

Fraunhofer CSE Building Technology Showcase

Energy Efficiency, Design Innovation, Historic Urban Architecture

Fraunhofer's Building Technology Showcase (BTS) represents the bright future of sustainable design in North America. This is a future that Price Industries is deeply committed to being a part of.

The BTS is Fraunhofer Center for Sustainable Energy Systems' headquarters in Boston's fast-growing Innovation District, a deep energy retrofit of a 100-year-old building that serves as a living laboratory for R&D of advanced sustainable energy technologies. Completed in 2013, the BTS leverages cutting-edge materials and equipment in an effort to facilitate the widespread, nationwide adoption of energy-saving technologies in commercial and residential sectors.

Prior to beginning the retrofit, Fraunhofer reached out to BR+A Consulting Engineers – a noted leader in the sustainable design community. BR+A then enlisted Price to supply the majority of the HVAC equipment on the project, as no other manufacturer could respond to the strict demand for highly innovative, research-driven products. Price jumped at the chance to participate in this sophisticated project, which would allow us to test our products in a variety of new applications, and we are continuing to work with Fraunhofer on a number of research initiatives related to air distribution and control.

Project Summary

PRICE PRODUCTS

See individual floor pages

PROJECT HIGHLIGHTS

Location: Boston, Massachusetts

Project Type: Retrofit, Living Laboratory

Completion Date: March 2013

Square Footage: 50,000 ft²

DESIGN TEAM

Architect: DiMella Shaffer

Engineer: BR+A Consulting Engineers

Price Representative: Buckley Associates, Inc.

First Floor

Research

Lobby Reception, Gallery, Large Conference Room:

- Compare the effectiveness of three different displacement ventilation setups – with chilled floors, with chilled ceilings, and with both systems operating
- Measure effects of stratification, air quality, and load split between products
- Conduct tests under varying loads
- Conduct tests during peak and nonpeak hours.

The results of this research will provide

Price with real-world test data to complement the extensive data we've collected in our lab experiments.

Guide

A number of Price products can be found immediately upon entering the Building Technology Showcase. In the front entrance vestibule, a Price Diffuser is recessed in the ceiling, while in the lobby {1} a row of convective units can be seen installed along the vertical mullions of the front window. These units have been custom finished to match the window mullion, demonstrating

Price's ability to "hide" equipment for seamless integration into a facility.

Up the short set of stairs are the lobby reception and gallery {2}. In these areas, Price Chilled Sails can be seen installed in the ceiling between the support struts. The lobby reception also has Price DF1R Displacement Ventilation installed along the wall. The controls setup runs displacement as the first stage of cooling, and uses chilled sails as a second stage of cooling under normal operating conditions. The chilled sails rely on the displacement system to provide ventilation and satisfy latent loads, which results in a greatly reduced supply air volume requirement, making this hybrid solution extremely energy efficient when compared to a traditional all-air system.

From this space you can also see the PV High Bay Area and the Facade Preparation Facility {3} through the viewing window. The majority of the Price equipment in the basement can be seen from this window, with the exception of the vertical blower coils. *Please reference the Basement section on page 10 for more details.*

Beside the lobby reception is the Large Conference Room {4}, which also houses Price Chilled Sails and

| PRODUCTS | ROOMS |
|---|--|
| Grilles, Registers, Diffusers | Throughout building |
| Window Convective Units | Lobby |
| Chilled Sails – CSA | Lobby Reception, Large Conference Room |
| Displacement Ventilation – DF1R | Lobby Reception, Large Conference Room |
| Displacement Ventilation (Overhead) – DF1L-HC | Work Room |
| Active Beams - ACBL-HE | Office F115, Elevator Lobby |
| Industrial Displacement Ventilation – DR360i-HC, DDIA | PV High Bay |
| Blower Coils - BCH, BCV | PV High Bay |
| Fan Coil Units – FCHG | Elec. Room, Loading, Elevator Control Room |



First Floor Map

1. Lobby
2. Lobby Reception / Gallery
3. PV High Bay
4. Large Conference Room

■ Research area ■ Non-research area

*Please refer to bold numbers in text for corresponding room and product information



Window Convective Units:

- Fin tube radiator and tangential fan combination
- Custom finish for seamless integration
- Attached 6-way valve
- Heating and cooling

Displacement Ventilation. The chilled sails were built with a service border to accommodate installed lighting. The displacement ventilation is installed along the outer wall of the room. This space is controlled in the same way as the lobby reception, with displacement running as the first stage of cooling, and chilled sails as the second.

