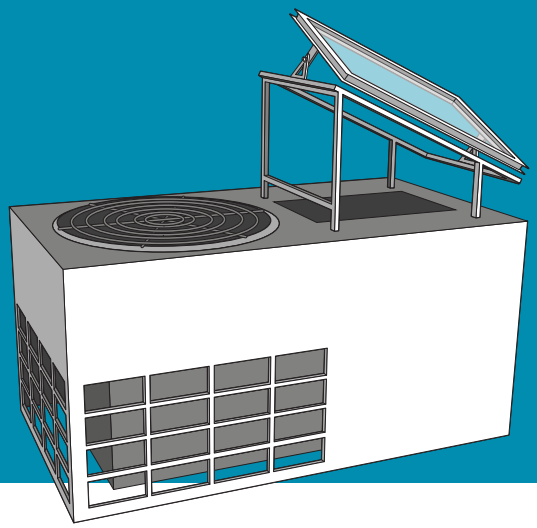
Technology Early Deployment

Hyper-Borean

Heat Driven Air Conditioning
for Off-Grid Cooling

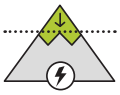


HyperBorean has developed a heat-powered compressor that can drive a standard vapor compression cycle for air-conditioning and refrigeration **without electricity**. HyperBorean's compressor can accept heat input from a variety of sources, including generators, dryers, and food processing. Initial pilot testing will be conducted this year using concentrated solar thermal as its power source. This will allow cooling to be provided directly from solar energy **without photovoltaic power generation**. Initial demonstration of this technology has been in the form of cooling for critical equipment in remote shelters (e.g., telecom).

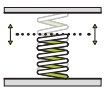
As the technology matures it may provide a solution for reducing the peak power demand on the grid from space cooling in buildings. Future versions of the technology will be hybrid units that switch seamlessly from electrically powered to heat powered operation when sufficient solar thermal heat input is available.

TECHNOLOGY BENEFITS

OFF GRID COOLING
without electrical support infrastructure.



REDUCED PEAK DEMAND
from cooling applications by up to 60%.



IMPROVED RESILIENCY
of critical cooling applications.

Disclaimer: HyperBorean's novel air conditioning system was chosen for TED because it supports **California's clean energy goals** of increased energy efficiency, reduced GHG emissions, and peak demand reduction. This document does not constitute or imply endorsement, recommendation, or favoring by EPRI or SCE of the product or company described herein. This publication is funded and administered by Southern California Edison's Emerging Technologies Program.

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HyperBorean heat-powered air conditioning compressor

This technology enables clean, off-grid cooling using energy directly from the sun, increasing resilience and reducing backup power requirements.

