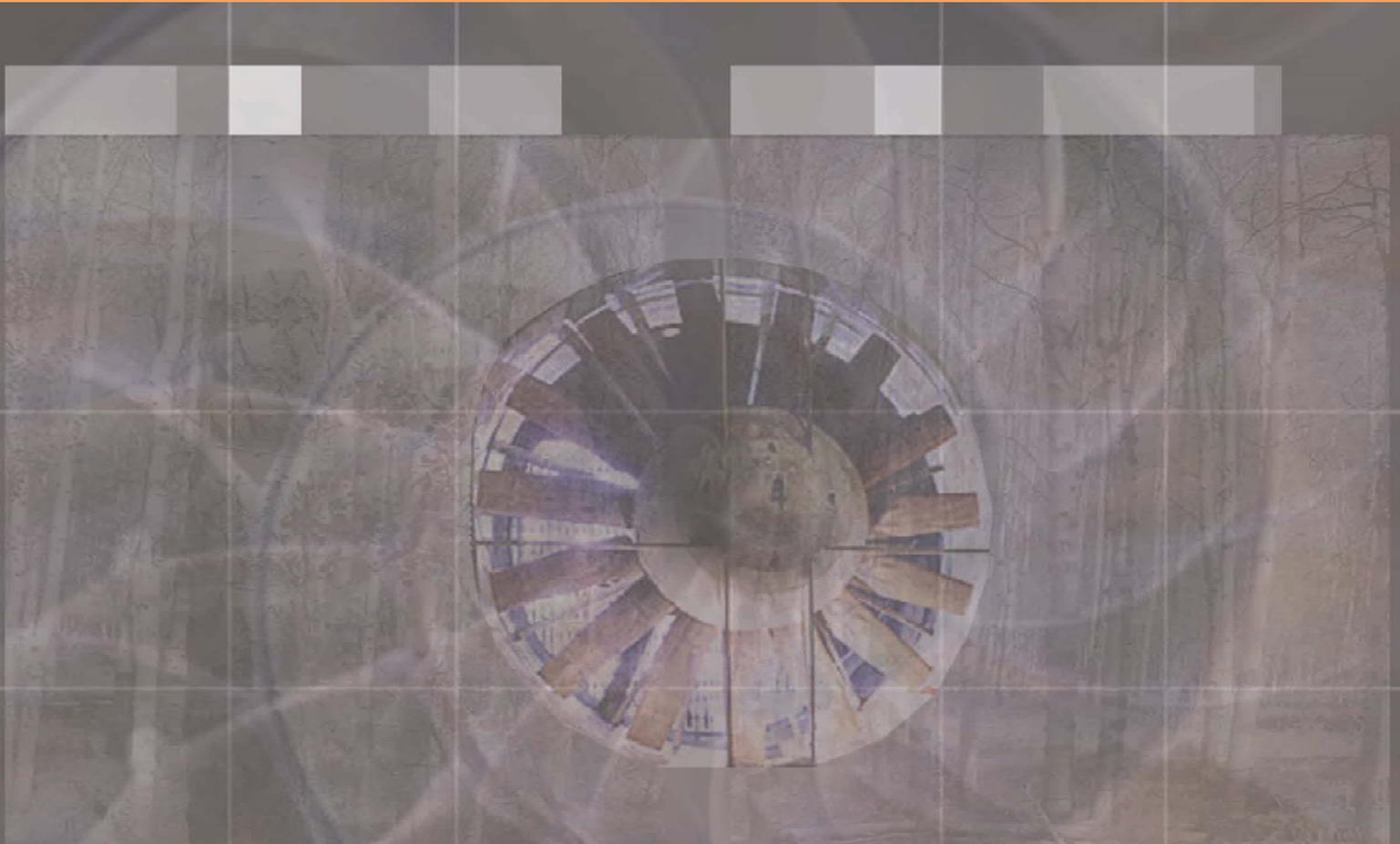


Design Freedom or Brain Freeze: The Effects of Air Conditioning



Body Shop:
Building
Strategies



By Lance Davis, AIA, LEED

80% satisfaction at what cost

- #1 Complaint - Office space is too cold.
- #2 Complaint – Office space is too hot. *R*
- Cooling load is the rate of heat rejection.
- Pumping 100,000 btu's of heat out of a building can cost twice as much as adding those same 100,000 btu's into the building. *R*

