Personal Comfort Systems (PCS)

COMFORT AND CONTROL FOR YOUR OCCUPANTS,

ENERGY SAVINGS FOR YOUR BUILDING.
C2M Team

Katie Dewitt
MBA

Ankit Jain
Ms Public Policy

Anna Maybank
MBA

Chris Hallas
MBA

Inventors

Professor Ed Arens
Director of CBE
Director of CEDR

Anoop Honnekeri
MS Architecture

Professor Hui Zhang
Research Specialist, CBE
Meet the Cast

Fred the Facilities Mgr
(Overall Comfort)

Barry the Boss
(Low Bills and Productivity)

Erica and Eric the Employees
(Individual Comfort)
The problem with current HVAC systems

Fred the Facilities Mgr (Overall Comfort)

76°! No, 68°!

Erica and Eric the Employees (Individual Comfort)

68°! No, 72°!

And quit touching the thermostat!

Barry the Boss (Low Bills and Productivity)

Why aren’t you working?!
Plus, the energy savings potential is huge!

Buildings = 81% of electricity
Commercial = 35% of building electricity
HVAC = 51% of commercial
Plug load as percentage of electricity = 15-30%

Thermo-receptors; a source of information

- Provide the brain with information about environmental temperature.
- Are distributed over the whole body.
What does it mean to heat/cool individual body parts?

Overall thermal comfort is dictated by local comfort

Cooling head is most effective in warm environments

Warming feet is most effective in cold environments

Preliminary surveys say: It works!

- Occupants were comfortable even at extreme temperatures of 64°F to 86°F
- Improved productivity vs. neutral conditions

Personal comfort system prototype

- Foot warmer (40W)
- Fan (4W)
Expand the deadband for energy savings

HVAC set point temperature °F

Energy savings in other cities

Phoenix- 24%

Miami- 15%

Chicago – 31%

HVAC electricity in San Francisco

58% Energy saving
Simulations confirm payback potential

**Assumptions**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>4,982 m² / 53,826 ft²</td>
</tr>
<tr>
<td>HVAC System</td>
<td>Multi-zone VAV</td>
</tr>
<tr>
<td>Occupants</td>
<td>18.5 m² / 200 ft² → 268 ppl</td>
</tr>
<tr>
<td>Deadband</td>
<td>7 F wider → 66 – 79 F</td>
</tr>
<tr>
<td>Cost of system</td>
<td>$100/unit → $26,800</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>City</th>
<th>% Savings kWh</th>
<th>kWh saved</th>
<th>Savings ($)</th>
<th>Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Francisco</td>
<td>58%</td>
<td>79,044</td>
<td>$10,132</td>
<td>2.6 years</td>
</tr>
<tr>
<td>Phoenix</td>
<td>24%</td>
<td>81,597</td>
<td>$7,260</td>
<td>3.7 years</td>
</tr>
<tr>
<td>Miami</td>
<td>15%</td>
<td>55,414</td>
<td>$4,346</td>
<td>6.2 years</td>
</tr>
<tr>
<td>Chicago</td>
<td>31%</td>
<td>94,061</td>
<td>$5,644</td>
<td>4.7 years</td>
</tr>
</tbody>
</table>

PCS can reduce hot/cold calls $\rightarrow$ maintenance cost

**Data from CBE study**

<table>
<thead>
<tr>
<th>Time per call-out</th>
<th>1.8 hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\times$ Labor rate</td>
<td>$35$</td>
</tr>
<tr>
<td><strong>Cost per call-out</strong></td>
<td><strong>$63$</strong></td>
</tr>
<tr>
<td>Uncomfortable occupants</td>
<td>20%</td>
</tr>
</tbody>
</table>

**Significant avoided cost**

**Real estate owners:**
- Significant savings
- Increased comfort $\rightarrow$ happy occupants $\rightarrow$ Reduced T/O

Federspiel, C., 10/01/2000, “Predicting the frequency and cost of hot and cold complaints in buildings”, Center for Environmental Design Research.
Combined savings improve payback, <3 years

**Assumptions**

- Cost per call-out: $63
- Uncomfortable occupants: 20%
- 2 calls per year (1 hot/1 cold): $6,754
- Cost of system: $26,800

<table>
<thead>
<tr>
<th>City</th>
<th>Energy</th>
<th>Maintenance</th>
<th>Total savings</th>
<th>Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Francisco</td>
<td>$10,132</td>
<td>$6,754</td>
<td>$16,885</td>
<td>1.6 years</td>
</tr>
<tr>
<td>Phoenix</td>
<td>$7,260</td>
<td>$6,754</td>
<td>$14,014</td>
<td>1.9 years</td>
</tr>
<tr>
<td>Miami</td>
<td>$4,346</td>
<td>$6,754</td>
<td>$11,100</td>
<td>2.4 years</td>
</tr>
<tr>
<td>Chicago</td>
<td>$5,644</td>
<td>$6,754</td>
<td>$12,397</td>
<td>2.2 years</td>
</tr>
</tbody>
</table>

Productivity trumps all

Types of productivity:

- Individual productivity
- Sick days, working from home
- Office climate war peace accord
- Loyalty, morale

<table>
<thead>
<tr>
<th>Who</th>
<th>$/hour</th>
<th>Hours needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>kWh</td>
<td>$0.10</td>
<td>1,000 hours</td>
</tr>
<tr>
<td>Maintenance wage</td>
<td>$35</td>
<td>3 hours</td>
</tr>
<tr>
<td>Key Employees</td>
<td>$50-100+</td>
<td>1-2 hours</td>
</tr>
</tbody>
</table>
What’s next: From pilot to scale

Developed: United States
- UC Berkeley
- Owner-occupied commercial office space
- Commercial office space, government, universities