Chilled Sails - CSA



Features

- Transfer heat via natural convection and radiation
- Higher cooling capacity than radiant panels
- Architecturally appealing
- Improved indoor air quality and thermal comfort
- Attached 6-way valve
- Heating and cooling

Second Floor

Research

PV Office Area and Workshop:

- Evaluate life cycle cost and operation of active beams vs. fan coils
- Monitor thermal comfort conditions
- Active Beams: evaluate flow rates and energy consumption during different operation modes
- Fan Coils: evaluate demand control ventilation, fan power when running wet/dry coil, and energy consumption during different operation modes

Wet Chemistry Laboratory:

- Compare venturi valve supply/exhaust combination to single duct terminal supply with modulating air volume control valve exhaust
- Monitoring pressure stability
- Occupancy sensor for primary air reset; 6ACH occupied and 4ACH unoccupied

Guide

On the second floor, the design team chose to utilize Price VAV Fan Coil units in the interior and exterior zones of the PV Office Area { 1 }.

The fan coils in this area are designed to operate under dry coil conditions, but can also be used for low chilled water temperature applications. These units provide conditioned air with minimal ductwork, and are more economical to install than central heating systems with air handling units.

In the PV Workshop { 2 } – which dominates the majority of the second floor – Price ACBL-HE Active Beams are used to deliver a combination of thermally conditioned primary and induced air. Each of these beams utilizes the wings option for exposed application, while the two units closest to the far wall also have the slimline coupling option and an integrated return section.

During normal operations Siemens controls the PV Office Area and Workshop spaces, but Price has the ability to take control of one or both areas in order to conduct research.

Directly beside the PV Office Area is the Wet Chemistry Laboratory { 3 }. In this space, Price supplied venturi valves, air dampers, single duct terminals, and radial flow diffusers. These products play an important role in maintaining the strict environmental conditions necessary for a laboratory space.

| PRODUCTS | ROOMS |
|---|-----------------------------|
| Fan Coil Units – FCHG, FCHGQ | PV Office Area, Office F214 |
| Active Beams with Wings Option – ACBL-HE | PV Workshop |
| Venturi Valves – VV | Wet Chemistry Lab |
| Air Dampers – CCD | Wet Chemistry Lab |
| Single Duct Terminals – SDV5, LDV5 | Wet Chemistry Lab |
| Radial Flow Diffusers – RFD | Wet Chemistry Lab |
| PIC-VV Tracking Pair Supply – Venturi Valve | Wet Chemistry Lab |
| LM Tracking Pair - Exhaust Venturi Valve | Wet Chemistry Lab |
| PIC Tracking Pair - Supply Terminal | Wet Chemistry Lab |
| LM Tracking Pair - Exhaust Terminal | Wet Chemistry Lab |
| Slot Diffuser – AS210, UP | Office F214 |



Second Floor Map

1. PV Office Area
2. PV Workshop
3. Wet Chemistry Laboratory
4. Office (F214)

■ Research area ■ Non-research area

*Please refer to bold numbers in text for corresponding room and product information



Venturi Valves – W:

Venturi valves are mechanically pressure independent control valves designed specifically for healthcare room pressure and fume hood control applications. The highly engineered internal plunger assembly ensures the valve will respond to changes in duct static pressure in less than one second.

The laboratory also has two supply and exhaust duct branches installed. The first branch is a venturi valve supply/exhaust combination, while the second branch is single duct terminal supply with a modulating air volume control valve exhaust. Depending on which branch is being tested, the air dampers for each supply and exhaust branch will be open or closed. Flow sensors monitor the supply and return systems for stability. The Wet Chemistry Lab will be kept under negative pressure, and will be controlled with the Price Lab Controller (tracking pair) either through the venturi valve branch, terminal branch, or a mixed combination.