A better way

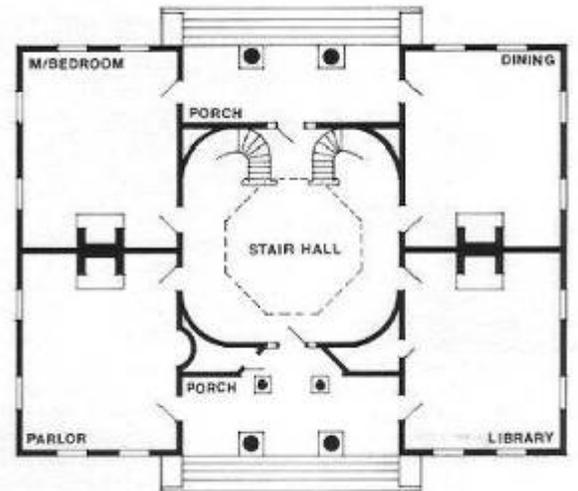
- We misuse AC. Designers frequently ignore thermal design consideration and sensible operation and simply overpower our mistakes.
- Simple strategies to reduce summer heat gain. *R*

What are you going to learn

- Generally, there are no completely passive means for providing positive comfort.
- AC unmistakably raises human productivity, reduces absenteeism, turnover, mistakes and accidents

Architecture before AC

Waverly Plantation, MS 1852



Historic Buildings



Historic Buildings



Air Conditioning History

- Most of AC history is the story of Dr. Willis Haviland Carrier. *W*
- ...Carrier believed that engineers were allowing excessively large “factors of safety” ...really “factors of ignorance.”

The Start of it all.

- **Sackett Wilhelms Lithographic – Carrier pumped cold water through heating coils. July 17, 1902. world's first scientific air conditioning system.**

AC must....

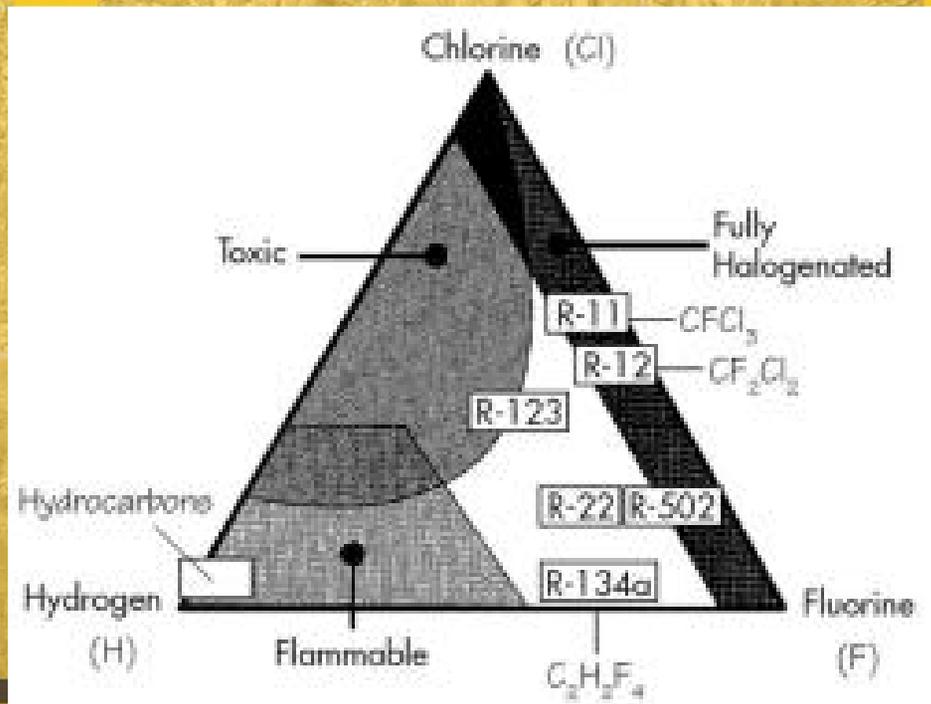
- **control temperature, humidity, air circulation and ventilation, and cleanse the air ..Carrier defined.**