SOLAR COLLECTOR

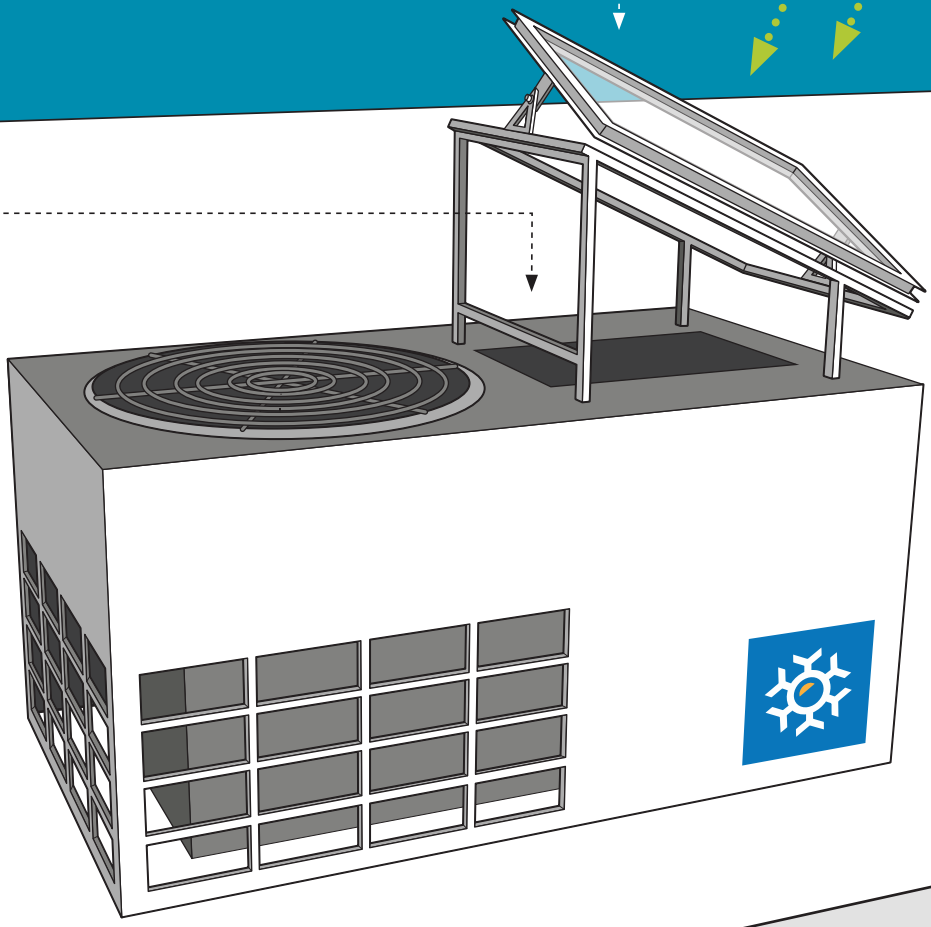
Concentrates solar energy to directly power the proprietary “burst compressor”.

COMPRESSOR

Converts solar thermal energy to kinetic energy to move refrigerant without energy conversion.

CONDENSER

Utilizes existing conventional refrigerant to allow for maintenance without extensive specialized training.



TARGET CUSTOMERS

- Critical infrastructure at remote locations requiring uninterrupted cooling.
- Telecom, railroad, cable TV providers, utilities, defense.
- Potential future applications in automotive, commercial HVAC and food processing.

HARDWARE COMPATIBILITY

- Solar energy is concentrated via proprietary “burst compressor” design to thermally drive vapor-compression cooling without electricity.
- Solar thermal energy is directly converted to kinetic energy to move refrigerant through a vapor compression system without any intermediate energy conversion (e.g. no photovoltaic cells or steam turbine) and its associated losses.
- Conventional refrigerant (currently R-410a) is used to allow for serviceability with minimal specialized training.
- Core technology can be applied to various waste heat sources (generators, dryers, food processing, etc.).

SYSTEM FEATURES

REDUCES ENERGY USE AND PEAK DEMAND OF COOLING EQUIPMENT

USES SOLAR ENERGY DIRECTLY FOR LOW CARBON “FREE COOLING”

INCREASED RESILIENCY DURING GRID INTERRUPTIONS

REDUCES BACKUP POWER REQUIREMENTS

MAINTAINS SERVICEABILITY VIA ESTABLISHED CONCEPTS

RECOVERS HEAT WITHOUT SORBENT MATERIAL

California's decarbonization challenge

California's executive order B-55-18 mandates that the state achieve carbon neutrality by 2045. Additional legislation supports this goal through multiple strategies that include double energy savings by 2030 (SB 350), increased demand flexibility (19-OIR-01), advanced energy storage and 100 percent of all retail electricity from renewable energy (SB 100). Applying these strategies to new construction and upgrades to existing buildings provides a path to achieving carbon neutrality but also comes with a new set of challenges:

1.

New technologies for buildings

must support desired outcomes for CA.

2.

Testing, compliance & standards

including utility participation and enabled workforce.

3.

Establishing trust

that replacement of old systems will meet/exceed performance expectations.

HYPERBOREAN SUPPORTS CALIFORNIA'S DECARBONIZATION GOALS

INCREASED ENERGY OPTIONS
a reliable, efficient, non-electric alternative to conventional HVAC.

<90%

REDUCED PEAK DEMAND
from cooling equipment.

REDUCED ENERGY USE
from cooling equipment.

INCREASED RESILIENCY
during grid interruptions.