Developing: India
- Local universities: CEPT/ NIT Jaipur
- New builds: HVAC/mixed-mode
- India and China: Commercial office space

1 year Pilot
2-5 years Pioneers
5 years + Scale
Case study: Zynga

Characteristics:
• Built in 1988, bought by Zynga in April, 2012
• HVAC building, atrium with skylight (natural ventilation)
• USGBC Best Building Challenge – 20% reductions in 2 yrs
• Applying for LEED certification

Value proposition:
• Helping to meet energy savings goals & LEED points
• Culturally aligned → innovative workplace
• Help meet CA Title 24: NZE commercial buildings by 2030

Go-to-market strategy:

Validation: University pilot, endorsement from USGBC
Partnership: Revenue share with leading furniture designers
Target market: Innovative companies, property managers
Promotion: Zynga & Cushman & Wakefield

Source: interview with Preston Richards, property manager of 650 Townsend Street
Case study: Paharpur Business Center, India

Characteristics:
- 50,000 sq ft office building, built in 1990
- Widened deadband from 72 to 79 degrees → Energy savings- ~60,000 kWh /yr
- Comfort mitigation; green plants and mesh chairs

Value proposition:
- Rationale for widening set-point → Energy savings
- Rationale for PCS → employee comfort at higher set-point
- Help meet Energy Conservation Building Codes

Go-to-market strategy:

Validation: Indian pilot, Leverage ASHRAE & USGBC

Partnership: Revenue share with accredited partners e.g. Schneider Electric

Target market: New builds, Forward-thinking companies

Promotion: Domestic & internationally via multinational partners
Key opportunities for development

**Partnerships**
Establish a collaborative partnership with a leading office furniture designer/manufacturer

**Product features**
Develop value-add features, i.e.
- Sleek design
- Furniture attachments
- A “smart-desk” suite

**Pioneers**
Identify pioneering companies and facilities managers in our premium markets
Thank you!
Market sizes

<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>California</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office employees</td>
<td>72 M</td>
<td>8 M</td>
<td>166 M</td>
</tr>
<tr>
<td>TAM</td>
<td>$7 B</td>
<td>$800 M</td>
<td>$16 B</td>
</tr>
<tr>
<td>10% market share</td>
<td>$700 M</td>
<td>$81 M</td>
<td>$1.6 B</td>
</tr>
</tbody>
</table>
Additional value created by enhanced productivity

- Warmth
- Concentration
- Cold
- Manual dexterity
- Individual control
- Performance

Diagram:
- Higher market value of building
- Investment
- Better IEQ
- Better productivity
- Less sick leave
- Less complaints
- Benefits to employer
- Higher rent
- Building owner
Replacing the Space heater is an easy win

Advantages vs. Space heater:
✓ Reduced plug load
✓ Reduces effect on building HVAC

<table>
<thead>
<tr>
<th>City</th>
<th>Months in use</th>
<th>kWh saved</th>
<th>Savings ($)</th>
<th>Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Francisco</td>
<td>4</td>
<td>1,004</td>
<td>$100</td>
<td>0.5 years</td>
</tr>
<tr>
<td>Phoenix</td>
<td>3</td>
<td>753</td>
<td>$75</td>
<td>0.7 years</td>
</tr>
<tr>
<td>Miami</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a years</td>
</tr>
<tr>
<td>Chicago</td>
<td>5</td>
<td>1,256</td>
<td>$63</td>
<td>0.8 years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Space heater</th>
<th>Footwarmer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$50</td>
</tr>
<tr>
<td>Watts</td>
<td>1,500 W</td>
</tr>
</tbody>
</table>

Space heater vs. Footwarmer:
- Cost: $50
- Watts: 1,500 W vs. 40 W

Advantages of Footwarmer:
- Reduced plug load
- Reduces effect on building HVAC
Comparing directly vs regular desk fan

Advantages vs. Regular desk fan:
✓ Smaller footprint
✓ Less noise
✓ Less air turbulence
✓ Dial for speed setting

<table>
<thead>
<tr>
<th>City</th>
<th>Months in use</th>
<th>kWh saved</th>
<th>Savings ($)</th>
<th>Payback</th>
</tr>
</thead>
<tbody>
<tr>
<td>San Francisco</td>
<td>4</td>
<td>8</td>
<td>$1</td>
<td>66 years</td>
</tr>
<tr>
<td>Phoenix</td>
<td>3</td>
<td>6</td>
<td>$1</td>
<td>88 years</td>
</tr>
<tr>
<td>Miami</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a years</td>
</tr>
<tr>
<td>Chicago</td>
<td>5</td>
<td>9</td>
<td>$0.5</td>
<td>106 years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Desk fan</th>
<th>PCS fan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$15</td>
<td>$15</td>
</tr>
<tr>
<td>Watts</td>
<td>15 W</td>
<td>4 W</td>
</tr>
</tbody>
</table>
Why don’t existing technologies solve this?

1.) Space heaters and personal fans: 
Facilities managers hate them!

- Safety
- High energy usage, yet thermostat doesn’t change
- Take up plug load

2.) The Herman Miller C2
The C2 didn’t do what it promised

- Heating and cooling the face didn’t have the desired effect
- No impact on the office thermostat
Case study: Wurster Hall, UC Berkeley

Characteristics:
- Built in 1964 with minimal retrofits since due to lack of funding
- Central heating but no AC

Value proposition:
- Enhanced employee control and comfort
- Financial reward for energy savings
- Culturally aligned with CBE’s mission

Go-to-market strategy

Key partner: University-endorsed furniture manufacturer

Customer: Individual building managers

Cost structure: One-off product sales and consultancy services

Promotion: Offer educational demonstrations across campus