BIG ASS FANS

Sustainable HVAC Design:
Using Air Movement in Air Conditioned Buildings

Overview

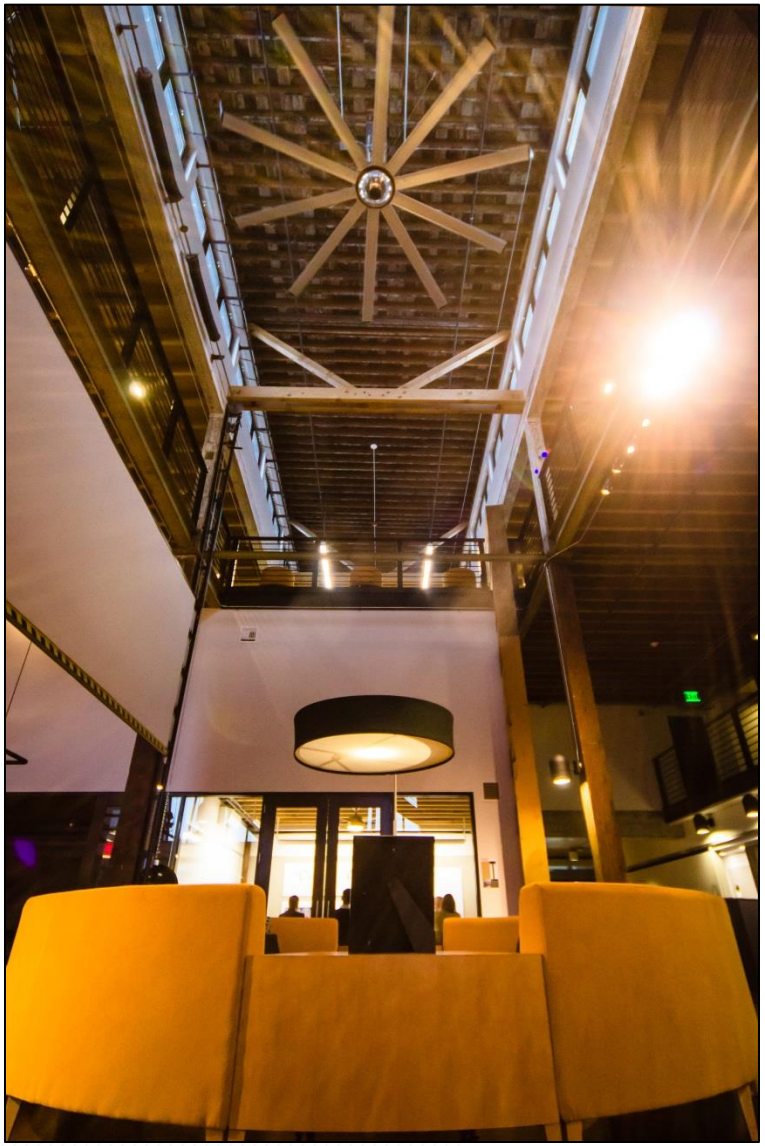
- Thermal Comfort
- Heat Transfer
- Fans + Air Conditioning Theory
- Example Scenarios
  - A/C
  - Fans + A/C
- Application Examples
- Ancillary Benefits of Elevated Air Speed

Thermal Comfort

What is Thermal Comfort?

Definition:
"That condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation."

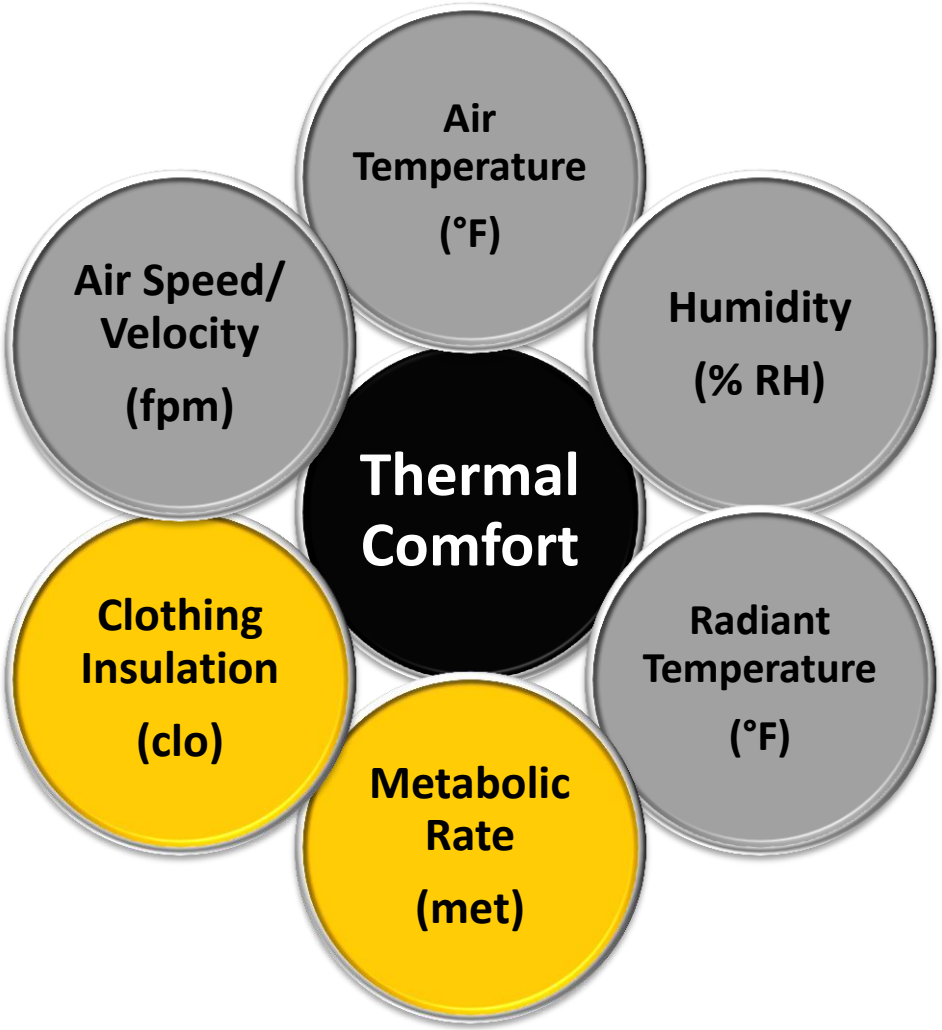
ANSI/ASHRAE Standard 55-2010, Section 3



What is Thermal Comfort?

- **It's all a matter of perspective**
- Thermal comfort is a lack of noticing discomfort
- Ability to focus on the work at hand

Thermal Comfort – what affects it?



Environmental Factors

Personal Factors

Clothing Insulation

- Clothing = thermal insulation
- Increased insulation = reduced heat loss

Clothing	**Clo***
Shoes	0.02
Socks	0.03
Underwear	0.04
Trousers	0.15
Polo	0.17
Total	**0.41**

Metabolic Rate

- The amount of energy expended in a given period
- 1 met = energy produced for an average person seated at rest
- Increased met rate = increased heat generation

Example: Met Rate

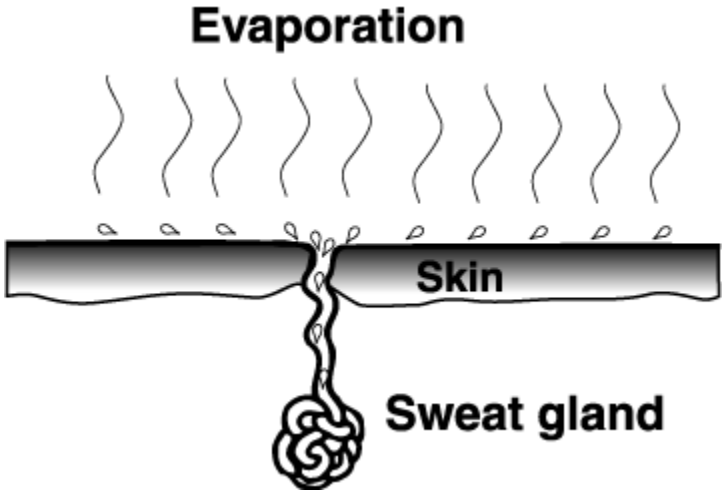
- Skier with child on his back
- Different met rates