Addressing market barriers to critical infrastructure

The ½-ton HyperBorean prototype has had initial interest from telecom and railroad customers who have many remote shelters for critical equipment that require continuous cooling. In addition to reducing the energy consumed for space cooling at these locations by providing daytime supplemental cooling, the technology increases resiliency at these sites by not requiring backup power to provide cooling during daytime power interruptions. Identified barriers include:

GENERAL BARRIER

- ✓ Only operates in heat powered mode during sunlit hours, limiting applicability and cost effectiveness.

EXPANSION BARRIERS

- ✓ Scale-up to commercial size.
- ✓ Field data from pilot testing.
- ✓ Test data from utility application.

FUTURE BARRIERS

- ✓ Technical design of hybrid systems.

LEVERAGE POINTS TO SCALE

- ✓ **$1.7B serviceable, obtainable market** in automotive, commercial HVAC, and food processing sectors.
- ✓ **$2.1M pre-seeded funding** from angel investors and founder.
- ✓ Applied for **$340K grant** from the US Air Force (AFWERX).
- ✓ First **sale to Sprint/T-Mobile scheduled** for Q4 2021.

Market readiness

5
TECHNOLOGY READINESS LEVEL SCORE

- Commercial prototype developed for pilot testing.

3-5
YEARS TO MARKET

- After field demonstrations TRL expected to improve.

4
MANUFACTURER READINESS LEVEL SCORE

- Scaling up system to larger capacity while maintaining small form factor requirements.

2
KEY OUTCOMES

- **EFFICIENT COOLING**
  Directly utilizes solar energy with no need for photovoltaics.
- **REDUCED DEMAND**
  Up to 60% reduction.

Supporting utility goals for decarbonization

RENEWABLE INTEGRATION
Directly utilizes solar energy for cooling.

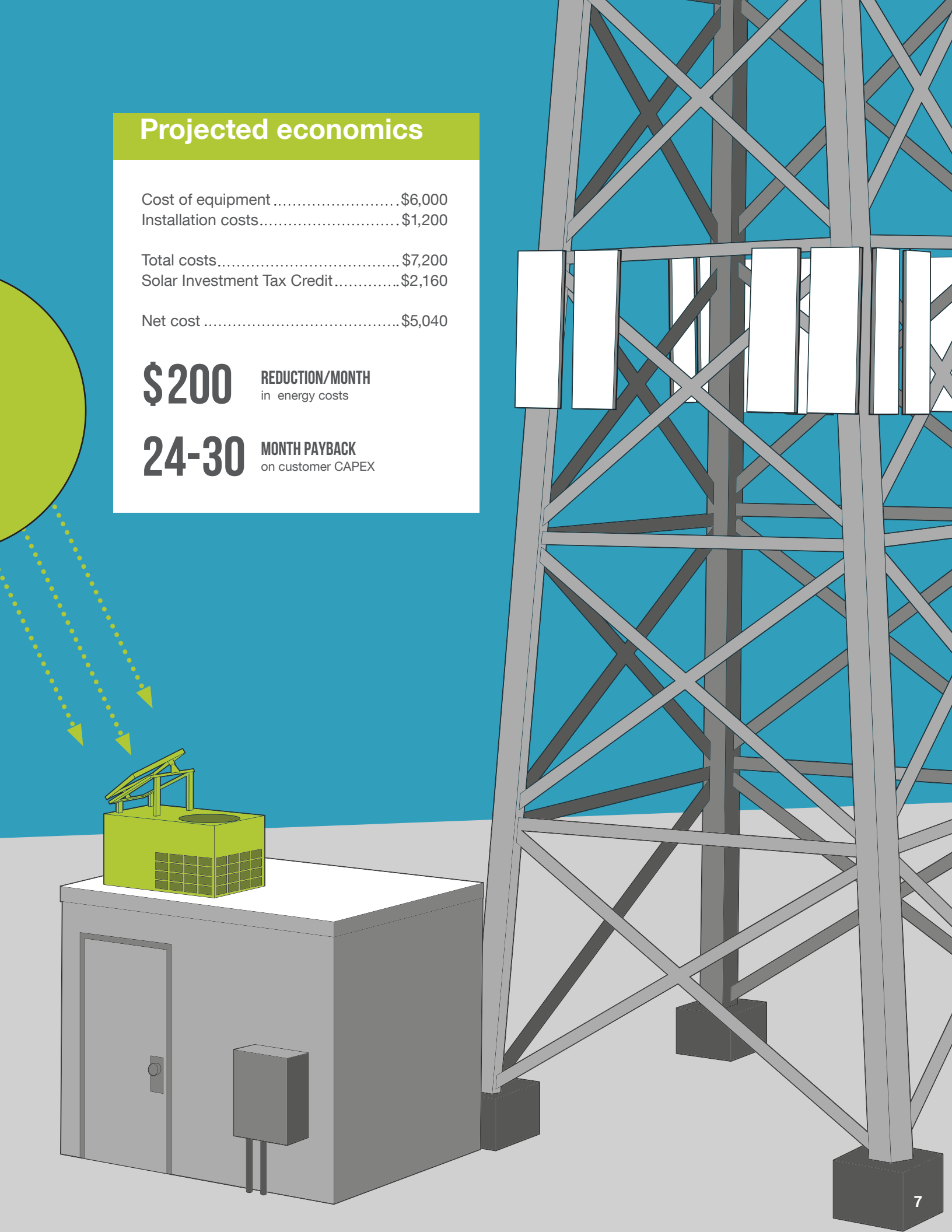
DEMAND REDUCTION
Eliminates ~90% of peak electrical demand.