Office F214 { 4 } also utilizes Price products, including a fan coil connected to an AS210 slot diffuser. However, no research is currently planned for this space.

Active Beams – ACBL-HE:



Features

- 1 way and 2 way air pattern
- Adjustable mounting brackets
- Perforated or grille face
- Pressure port for air-side balancing and flow verification
- Pressure tested to 450 psi [3.1MPa]
- Vent and drain
- Suitable in new buildings and historic retrofits

Third Floor

Research

Offices 315, 316, 317:

- Evaluate a thermally (Varitherm®) and electronically (Prodigy®) controlled VAV diffuser vs. a standard VAV box and square plaque diffuser (SDV8, ASPD)
- Data log temperature (room, supply,

and return), CO2, humidity, and supply air volume

Offices 314, 313:

- Evaluate low flow conditions
- Confirm ASHRAE standards built around low flow measurements
- Calculate differences between a higher accuracy transducer and a standard one

- Compare performance of Price VAV Boxes vs. Siemens VAV Boxes (installed in two nearby offices)

Interior Conference Room:

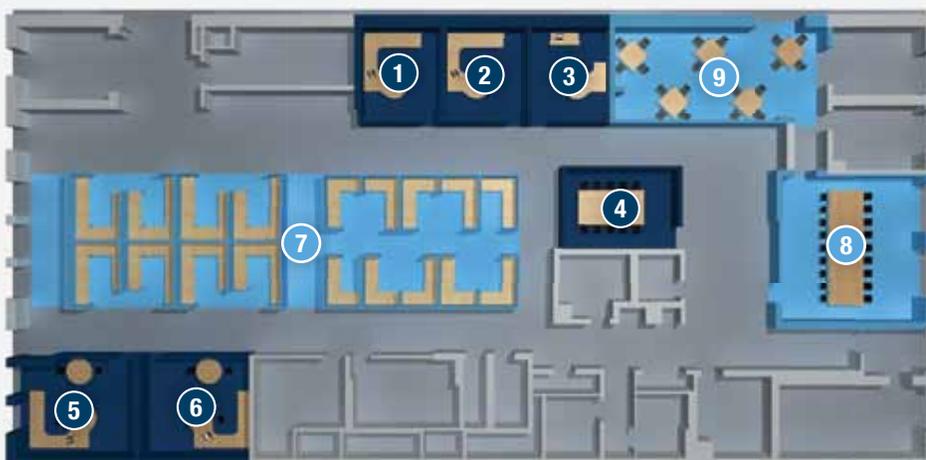
- Evaluate energy usage and comfort changes when using the beam in different modes
- Test the effects of running an active beam in passive mode (primary air shut off to beam)
- Calculate recovery time from unoccupied to occupied mode

| PRODUCTS | ROOMS |
|--|--------------------------|
| Varitherm® Diffuser – VPD-HC | Office 315 |
| Prodigy® Diffuser – PPD2 | Office 316 |
| Square Plaque Diffuser – ASPD | Office 317 |
| Single Duct Terminal Box – SDV8 | Office 317 |
| Active Beams with Wings Option – ACBL-HE, ACBL | Interior Conference Room |
| VAV Boxes – SDV5 | Office 314, 313 |
| Opticlean Diffuser | Office 314, 313 |
| Price Controller – PIC Monitoring Station (Input Signals from AFMS Ebtron) | Office 314, 313 |
| Active Beams with Linear Slot Diffuser – ACBR | Open Office Area |
| Radiant Panel – RPL | Open Office Area |
| Chilled Sails – CSA | Elevator Lobby |
| Displacement Ventilation (Overhead) – DF1L-HC | Cafe |
| Active Beams – ACBC | Large Conference Room |

Guide

The Showcase's third floor houses three offices of similar size: 315, 316, and 317. Each of these offices has a different type of Price air distribution product installed in it. The first office, 315 {1}, has a Price Varitherm® Diffuser with a flow sensor; the second, 316 {2}, has a Prodigy® Diffuser with a flow sensor; and the last office, 317 {3}, has a square plaque diffuser with a single duct terminal box, flow sensor, and temperature sensors.