Air Temperature

Average temperature of the air surrounding the occupant

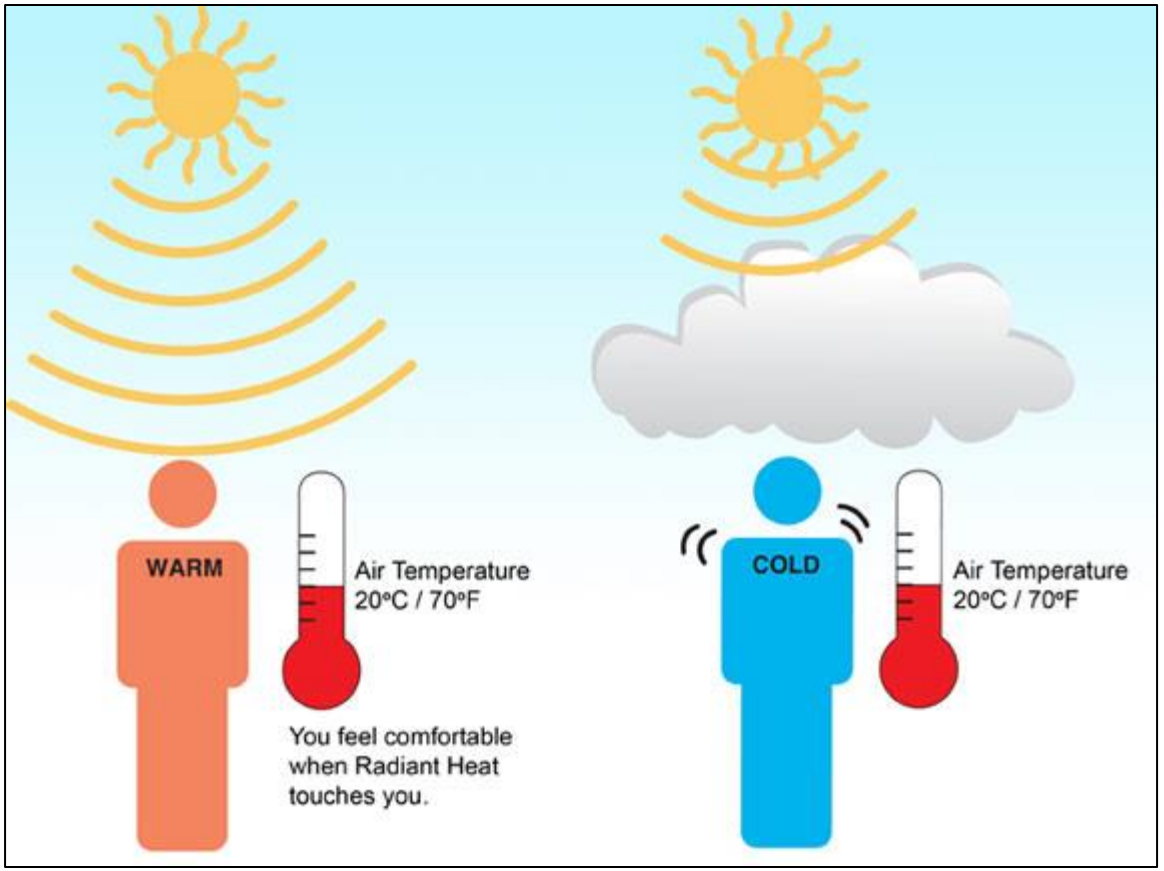
Humidity

- Amount of moisture in the air
- Relative humidity or humidity ratio
- Sweat evaporates off skin more easily at lower humidity



Radiant Temperature

Heat is exchanged between objects at different temperatures via radiation



The Masonry Heaters Association of North America

Example: Radiant Effects

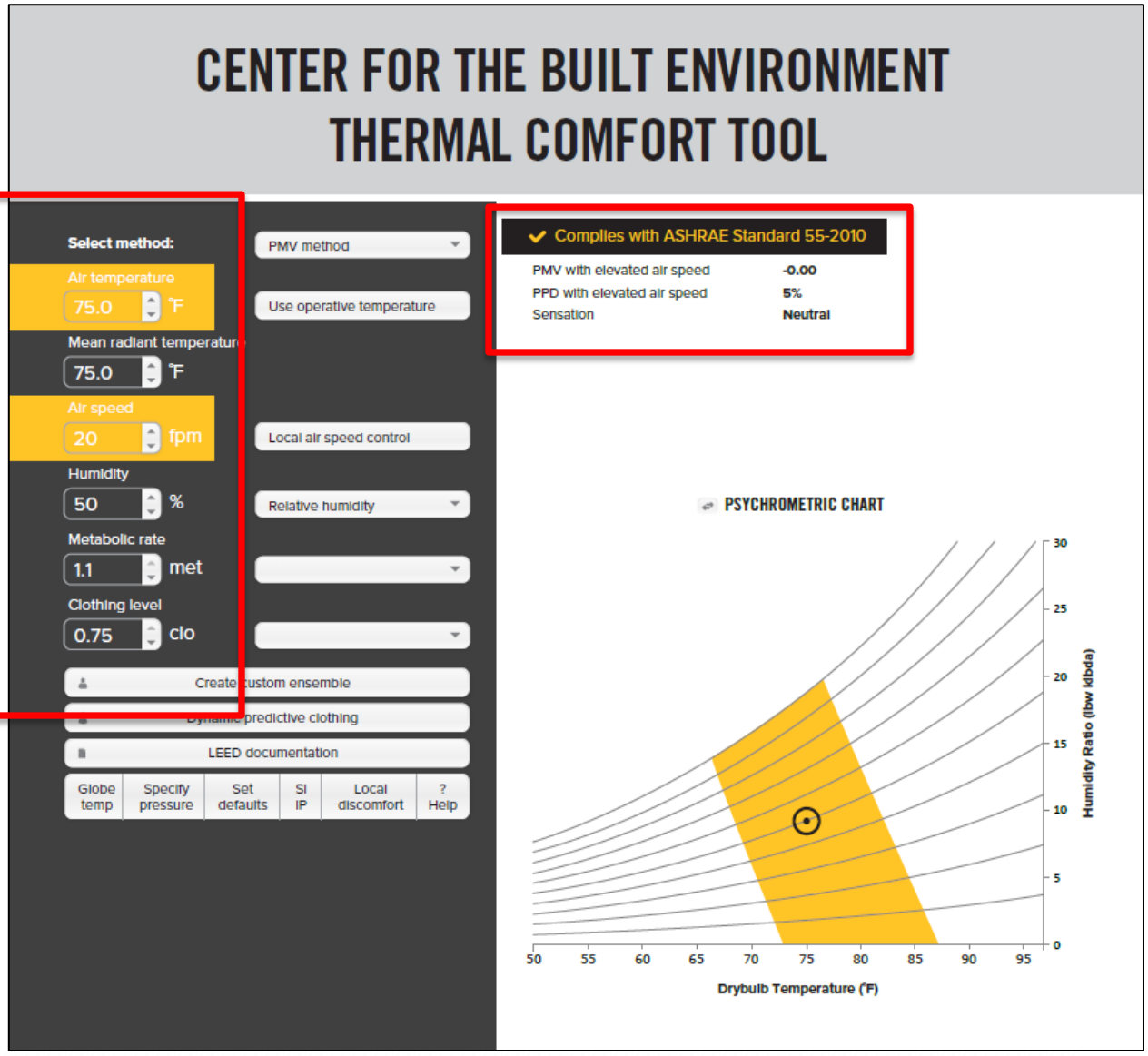
Shady side of car versus sunny side

Air Velocity

- Influences flow of heat to and from the body
- Impacts rate of moisture evaporation from the skin

All six factors work together and can be equally important

Thermal Comfort Tool



Source: CBE Thermal Comfort Tool

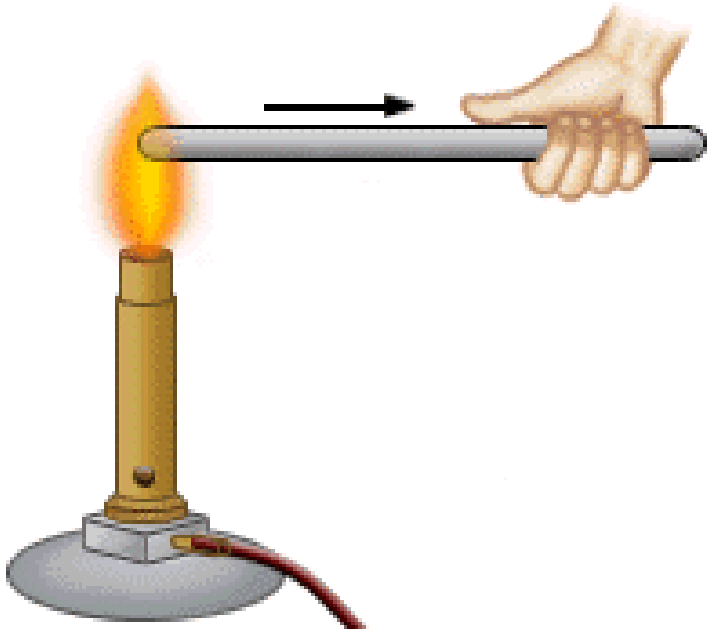
Heat Transfer

Heat Transfer

- Heat always flows from higher temperature to lower temperature
- Heat is transferred until equilibrium is reached
- Cooling = removing heat
- Three modes of transfer: Conduction, Convection, Radiation

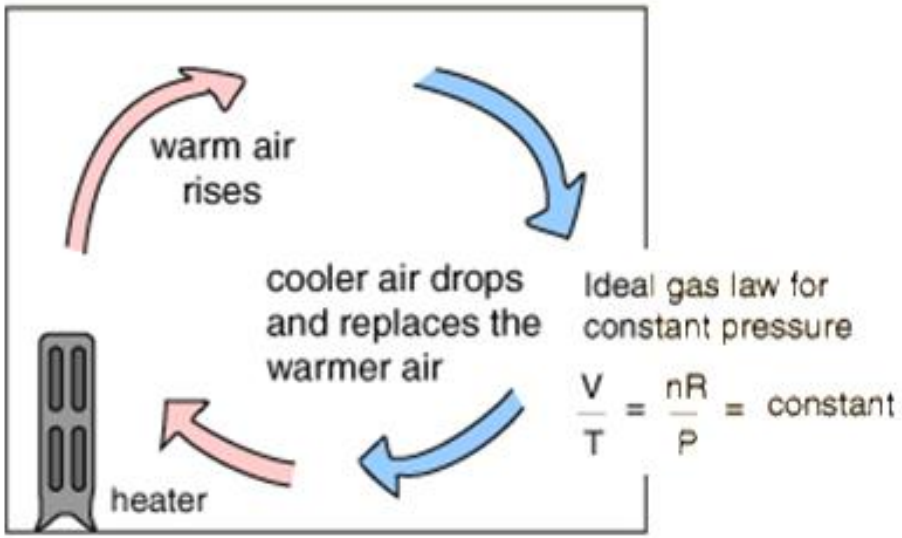
Conduction

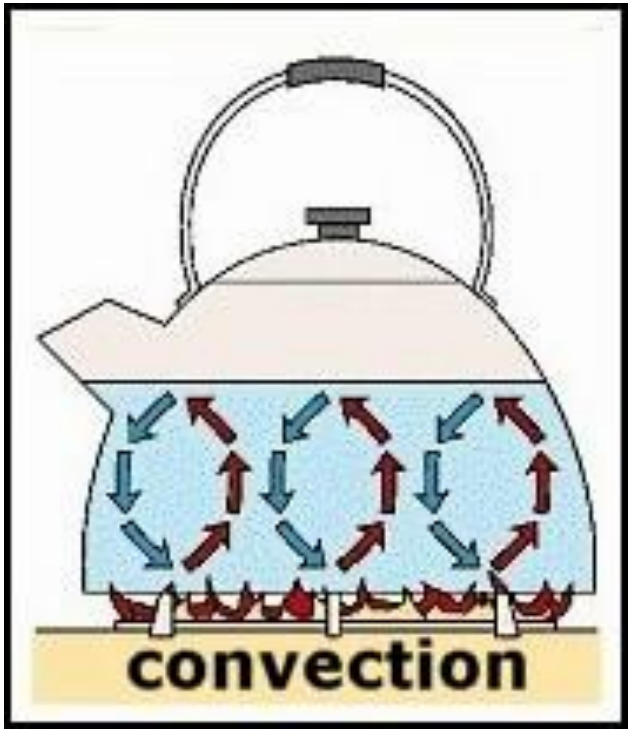
- Transfer of heat through a solid, from a warmer to cooler