The freeze sets in.

- 1906- Silk Mill Wayland, Finally started figuring sun into heat calculations.
- Newark Cigar Plant – introduced white blinds on windows to serve as reflectors for the sun.
- 1907 Parke Davis capsule Department wanted 25 ton AC. *B*

Cooling developments

- 1930 DuPont combined chlorine, fluorine, and carbon to produce a new generation of nontoxic synthetic refrigerants that were sold under the trade name Freon. *R*
- R-123 interim option *R*
- R-134a – lower heat transfer capacity *R*



The Chief

- **Prophesized air conditioned streets and whole cities from a central plant.**
- **Carriers shadow from his ideas has allowed...lunches in restaurants where heat cannot dull appetite. There will be no limit to the height and width and breadth of the monument.**

Architecture after AC

4 reasons for AC:

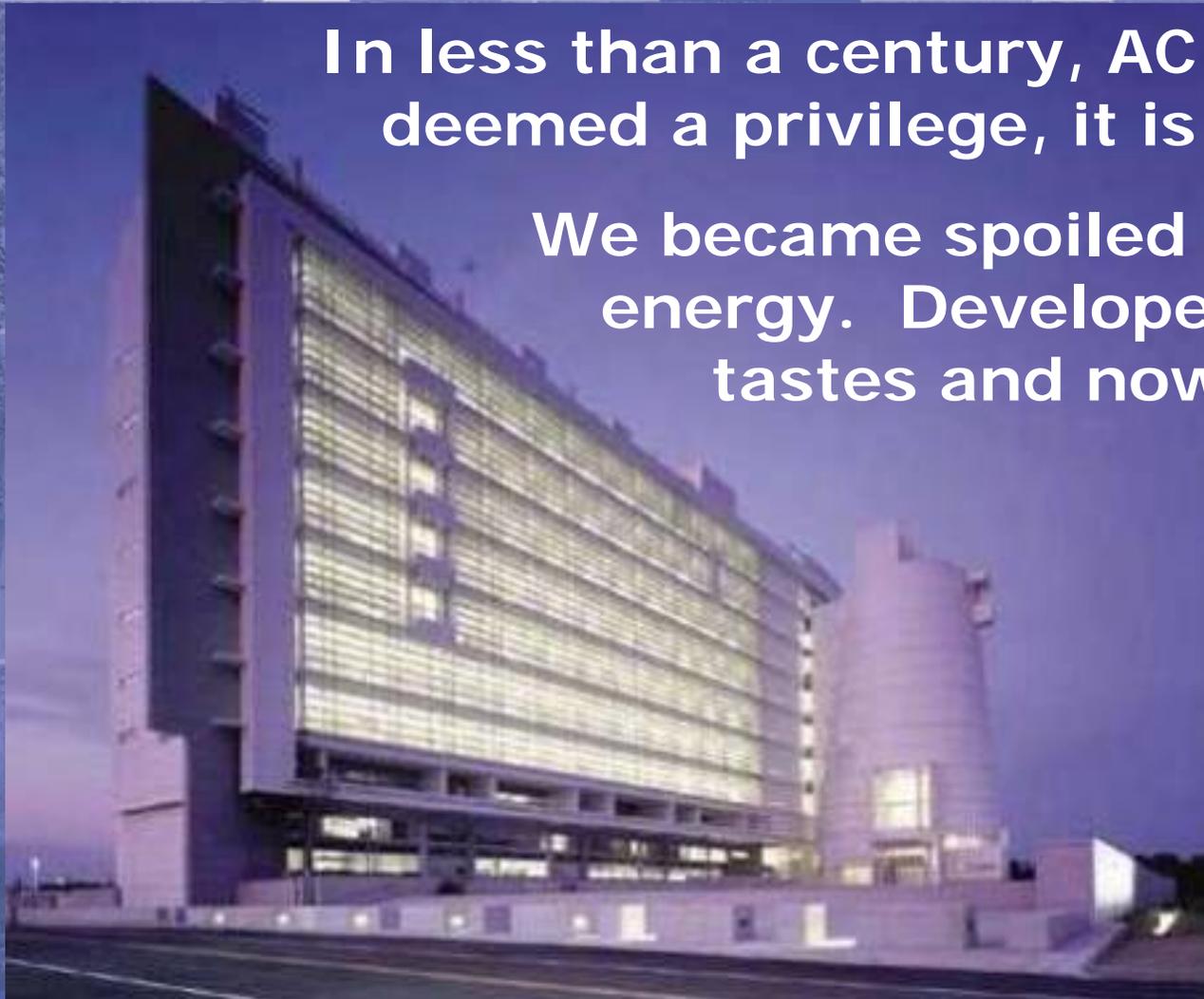
- Design flexibility
- Site utilization
- Air quality
- Thermal comfort