Across from Office 317 is the Interior Conference Room {4}. This room is being conditioned by a 1-way active beam with wings option for exposed



Third Floor Map

- | | |
|-----------------------------|--------------------------|
| 1. Office 315 | 5. Office 314 |
| 2. Office 316 | 6. Office 313 |
| 3. Office 317 | 7. Open Office Area |
| 4. Interior Conference Room | 8. Large Conference Room |
| | 9. Cafe |

■ Research area ■ Non-research area

*Please refer to bold numbers in text for corresponding room and product information



Floor Mounted Active Beam – ACBC:

- Exposed perimeter unit
- Induces air through upper portion; discharges low velocity fresh air through lower portion
- Ideal for classrooms and office spaces
- Quiet operation (no fan or motor)
- Heavy gauge face

installation, integrated VAV air diffuser, and integrated return sections. At first glance, the unit appears to be a 2-way active beam, but this is simply because it has a symmetrical face to mimic the other beams installed in the building.

The other side of the building contains two more office spaces: 314 {5} and 313 {6}. These offices are of similar size and both use VAV boxes with Opticlean Diffusers. However, the offices differ in that each utilizes different sensors and controllers. The first office, 314, has Ebtron flow sensors (electronic) and Price Intelligent Controller, while the second office uses an SP300 (pneumatic) and Ebtron flow sensors, as well as a Price Intelligent Controller with a high accuracy pressure transducer. Low flow sequencing

has been programmed into the controllers to match the California code.

A number of other rooms on the third floor utilize Price products, but are Siemens controlled areas.

These include:

- Open Office Area {7}: Active Beams in cloud ceiling with linear slot diffuser; Radiant Panel– ACBR, RPL
- Large Conference Room {8}: Floor Mounted Active Beam – ACBC
- Cafe {9}: Overhead Displacement Ventilation with reheat changeover via electric actuator – DF1L-HC

Prodigy® Diffuser – PPD2:



- Adjustable damper modulates inside diffuser assembly
- DDC provides stable and precise control
- Space temperature control within 1°F of set point
- True VAV cooling and heating
- Activation of perimeter heat
- Optional BACnet interface

Sixth Floor & Roof

Research

BEEG Workshop:

- Evaluate occupant thermal comfort conditions throughout various seasons and determine how much of the year we can utilize NV in a climate like Boston
- Compare conditions when using NV alone, to when using NV with radiant panels
- Develop algorithms that predict ventilation rates based on differential pressures, fan speed, and damper position
- Conduct occupant surveys to gauge the NV system for comfort and response

Conference/Telephone Room:

- Conducting research related to heating

and cooling control strategies

- Compare active beams and fan coils in regards to performance and energy usage

Guide

The entire central section of the sixth floor is dedicated to the BEEG Workshop {1}. This space is being conditioned using a natural ventilation (NV) system in combination with a radiant ceiling. The space is currently split into three zones (east, center, and west) for the mechanical portion, with three natural ventilation boxes installed in the ceiling. The BEEG Workshop also utilizes Price Radiant Panels to complement the natural

ventilation system. These panels have active and inactive linear slot diffuser sections, and are hooked up to a 6-way valve for heat/cool changeover.

The system in the BEEG Workshop is governed by an experimental controls sequence:

1. When appropriate exterior and interior temperature and humidity conditions exist, controls will attempt to satisfy occupied space conditions using natural ventilation system and operable windows.
2. Provide supplemental cooling when necessary using the radiant panels.
3. When the occupied space conditions cannot be maintained using NV and radiant panels, the mode of operation will change from NV to mechanical cooling using fan coils.
4. Provide supplemental cooling when appropriate using the radiant panels as a second stage.