Convection

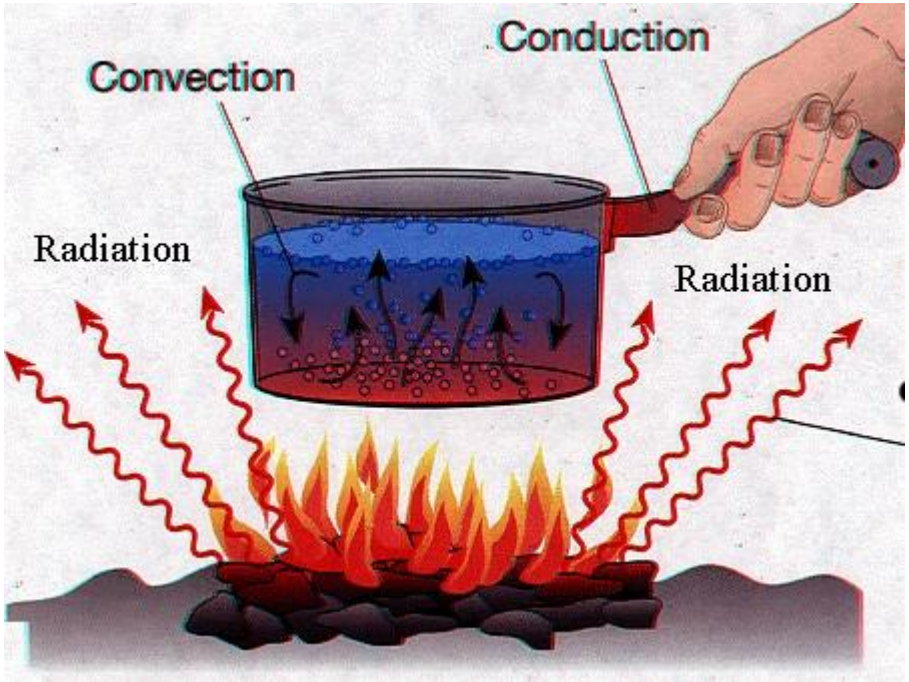
- Gas or liquid must be moving



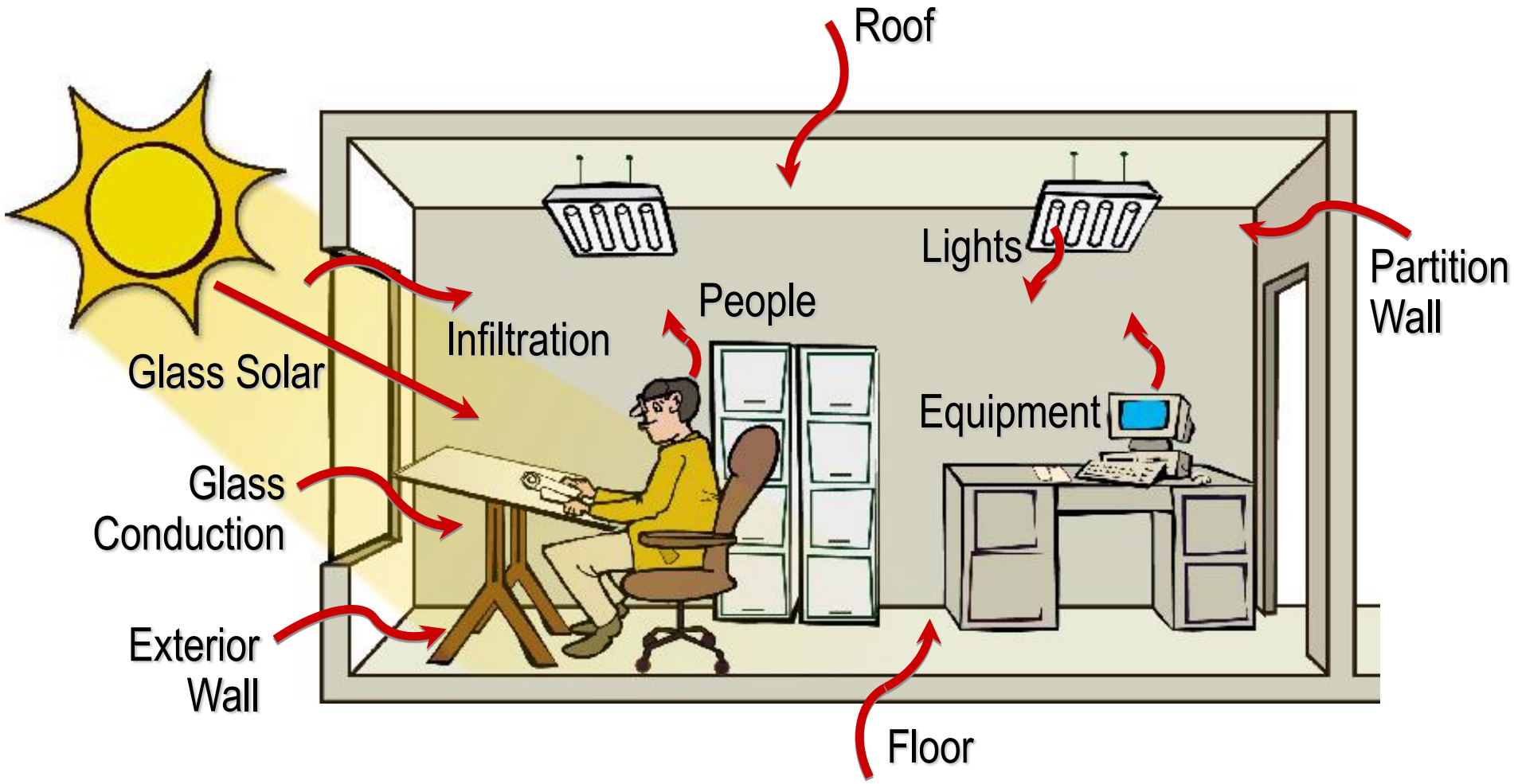


Radiation

- Energy carried by photons of light in the infrared and visible portions of electromagnetic spectrum



Heat Transfer in a Building



Heat Transfer in the Human Body

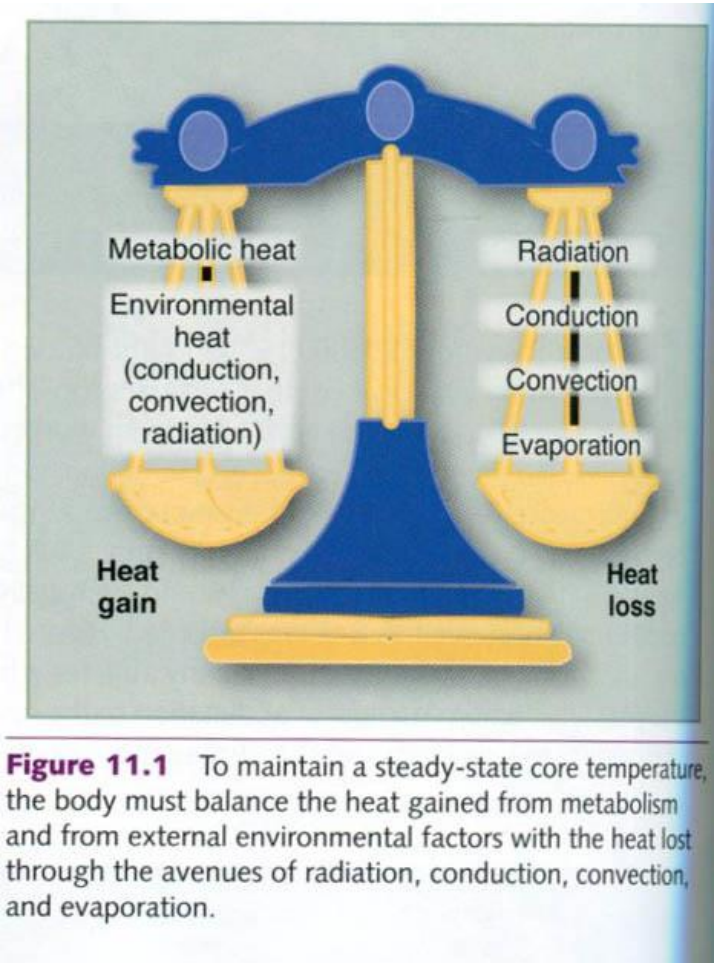
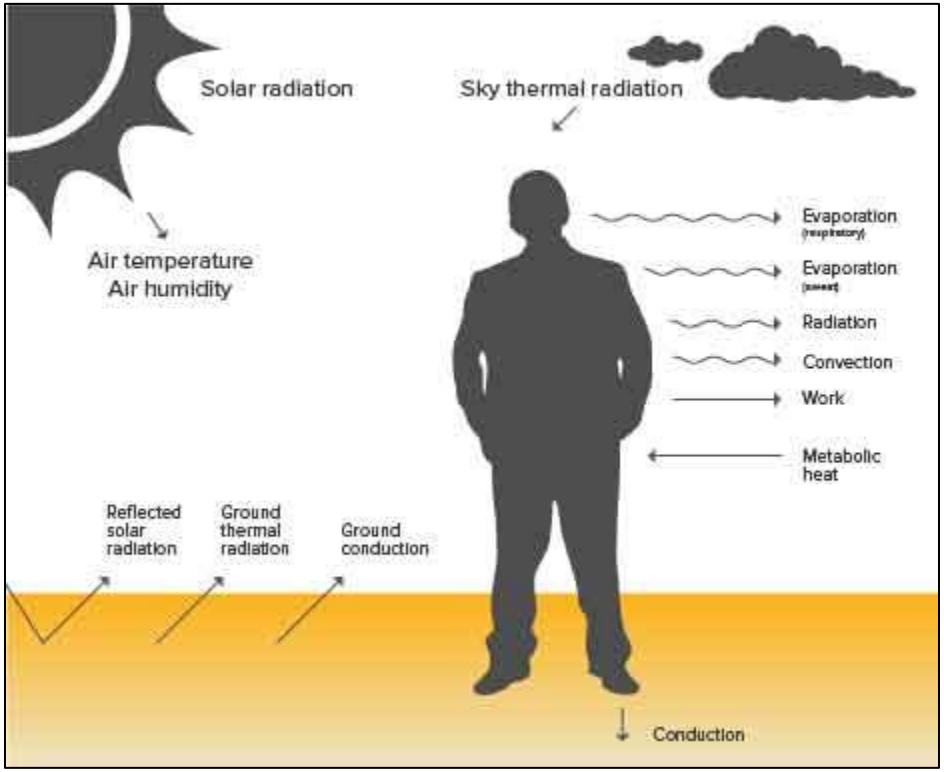


