

Thermal Radiation Measurement for Optimal Thermal Comfort

Technology Early Deployment

Hearth Labs Q Sense

Hearth Labs' Q Sense is a low-cost, easy-to-use measurement and analysis software designed to evaluate thermal comfort in the built environment. Q Sense includes a thermal-LiDAR tool that measures radiative and convective heat transfer which is then analyzed by Q Sense software. Q Sense provides measured quantities, a thermal comfort map, energy savings estimates based on suggested heating and cooling operational changes and recommended retrofit options for greater energy efficiency.

Q Sense also provides radiative and convective heat transfer measurements that can be used for research and investigations into retrofits and new designs. These measured data outputs easily integrate into common modeling file formats, enabling a streamlined workflow. Q Sense is an all-in-one tool for understanding heat transfer in a space. It is intended to be used by energy auditors, AEC companies, and researchers.

TECHNOLOGY BENEFITS



REDUCES ENERGY CONSUMPTION for HVAC systems by 8%.



OPTIMIZES EFFICIENCY for both summer cooling and winter heating.



FACILITATES DIAGNOSIS of thermal space issues.



SUPPORTS RESEARCH/DESIGN around thermal radiation and convection.

Disclaimer: Hearth Labs' Q Sense sensor and analysis 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.



Hearth Lab's Q Sense thermal LiDAR

Hearth Labs' Q Sense thermal sensor along with LiDAR, measures surface temperatures and spatial geometry. The Q Sense framework algorithms use these measured data to calculate heat transfer in the space, which in turn is used to produce thermal comfort maps, industry standard metrics, and the potential impact of retrofits.

To create measurements, Q Sense leverages the capability of iPhones with LiDAR (iPhone 12 Pro, iPhone 12 Pro Max, iPhone 13 Pro, iPhone 13 Pro Max and future models). Using the Q Sense application, the contractor is able to scan walls while walking through the space. Measurement data are then available in a raw file format or in standard file formats commonly used in energy analysis tools.

TARGET CUSTOMERS

- ✓ AEC technical consulting firms.
- Energy audit program implementors.
- ✓ Architecture firms.
- ✓ Facilities managers.
- ✓ Researchers in industry/academia.

HARDWARE COMPATIBILITY

 Q-Sensor works with LiDAR-equipped iPhones.





FRAMEWORK FOR THERMAL COMFORT resulting in reduced energy use and lower CO₂ emissions.



DATA POINTS to easily characterize thermal comfort of a space.



EVALUATION of thermal levels pre and post occupancy.



COMMUNICATION of complex heat transfer information for non-technical stakeholders.



ALGORITHMS to aid in the design process for new projects or retrofits.

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.

HEARTH LABS SUPPORTS CALIFORNIA'S DECARBONIZATION GOALS

212 GT REDUCED CO₂E if total adoption of the technology is accomplished. TITLE 24 POTENTIAL TOOL

to help builders comply with performance standards.



Addressing market barriers to decarbonization of commercial buildings

Space conditioning in buildings represents a significant opportunity for energy savings in the United States. Hearth Labs' Q Sense sensor and analysis platform may enhance conventional approaches to balance comfort and efficiency in space conditioning. Barriers and opportunities include:

LOW AWARENESS

- Impact of thermal radiation on comfort has largely been ignored in space conditioning.
- Thermal radiation is rarely measured; many buildings rely on temperature alone (without humidity).
- Limited understanding by building owners / managers of the value of measuring radiation.

COST

- Cost-effectiveness of Q Sense may be limited to building auditors and energy service providers.
- Limited published data from case studies, but energy savings expected to vary significantly by building type and construction.
- Hardware-as-as-Service business model relies on recurring costs, which are difficult to recoup without a portfolio of buildings.
- Larger energy efficiency gains may need a retrofit, requiring a larger initial investment.

LEVERAGE POINTS

- Pre-seed fundraising from SOSV and HAX collaboration with EPRI.
- Department of Energy CleantechUP National Building Technology Prize field test in CA.
- Autodesk Entrepreneurship Impact Award
- LaunchR 2nd Place Cleantech Startup funded by PSEG.
- Princeton New Ventures Fund.

- Department of Defense Operational Energy National Finalist.
- Lawrence Berkeley National Lab Building Robotics Prize.