Along the edge of the BEEG Workshop there are two Conference/Telephone rooms. These spaces each have a different Price product installed: the first room {2} has a FCHGQ VAV fan coil, while the second room {3} uses an ACBL-HE Active Beam with optional wings

| PRODUCTS | ROOMS |
|---|---|
| Natural Ventilation – NVR | BEEG Workshop |
| Radiant Panels – RPL | BEEG Workshop |
| Integrated Slot Diffuser – AS225, ASPI225 | BEEG Workshop |
| Chilled Sails – CSA | Elevator Lobby |
| Fan Coil Units – FCHG, FCHGQ | Conf/Tel Room 1, Conf/Tel Room 3 |
| Active Beams – ACBL-HE | Conf/Tel Room 2, Conf/Tel Room 4 |
| PIC DDC Fan Coil | BEEG Workshop, Conf/Tel Room 1, Conf/Tel Room 3 |
| PIC DDC Hydronic Systems | BEEG Workshop, Conf/Tel Room 2, Conf/Tel Room 4 |



Sixth Floor Map

1. BEEG Workshop
2. Conference/Telephone Room 1
3. Conference/Telephone Room 2
4. Stairwell to Roof
5. Conference/Telephone Room 3
6. Conference/Telephone Room 4

Research area Non-research area

*Please refer to bold numbers in text for corresponding room and product information



Natural Ventilation – NVR:

Price Natural Ventilation systems can provide energy savings, improved indoor air quality, reduced capital cost, reduced maintenance, and an increased range of thermal comfort.

for exposed installation. The second conference/telephone room is currently being utilized as an office, and research initiatives have been repurposed accordingly.

The roof of the Building Technology Showcase can also be accessed via a stairwell on the sixth floor {4}. From this location, you can clearly view the louver and curbs for the natural ventilation units.

The following spaces have Price product and are Price controlled for normal day functions. There are no plans at this time for testing and research in these areas.

- Conf/Tel Room 3 {5}: Active Beam – ACBL-HE
- Conf/Tel Room 4 {6}: Fan Coil – FCHGQ

Radiant Panels – RPL:

The radiant panels on the sixth floor of the BTS use water to efficiently condition the BEEG Workshop's sensible load, relying on the NV system to provide ventilation and satisfy latent loads.

- Reduced supply air volume requirement
- Sensible cooling and heating
- Integrated aluminum heat sinks
- Multiple face finish options
- 2-pipe system, 4-pipe system, inactive section, or double saddle



Basement

Guide

In the PV High Bay {1}, two blower coil units are installed in the ceiling near the first floor viewing window. These units are supplying air to the four DR360i-HC round industrial displacement units in the space. The DR360i-HC units have a damper blade located in the middle of the unit to vary air flow through either the top or bottom sections. In heating mode, only the bottom portion of the diffuser is active, with a higher face velocity to increase warm air penetration. In cooling mode, the air is spread over the entire face to lower the face velocity.

The controller for the displacement in this space operates using room temperature set point, CO2, and humidity. If more air is required, the primary air will increase to maintain discharge

temperature. When the CO2 reading is above the set point, the fresh air inlet damper opens to allow a higher volume of fresh air into the space, and vice versa when below the set point. Similarly, when the humidity reading is above the set point, the fresh air inlet damper will open to allow fresh, drier air into the space. There are also purge and exhaust modes setup for this space, which are activated by the CO2 level, occupant activation, or process requirements.

The PV High Bay area also houses a venturi valve – located directly against the viewing window wall – and a fan coil unit with a swivel displacement outlet attached to it. The swivel displacement outlet is typically installed in production and work areas where it is not possible to locate the diffusers near the occupied