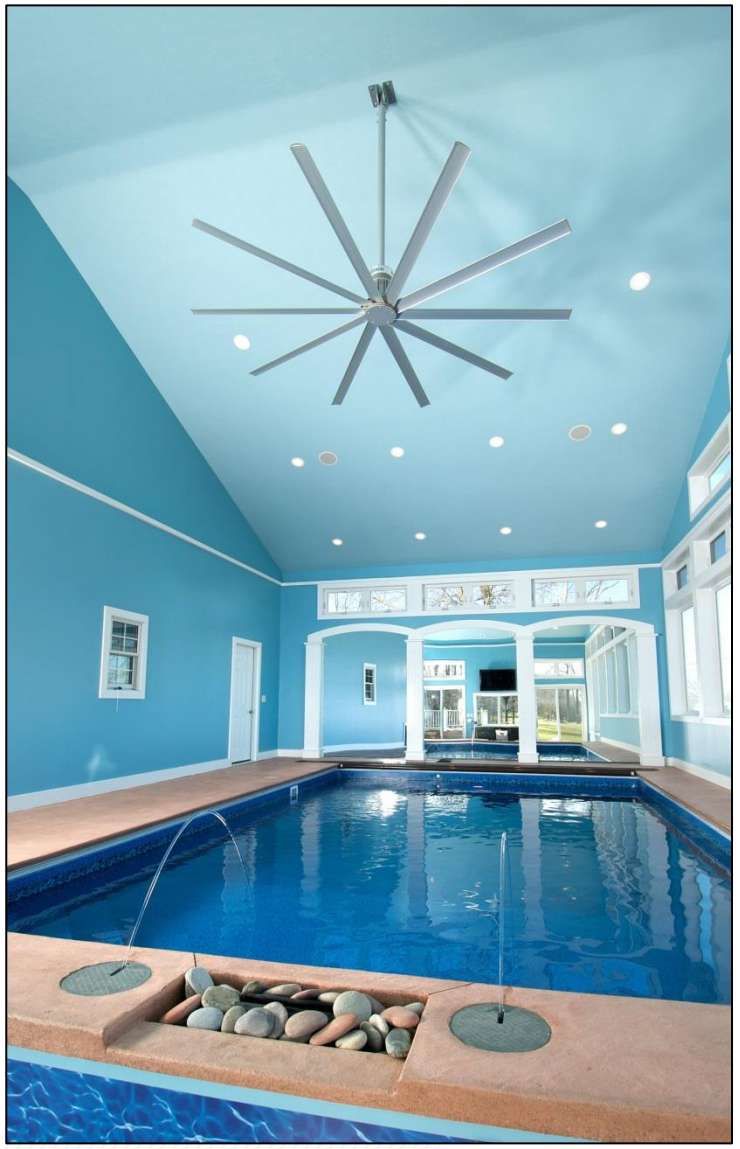
Figure 11.1 To maintain a steady-state core temperature, the body must balance the heat gained from metabolism and from external environmental factors with the heat lost through the avenues of radiation, conduction, convection, and evaporation.



http://completesoccertraining.blogspot.com/2012/07/normal-0-false-false-false.html

Human Thermometer

- Humans make bad thermometers
- Hot and cold are physiological phenomena
- Previous exposure influences perception
- Example: Jumping from hot tub to pool



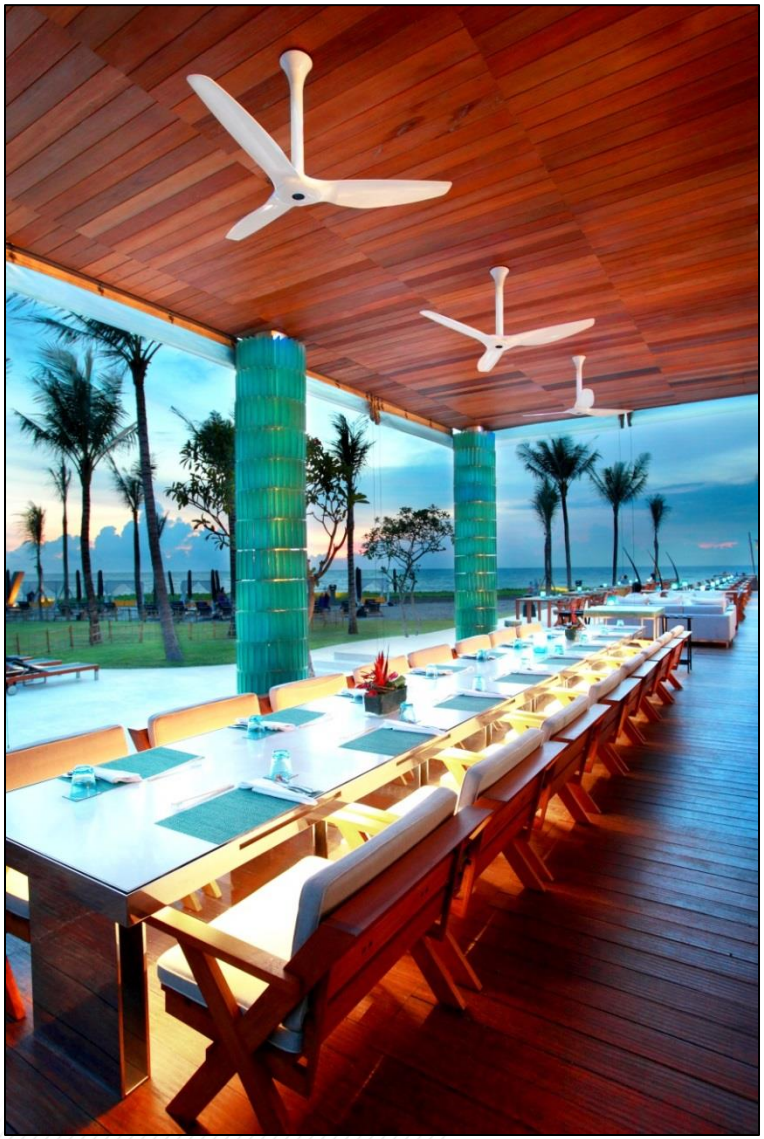
Body Heat Gain/Loss

Goal: maintain core temperature of 98.6 F

Accomplished by varying amount of heat rejected to surrounding air

Body Heat Gain/Loss

- Skin temperature is approximately 91.4 F for comfort
- Skin temp is 98.6 F under stress ≈ core temp



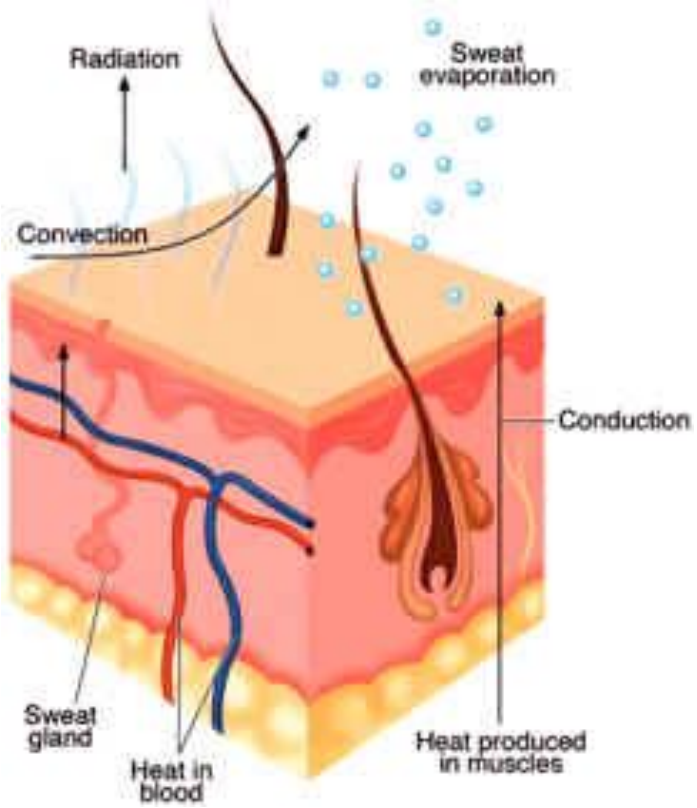
Body Heat Gain/Loss

heat loss at skin

+ heat loss due to respiration

---

heat production in body



http://general.utpb.edu/FAC/eldridge_j/KINE6362/unit4_l1.html

Body Heat Gain/Loss

If…	Then…
Heat loss = heat generated	Body maintains core @ 98.6F
Heat loss < heat generated	Body temp rises
Heat loss > heat generated	Body temp drops

