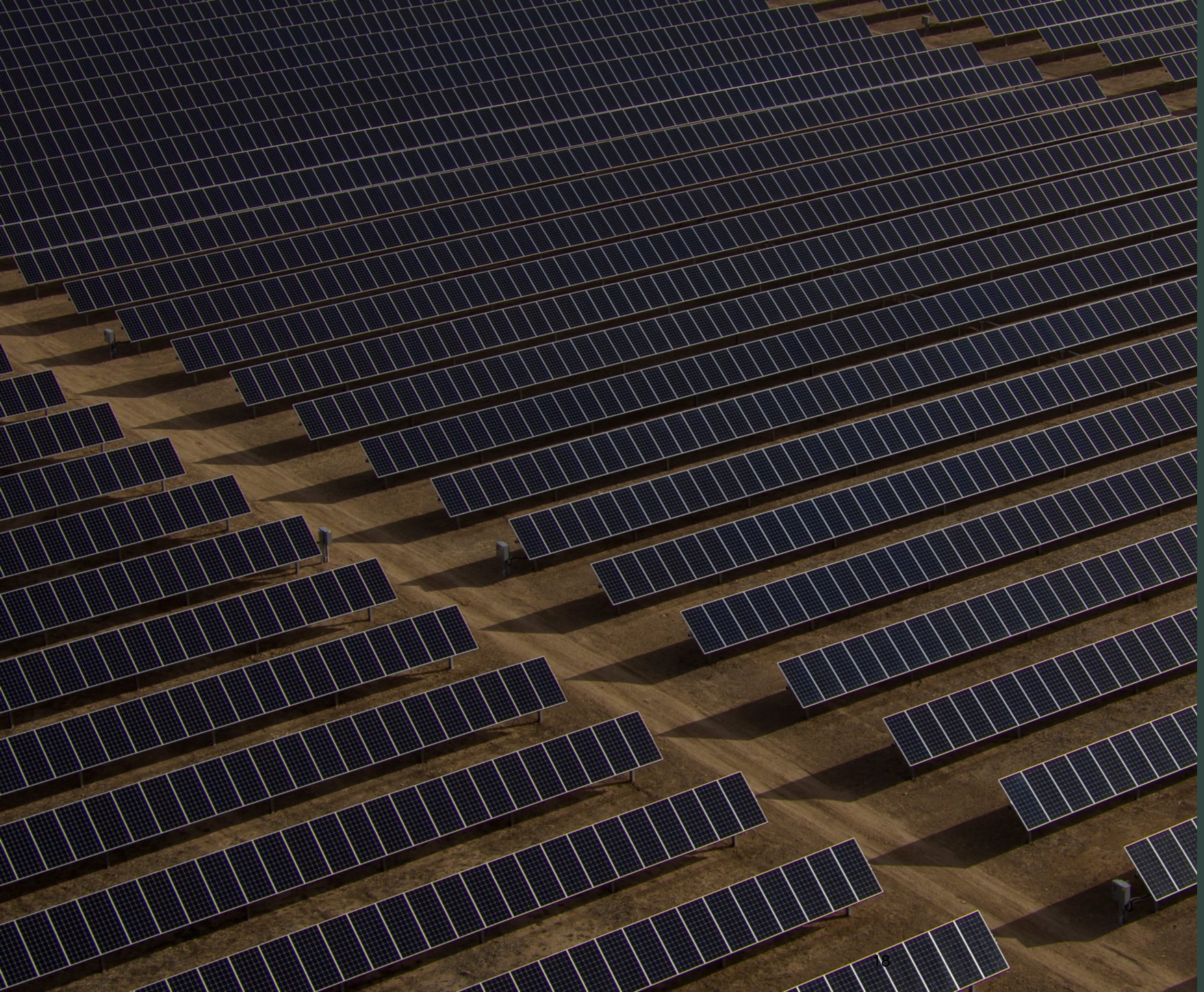
CALIFORNIA ENERGY COMMISSION

U.S. DEPARTMENT OF ENERGY

Conclusions



- Massive opportunity to switch our industrial heat fuel from gas & coal to renewables
- Key is deploying a thermal energy storage product to convert intermittency to reliability
- Antora is developing a simple solution to unlock rapid and *profitable* industrial decarbonization
- We are seeking commercial partners for projects in 2024 and beyond!