Market readiness



TECHNOLOGY Readiness level Score

- The standalone Q Sensor device was demonstrated through a case study, but the recent iPhone version needs to be evaluated in the field.
- Additional pilot testing is needed to validate savings across a range of typical buildings.
- Research completed on high volume production of sensors.
- Hardware and manufacturing risks reduced through relationships with manufactures and suppliers in U.S., China, and Mexico.
- Shenzhen company base during summer/ fall 2019 secured portion of supply chain



YEARS TO

MARKET

6 Key Outcomes

3.

C&S alignment

Potential to help

evaluation and

improvement.

builders comply with

Title 24 performance

- Path to market through building diagnostics for AEC (Architecture, Engineering, Construction) industry.
- Currently developing Q Sense software platform to integrate Q Sensor data into building controls.
- Created maps of thermal comfort distribution through space, highlighting areas regularly outside of occupant's comfort zone.
- Recommended adjustments to HVAC systems and retrofits to improve efficiency and comfort.
- Simulated impact of retrofits, developing baseline measurements and before/after comparison for implemented retrofits.

Supporting utility goals for decarbonization

1.

Energy savings

7-8

READINESS

LEVEL SCORE

MANUFACTURER

Up to 12,000 TBtu US energy reduction*.

2.

Decarbonization

2.12 GT CO₂e*.

4.

Demand flexibility

Characterize difficult to quantify measures for demand response systems.

* Potential savings assumes increased adoption of EE projects nationwide

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Example use case

Facility managers at Princeton's Chancellor Green Library would often receive complaints about the thermal comfort of the building. This was perplexing because the HVAC setpoints were being met.

Hearth Labs' Q Sensor, being developed at Princeton at the time, was brought in to investigate the problem. A scan of the library with the Q Sensor produce a dataset which was then used in the Q Sense framework. The result was a thermal comfort map which indicated the setpoints needed to be adjusted to account for the effects of thermal radiation, the culprit of the discomfort. In particular, the thermal mass of the walls caused a lag in temperature that was undetected by air temperature measurements.

Q Sense further showed that there were energy leaks in the library, which could be fixed with a retrofit. The combined sensor and analysis software made it simple to quantify the potential savings of the investment.

Hearth Labs Q Sense Utility Opportunity Assessment



TECHNOLOGY CATEGORY

Thermal Heating and Cooling



ETP PRIORITIES

ENERGY SAVINGS

Reduced HVAC energy consumption by an average of 8%.

DECARBONIZATION

Reduces 1,128 TBtu & 0.19 GT CO_2e through EE measures.

C&S ALIGNMENT

Design and verification of thermal/efficiency requirements. Potential to help builders comply with Title 24.

DEMAND FLEXIBILITY

Quantifies measures for demand response systems related to heating and cooling.



KNOWLEDGE INDEXES

TECHNICAL PERFORMANCE

Medium

MARKET KNOWLEDGE

Medium

PROGRAM INTERVENTION

Low

UTILITY VALUE

- Reduced HVAC energy consumption by an average of 8%.
- Reduces 1,128 TBtu & 0.19 GT CO₂e through EE measures.



OPPORTUNITIES

CRITICAL ETP ACTIONS

- Test with EPRI.Socialize within SCE.
- Socialize with other IOUs.

LEVERAGE POINTS

- Retrofit project for commercial NYC locations.
- >\$700K in funding and in kind.
- 2 patents granted and 1 pending through Princeton University that are exclusively licensed to Hearth Labs.

MARKET SIZE

 Commercial building market and residential via smaller HVAC companies.



COMPANY STRATEGY

STAKEHOLDERS

- Electric utilities
- EPRI
- Facility Managers
- AEC and AD
 design firms
- Researchers

GAPS TO FILL

- Impact of thermal radiation on comfort.
- Cost-effectiveness across a wider audience.

COMPANY GOALS

 Commercially available product that enables detailed thermal comfort measures.



NEXT STEPS

COMPANY

- Completion of retrofit project in NYC.
- Data collection/ model training for future product.
- Partnership w/ AEC, facility managers, and contractors.

UTILITY

- Field demo results.
- Value proposition and business use case.
- Easy-to-use tool for energy audit and EE programs.

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