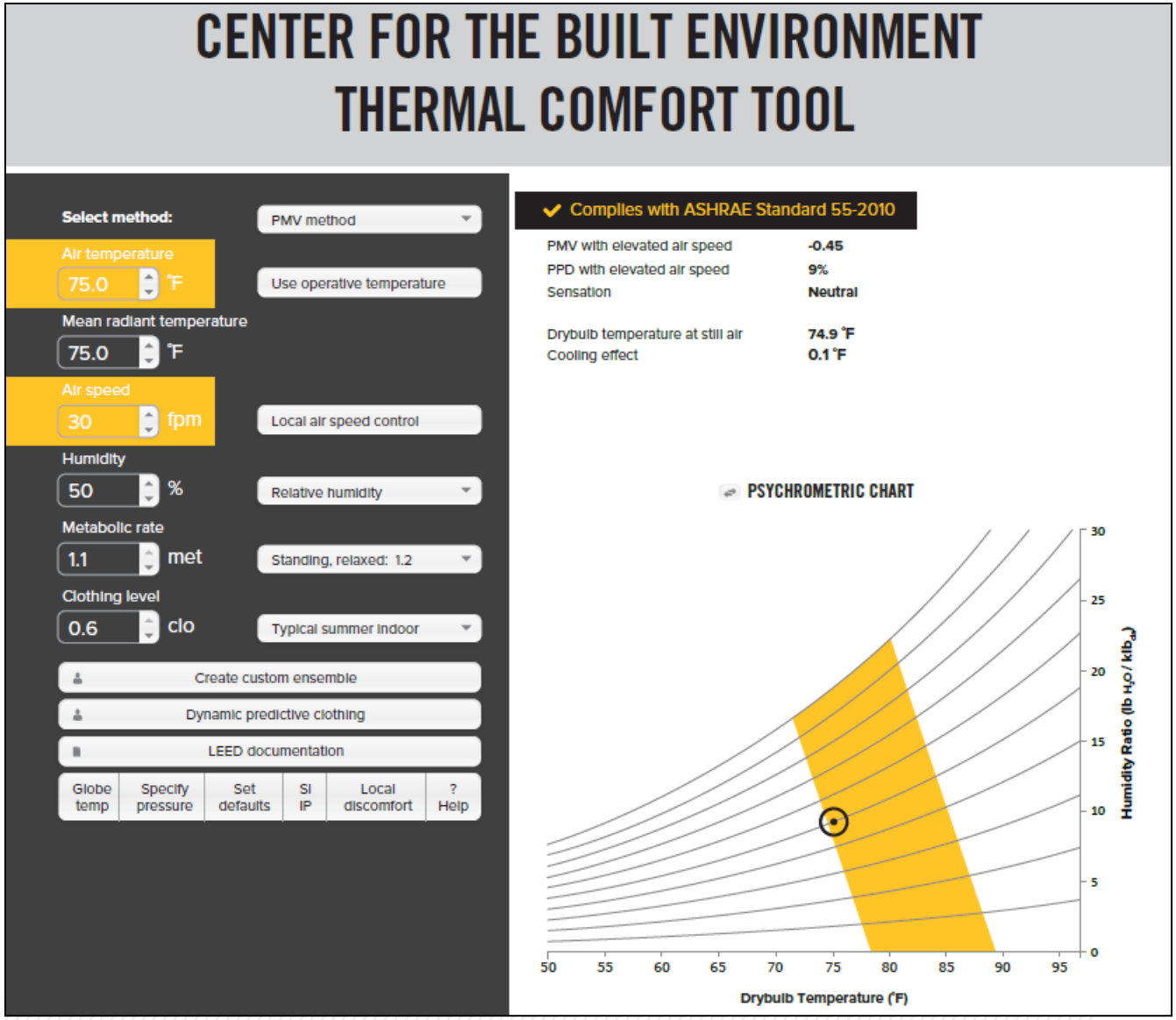
Fans + Air Conditioning

Heat Loss from the Human Body

Example – A/C:

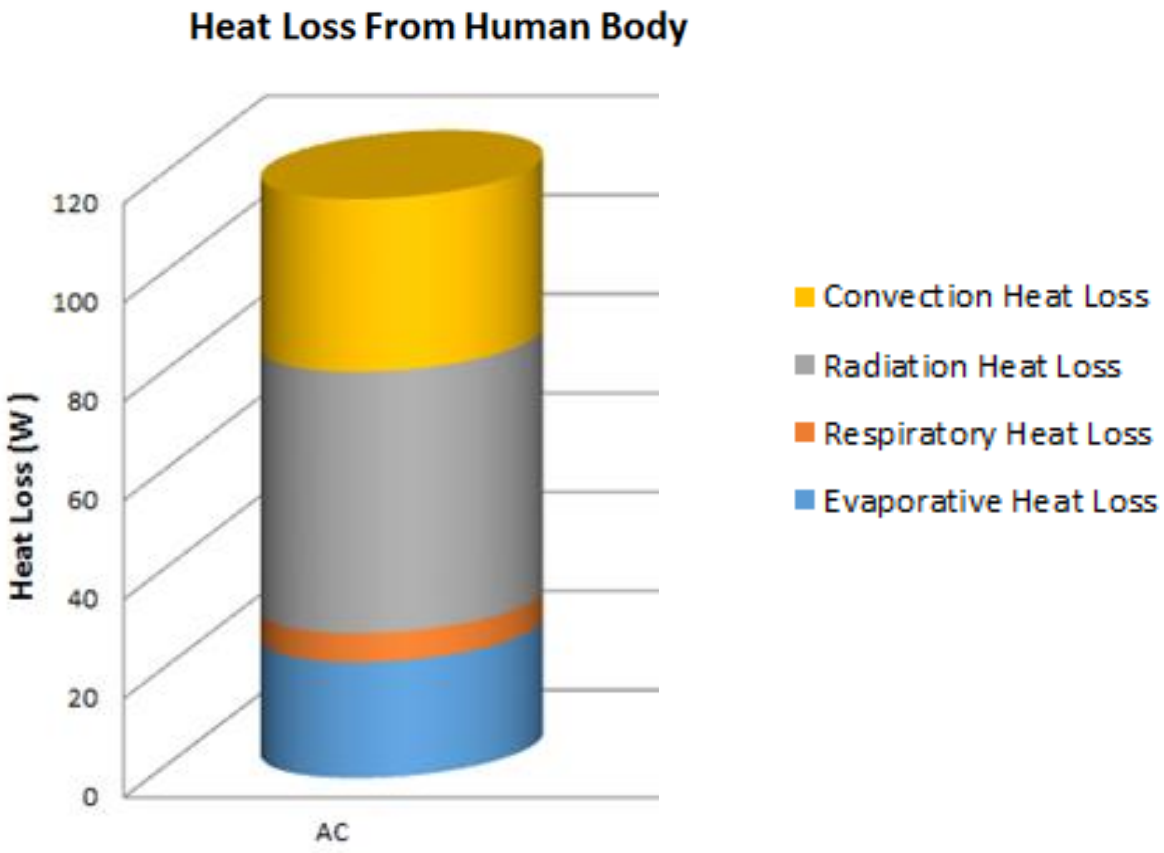
- Air Dry Bulb Temp. = 75 F
- Mean Radiant Temp. = 75 F
- Relative Humidity = 50%
- Air Speed = 30 fpm
- Metabolic Rate = 1.1 met
- Clothing Insulation = 0.6 clo

Heat Loss from the Human Body



Heat Loss from the Human Body

Total Heat Loss = 117 W



Heat Loss from the Human Body

Example – Fans and A/C:

- Air Dry Bulb Temp. = 80 F
- Mean Radiant Temp. = 80 F
- Relative Humidity = 50%
- Air Speed = 120 fpm
- Metabolic Rate = 1.1 met
- Clothing Insulation = 0.6 clo