Champagne wishes and caviar dreams

In less than a century, AC is no longer
deemed a privilege, it is a necessity.

We became spoiled with cheap
energy. Developed expensive
tastes and now rely on AC.



Death in a Box *B*

The common glass office building must have AC. But, during a power outage, the people must be evacuated.

It is not possible for humans to exist.



AC design strategies

- Keep heat out of buildings (reduce cooling loads)
- Expand our comfort range (modify work attire and provide air circulation)
- Get rid of heat once it gets in (heat rejection) —which can include both passive and active means.



AC is for thermal comfort.

- Self defeating to achieve energy savings through management that compromises comfort and well being.



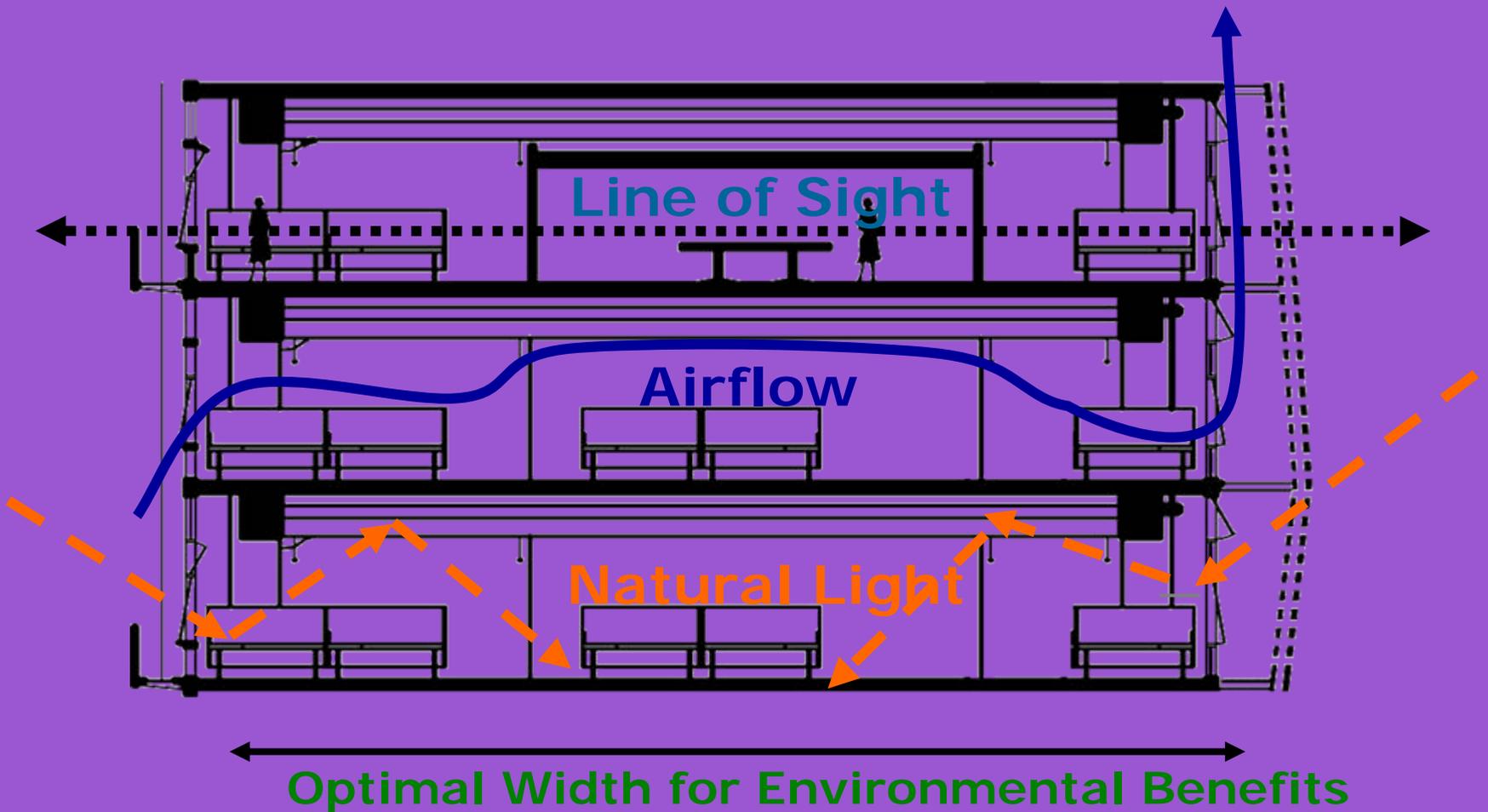
Bioclimatic design

- optimize the relationship of people and climate through the medium of site, building fabric, plants and equipment.
- **Climate is a critical factor influencing built form.**