Projected economics

Cost of equipment	$6,000
Installation costs	$1,200
Total costs	$7,200
Solar Investment Tax Credit	$2,160
Net cost	$5,040

$200 REDUCTION/MONTH
in energy costs

24-30 MONTH PAYBACK
on customer CAPEX

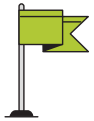


HyperBorean Utility Opportunity Assessment

TECHNOLOGY CATEGORY

1.
Efficient Cooling

2.
Peak Load



ETP PRIORITIES

DECARBONIZATION

Directly converts solar energy to cooling.

PEAK LOAD REDUCTION

Reduces peak demand by satisfying daytime cooling loads directly.

IMPROVED RESILIENCY

Offers alternative energy source for cooling loads.

KNOWLEDGE INDEXES

TECHNICAL PERFORMANCE

Medium

MARKET KNOWLEDGE

Medium

PROGRAM INTERVENTION

Low

UTILITY VALUE

- Reduced peak load demand driven by space cooling.

UTILITY TRAJECTORY PATH

- EE Operations (HVAC Energy Efficiency).
- Integrated DSM (DR and Solar/Storage).

OPPORTUNITIES

LEVERAGE POINTS

- Initial prototype testing with Sprint/T-Mobile, targeting first product sales in Q4 2021.
- Application to AFWERX (US Air Force grant program).
- Utility equipment shelters.

MARKET SIZE

- Beach-head: Telecom and railroad.
- SAM: 20k shelters/yr (300k existing). Est. $540M in telecom, cable, military, utilities.
- TAM: $1.5B incl. auto, buildings, and food processing.

BARRIERS

GAPS TO FILL

- Scale up capacity to 2-5 tons of cooling.
- UL certification.
- Integrate technology with conventional compressors (electrically driven) to offer hybrid product.

IN-PROGRESS

- Redesign solar collector to optimize size and reduce need for repositioning.

UPCOMING

- Engage OEM partners.

SOLUTION

- Demonstrate reliability of technology in remote, critical applications.

NEXT STEPS

COMPANY

- Utility-specific cost-benefit analysis.

CRITICAL ETP ACTIONS

- Socialize with SCE.
- Socialize with other IOUs.
- Field test in CA.

UTILITY

- Value proposition and business use case.

OTHER

- EPRI M&V testing and/or grant collaborator.
- Development and testing USWERX award.

ted

TED is a process where innovative technologies are selected for assessment and review based on the technology application, team strength, and alignment with the Technology Priority Maps, to fulfill the California decarbonization challenge.

FOR MORE INFORMATION

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