*Maintains same PMV and PPD

Heat Loss from the Human Body

CENTER FOR THE BUILT ENVIRONMENT
THERMAL COMFORT TOOL

Select method: PMV method

Air temperature: 80.0 °F — Use operative temperature

Mean radiant temperature: 80.0 °F

Air speed: 120 fpm — Local air speed control

Humidity: 50 % — Relative humidity

Metabolic rate: 1.1 met — Standing, relaxed: 1.2

Clothing level: 0.6 clo — Typical summer indoor

Create custom ensemble

Dynamic predictive clothing

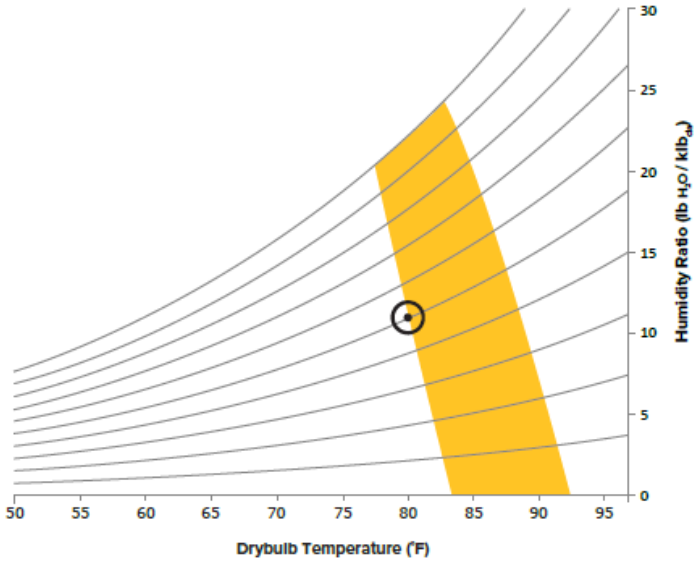
LEED documentation

Globe temp | Specify pressure | Set defaults | SI IP | Local discomfort | ? Help

✔ Complies with ASHRAE Standard 55-2010

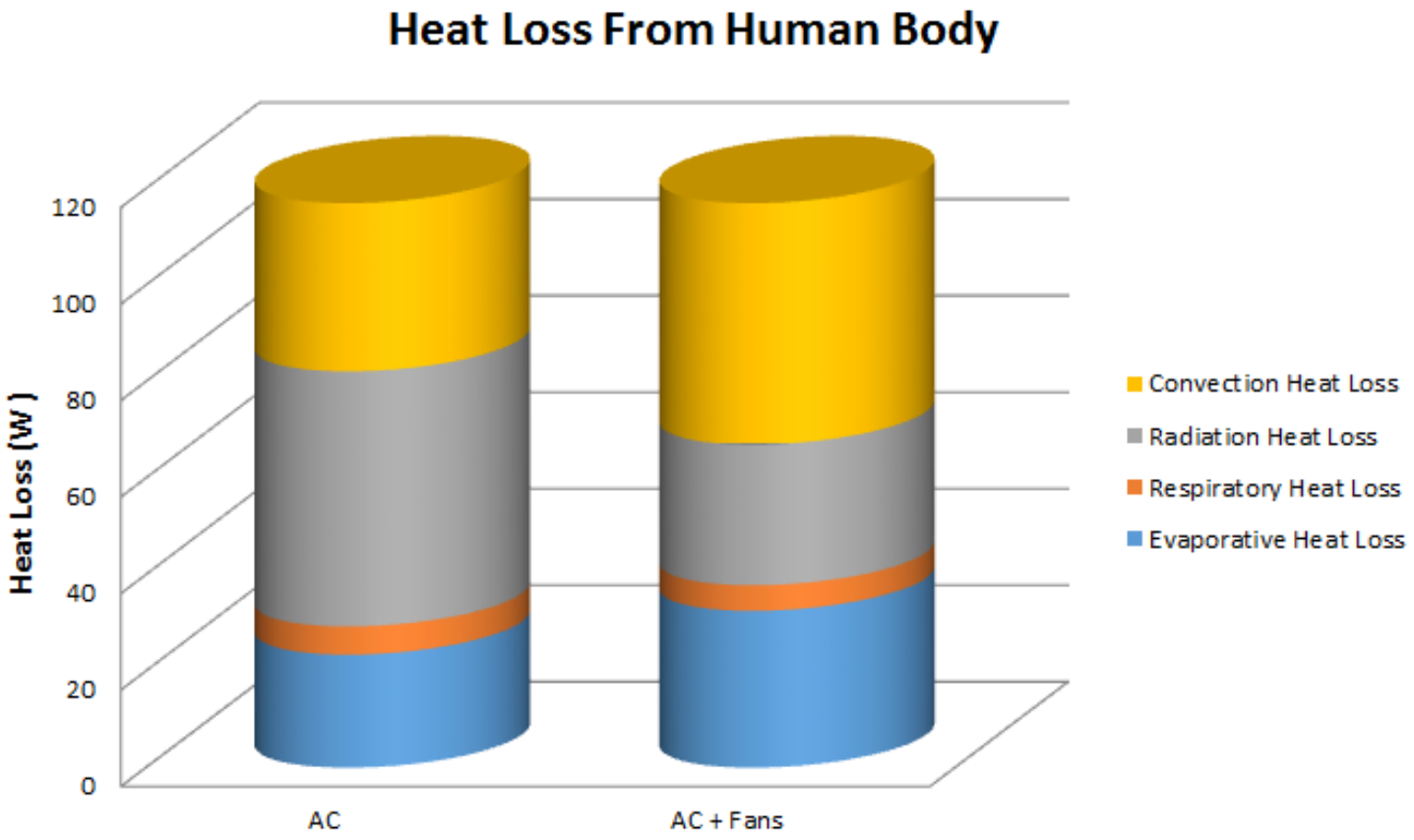
PMV with elevated air speed	-0.50
PPD with elevated air speed	10%
Sensation	Neutral
Drybulb temperature at still air	70.5 °F
Cooling effect	9.5 °F