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9/20/2022

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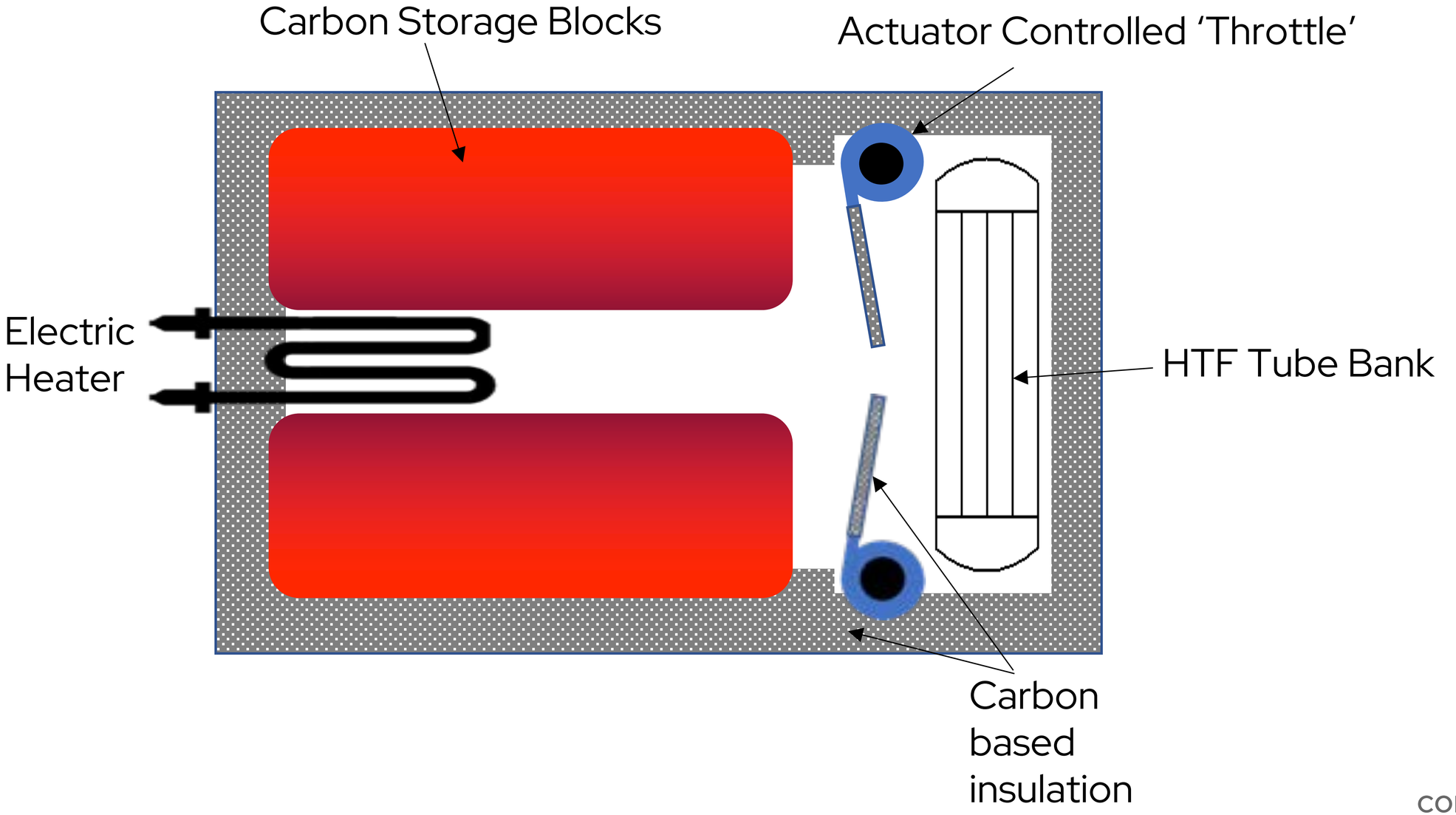
Basic components and architecture



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