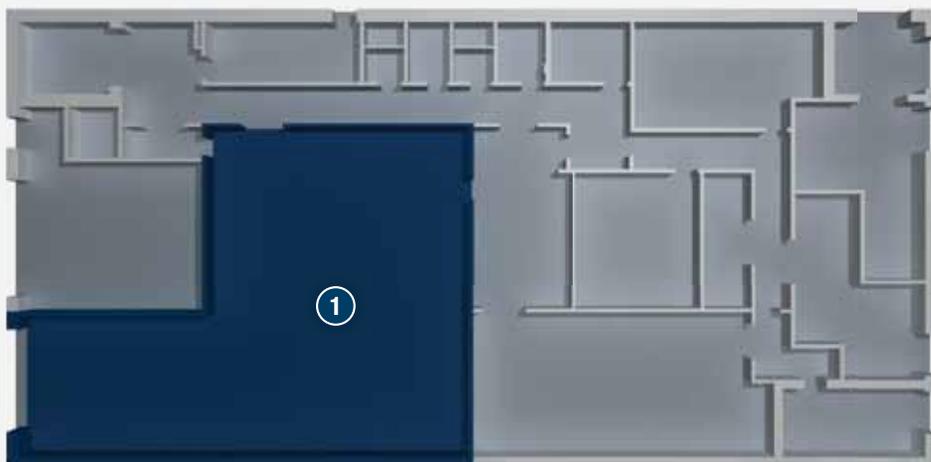
zone. These units are ideal for the removal of air pollutants from a large work zone. The control for this unit is the same as the units in the PV High Bay Area (F001).

DR360i-HC – Industrial Displacement Ventilation:



- Suitable for high-traffic, high-user areas
- Capable of supplying large volumes of air to an industrial space
- Stronger and more rigid than typical displacement ventilation diffusers
- Easily adjustable discharge direction
- Ideal for mounting above the occupied zone or on the floor
- Can save valuable real estate in industrial settings

| PRODUCTS | ROOMS |
|---|-------------|
| Blower Coils – BCH, BCV | PV High Bay |
| Industrial Displacement Ventilation – DR360i-HC, DDIA | PV High Bay |
| Venturi Valve – VV | PV High Bay |
| Fan Coil Units – FCHCB | IT Closet |



Basement Map

1. PV High Bay

■ Research area ■ Non-research area

*Please refer to bold numbers in text for corresponding room and product information



Design Team Profile

DiMella Shaffer:

For more than 40 years, the architecture firm of DiMella Shaffer has changed and adapted to address new dynamics in the marketplace and ground breaking developments in technology. Creating buildings that reflect an aesthetic point of view, a commitment to responsible environmental stewardship, and the day-to-day needs of the individuals who live, learn, and work in them – these are the hallmarks of DiMella Shaffer’s architectural practice.

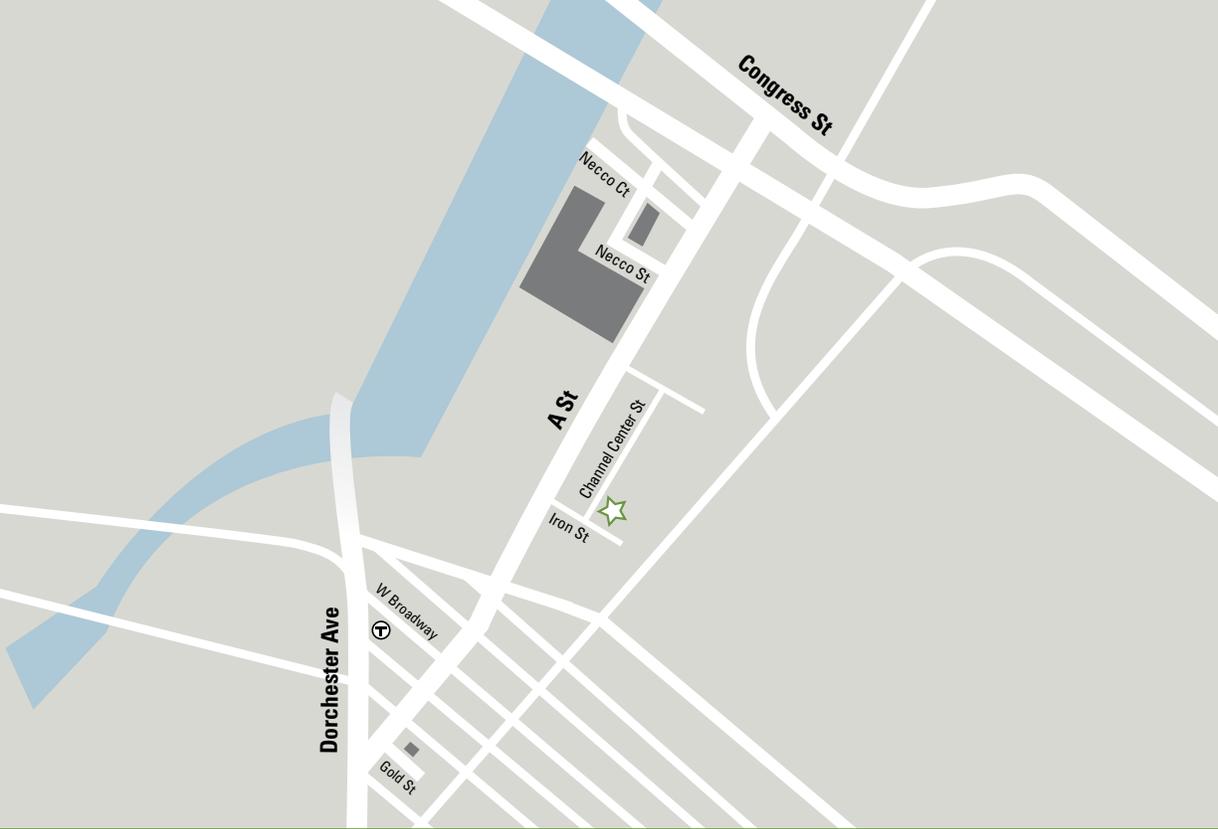
BR+A:

Bard, Rao + Athanas Consulting Engineers, LLC (BR+A) was founded in 1975 and provides state-of-the-art, integrated and coordinated mechanical, electrical, plumbing and fire protection consulting engineering. Sustainability is a central theme of BR+A’s culture of excellence, and their long track-record of performance includes nearly 20 million ft2 of LEED-Certified projects, and an average energy-cost savings of over twenty percent.

Booking a Tour

Due to the number of events taking place at the Showcase on a weekly basis, Fraunhofer requires that any use of their facilities is arranged at least one month before the date of the intended event.

If you’d like to arrange a tour through Price, please contact the Price Events Team at (770) 623-8050 or events@price-hvac.com



Legend

-  Fraunhofer CSE
-  Broadway Station
-  Parking

Directions

Address: 5 Channel Center Street, Boston, MA 02210 (<http://goo.gl/IPXOW5>)

DRIVING DIRECTIONS

From Logan International Airport: Upon exiting the airport, merge onto I-90 W and follow it for 2.1 miles. Take exit 25 toward South Boston and follow the signs for Seaport Blvd/Downtown. Turn left onto Congress Street and follow it for 0.3 miles, then turn left onto A Street and follow it for 0.4 miles. Turn left onto Iron Street, then take the first left onto Channel Center Street. (Google Maps Directions: goo.gl/f3xXpW)

From I-93 S: Take exit 15 onto Columbia Road and turn right onto Columbia. Take a right onto Dorchester Avenue and follow it for 1.4 miles, then turn left onto A Street and follow it for 0.4 miles. Turn left onto Iron Street, then take the first left onto Channel Center Street.

From I-93 N: Take exit 20 to Logan Airport. Continue for 1.4 miles and follow the signs for South Boston. Keep left at the fork for 0.1 miles and then turn left onto Congress Street. In 0.2 miles, turn left onto A Street and follow it for 0.4 miles. Turn left onto Iron Street, then take the first left onto Channel Center Street.

PARKING

Metered street parking can be found along A Street, and is metered from 10 AM to 6 PM with a maximum parking limit of 2 hours. Rates are \$0.25 per 13 minutes. Please note there is no public parking on Channel Center Street itself. There are several public lots within the Center's vicinity:

| Lot Address | Spaces | Daily Rate |
|-----------------|--------|------------|
| 10 Necco Street | 596 | \$15 |
| 284 A Street | 1256 | \$14 |
| 70 Gold Street | 11 | \$8 |

PUBLIC TRANSPORTATION

Train: Take the Red Line to Broadway Station. Follow West Broadway east to A Street. Take A Street north several blocks until you reach Channel Center.

Bus: Fraunhofer CSE's South Boston building is within easy walking distance of the 4, 7, 9, 11, 47, 448, and 449 bus lines.

www.price-hvac.com/sustainable