PSYCHROMETRIC CHART

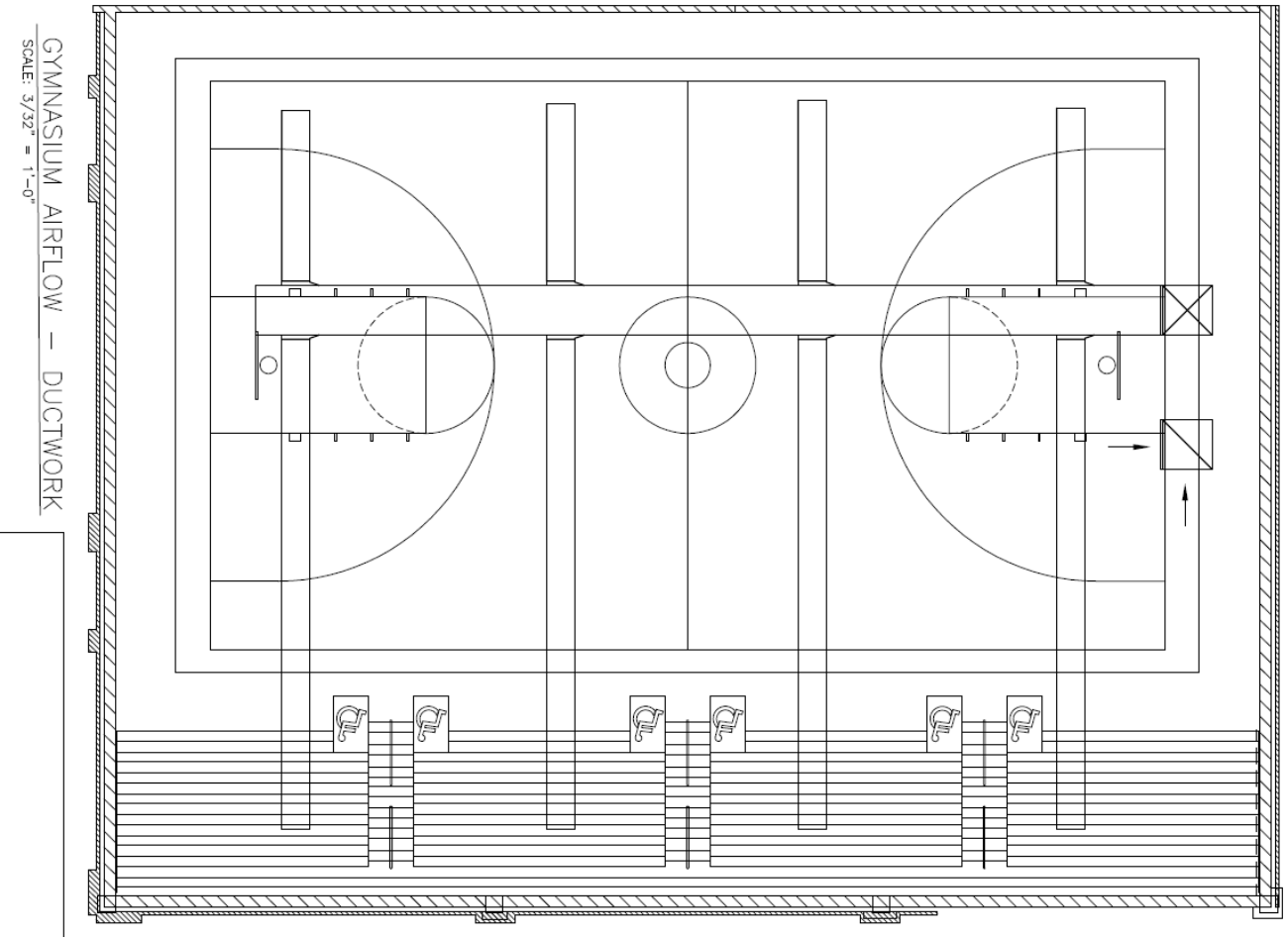


Heat Loss from the Human Body

Total Heat Loss = 117 W



Example: School Gym, A/C Only



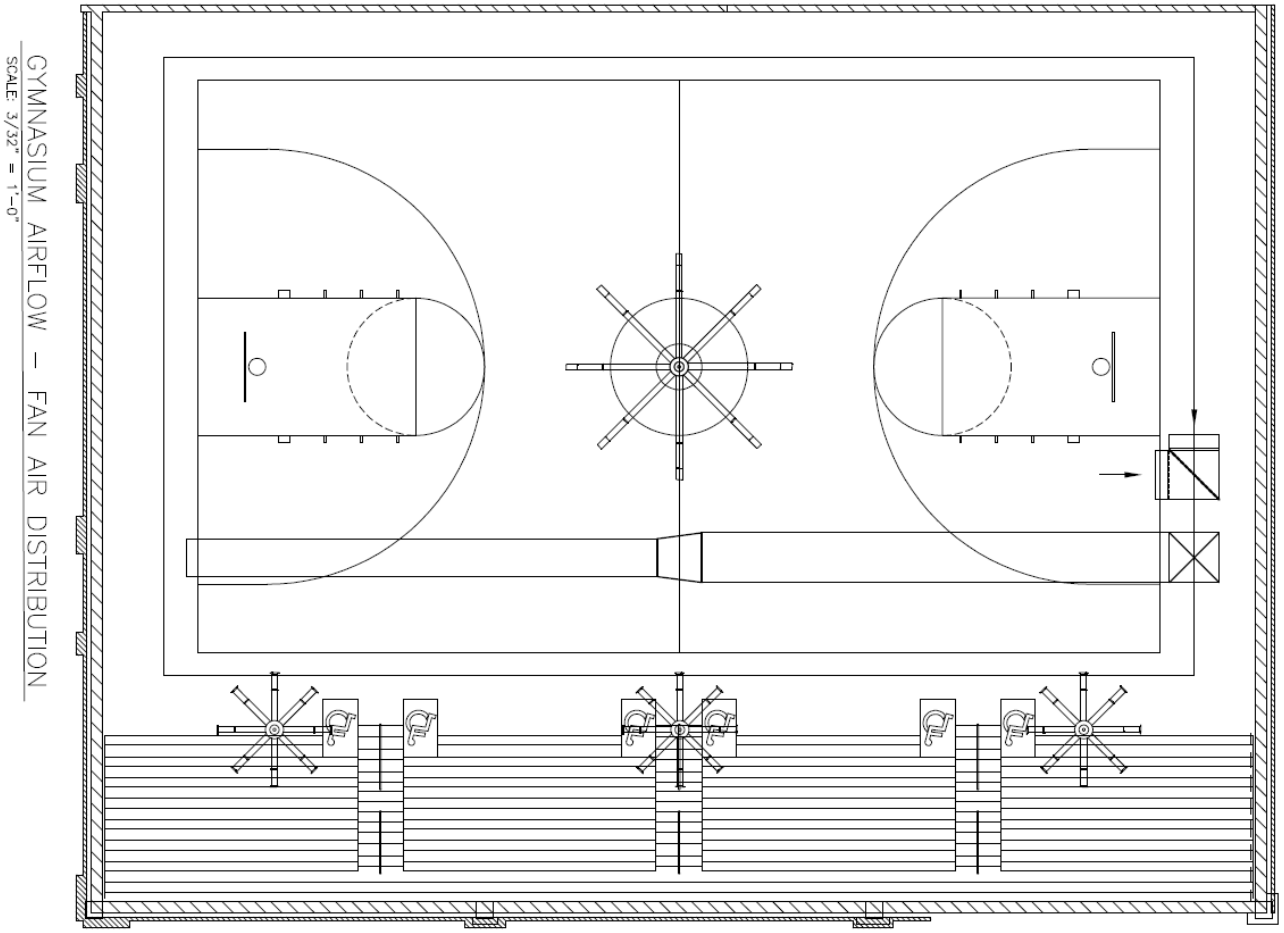
7,833 sq ft
Lexington, Ky.

Setpoint: 72 F
Feels Like: 72 F

Materials + Installation: $7.39/sq ft

RS Means 2013 Mechanical Cost data

Example: School Gym, Fans + A/C



7,833 sq ft
Lexington, Ky.

Setpoint: 78 F
Feels Like: 72 F

Materials + Installation: $6.79/sq ft

RS Means 2013 Mechanical Cost data

Example: School Gym

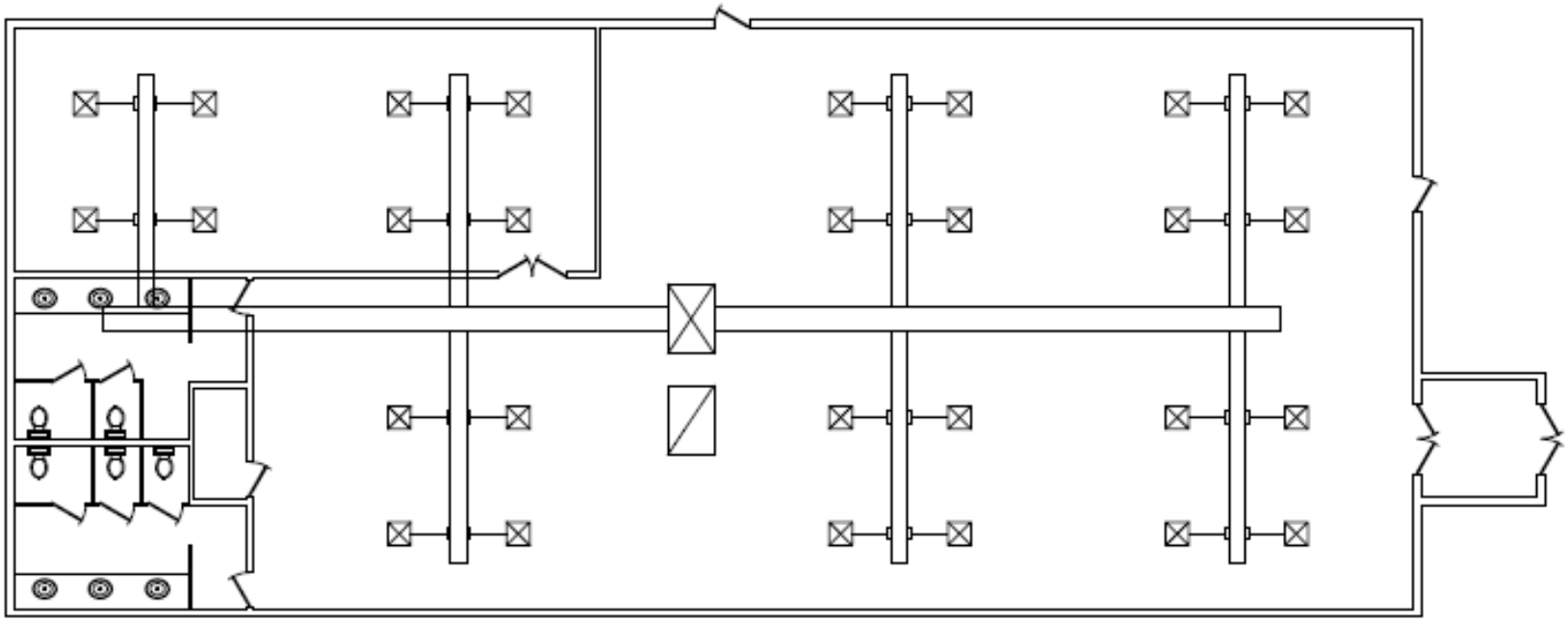
	Difference
Materials + Install Cost	$0.60/sq ft
A/C Electricity Consumption	38%
Annual Utilities Cost	17%

Example: School Gym, A/C Only

Example: School Gym, Fans + A/C

Example: Office Space, A/C Only

6,000 sq ft, Lexington, Ky.



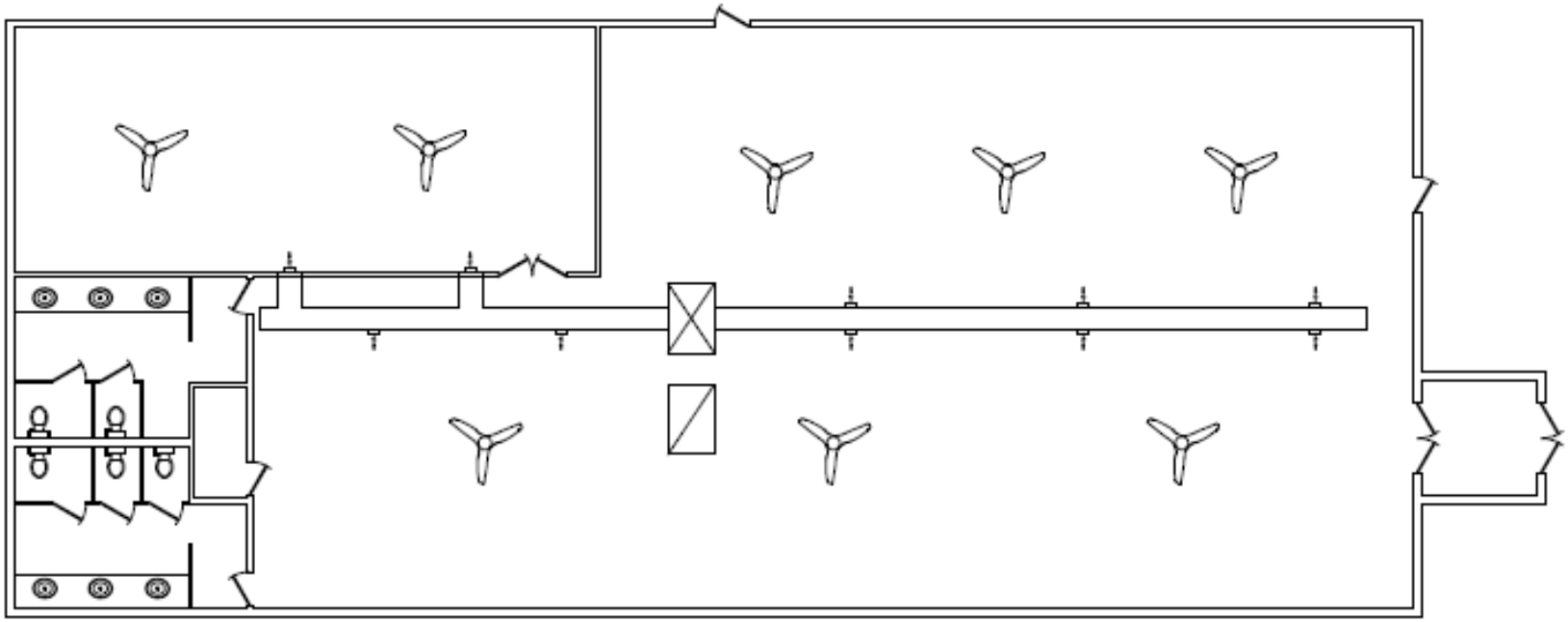
Setpoint: 74 F
Feels Like: 74 F

Materials + Installation: $2.61/sq ft

RS Means 2013 Mechanical Cost data

Example: Office Space, Fans + A/C

6,000 sq ft, Lexington, Ky.



Setpoint: 78 F
Feels Like: 74 F

Materials + Installation: $2.32/sq ft

RS Means 2013 Mechanical Cost data

Example: Office Space

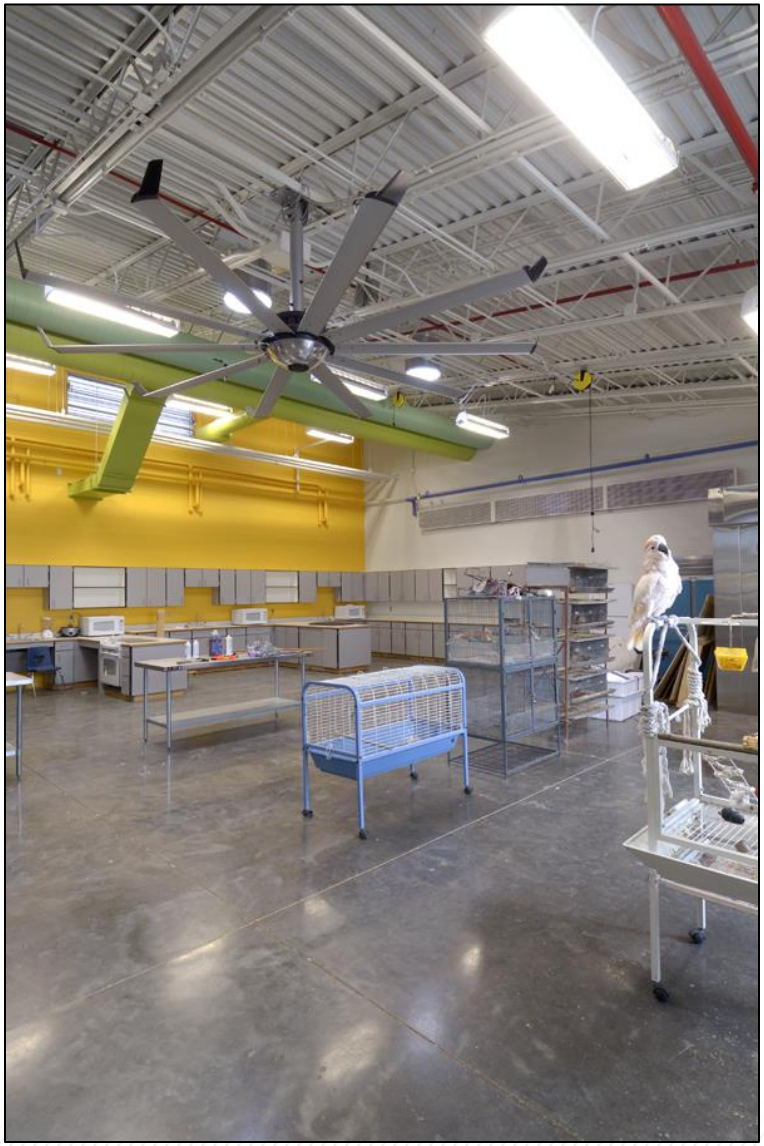
	Difference
Materials + Install Cost	$0.29/sq ft
A/C Electricity Consumption	24%
Annual Utilities Cost	10%

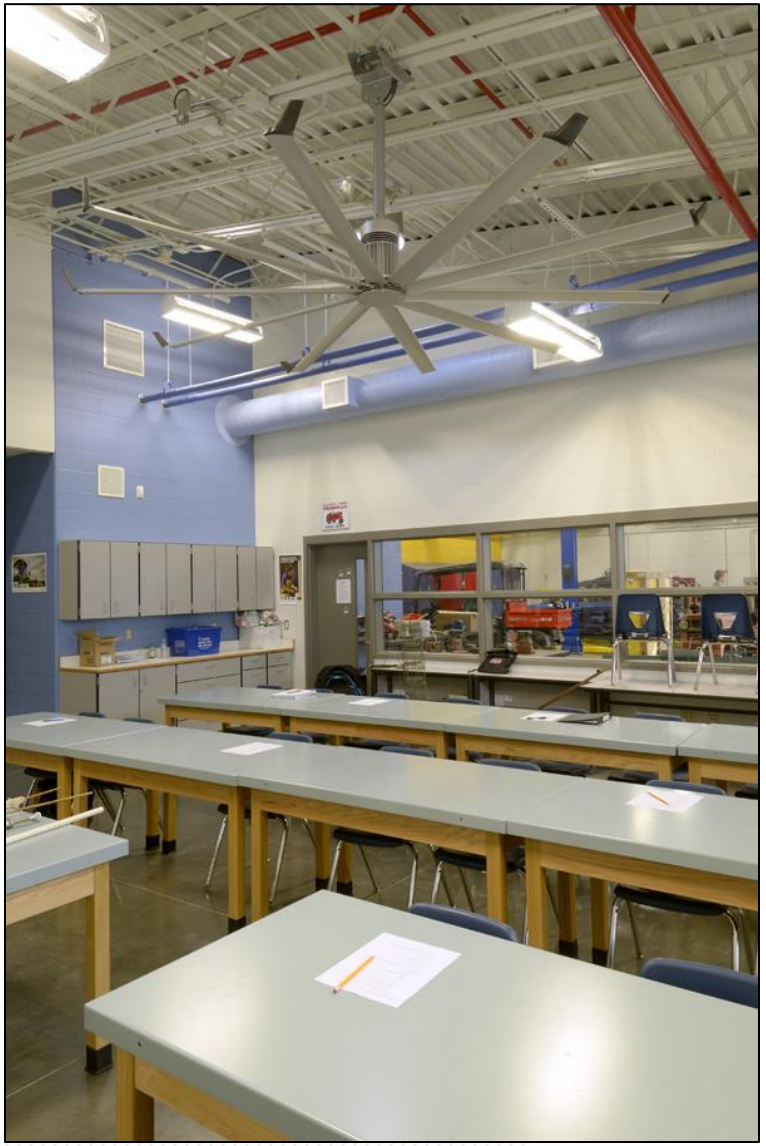
Example: Office Space, A/C Only

Example: Office Space, Fans + A/C

Application Examples

Locust Trace





Locust Trace

Oakland Unified School District

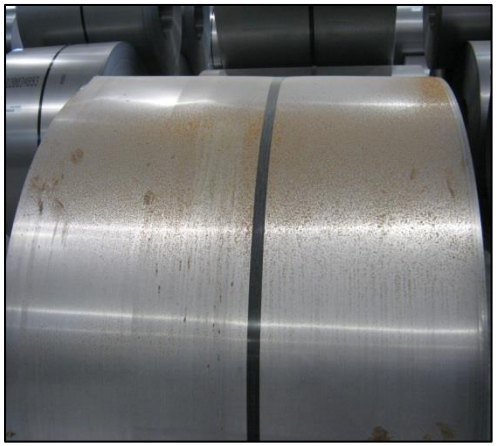
Oakland Unified School District

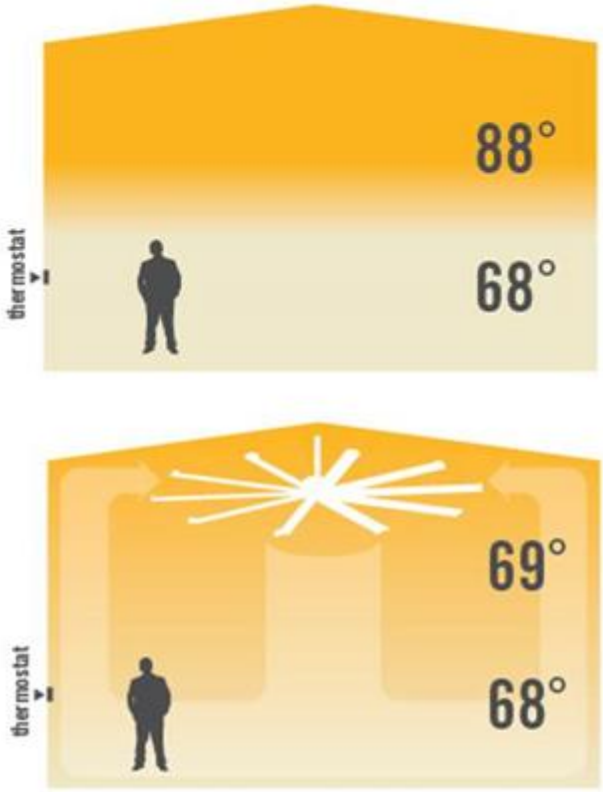
Oakland Unified School District

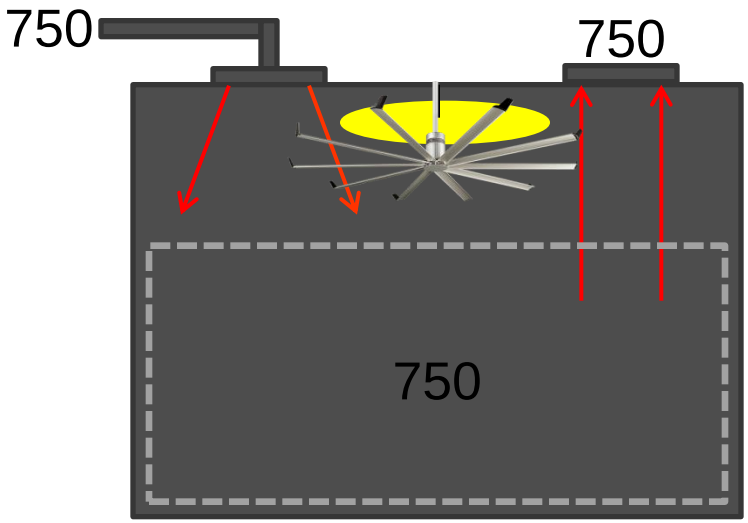
Ancillary Benefits of Elevated Air Speed

Stratification in Heating Mode

- Condensation mitigation
- Destratification
- Improved IAQ







Ez = 1.0

Summary

- Thermal Comfort
- Heat Transfer
- Fans + A/C Equal Comfort
- Elevated Air Speed: Ancillary Benefits

Questions?

info@bigassfans.com
877-BIG-FANS

BIG ASS FANS®
No Equal.