San Francisco Federal Office Building
San Francisco, CA

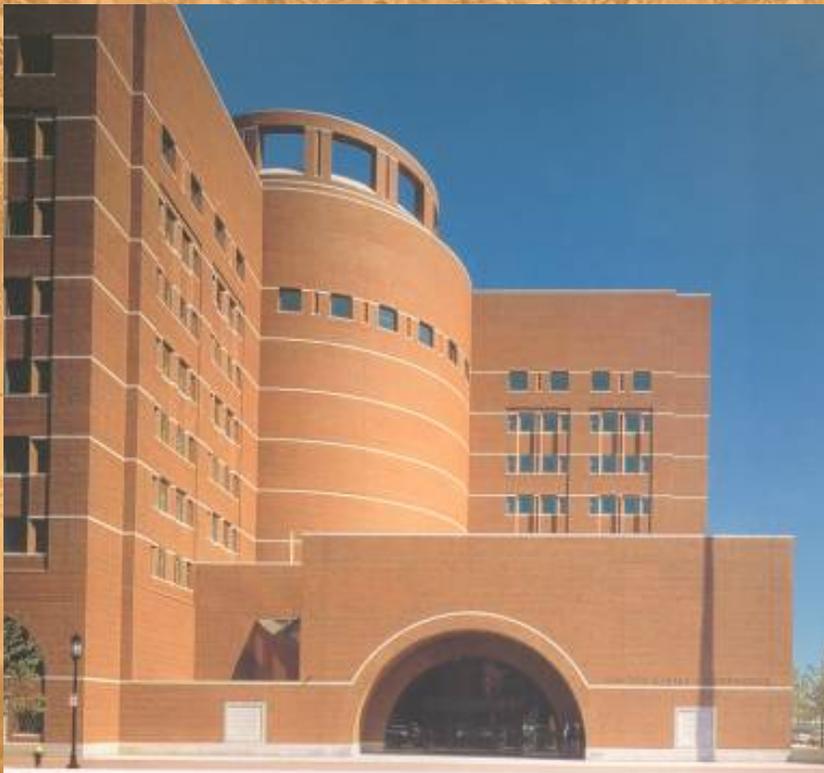


Passive Strategies

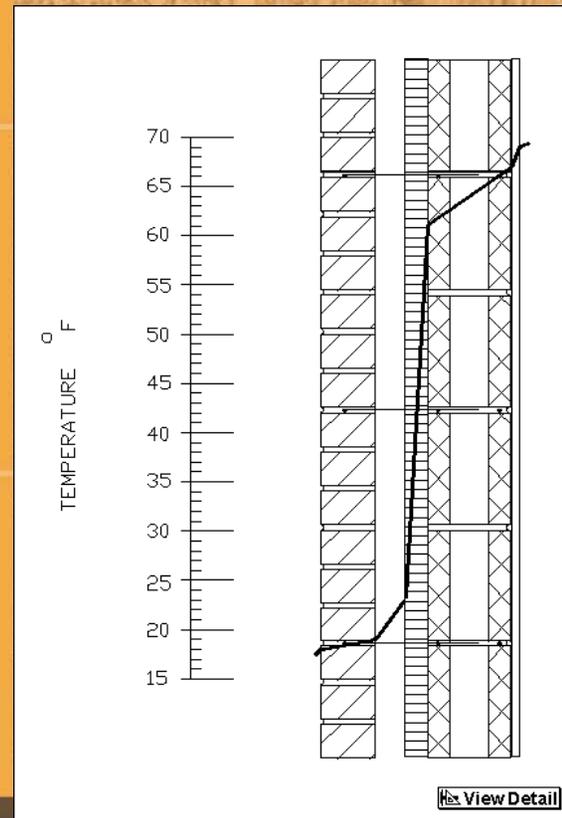


Exterior Materials

Carefully consider heat gain via conduction from the sun



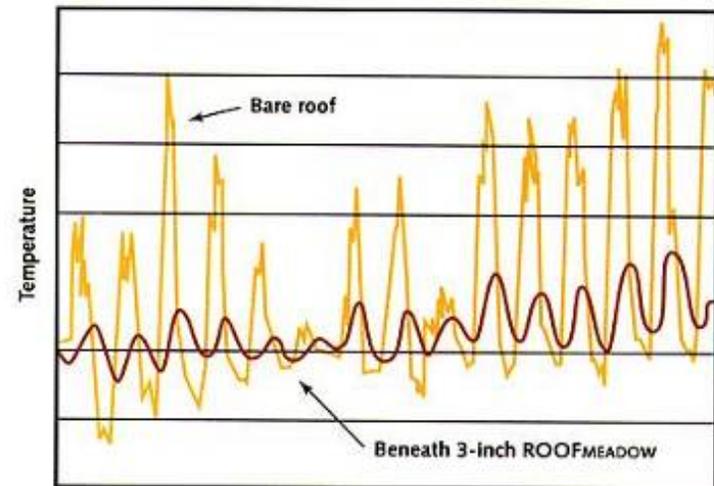
John Joseph Moakley U.S. Courthouse
Boston, MA



Roof

- **A light or white roof can save 15 - 20 % of total cooling energy.**
- **Roof insulation is critical**
- **Heat transfer can account for 30% of the cooling load.**

U.S. Border Station
Sault Ste. Marie, MI



Glazing

*Integrate the technical selection with
Architectural issues,
Views
Building appearance,
Daylighting,
Passive solar heating*

~ 1,000 BTU per square foot
per day in clear weather

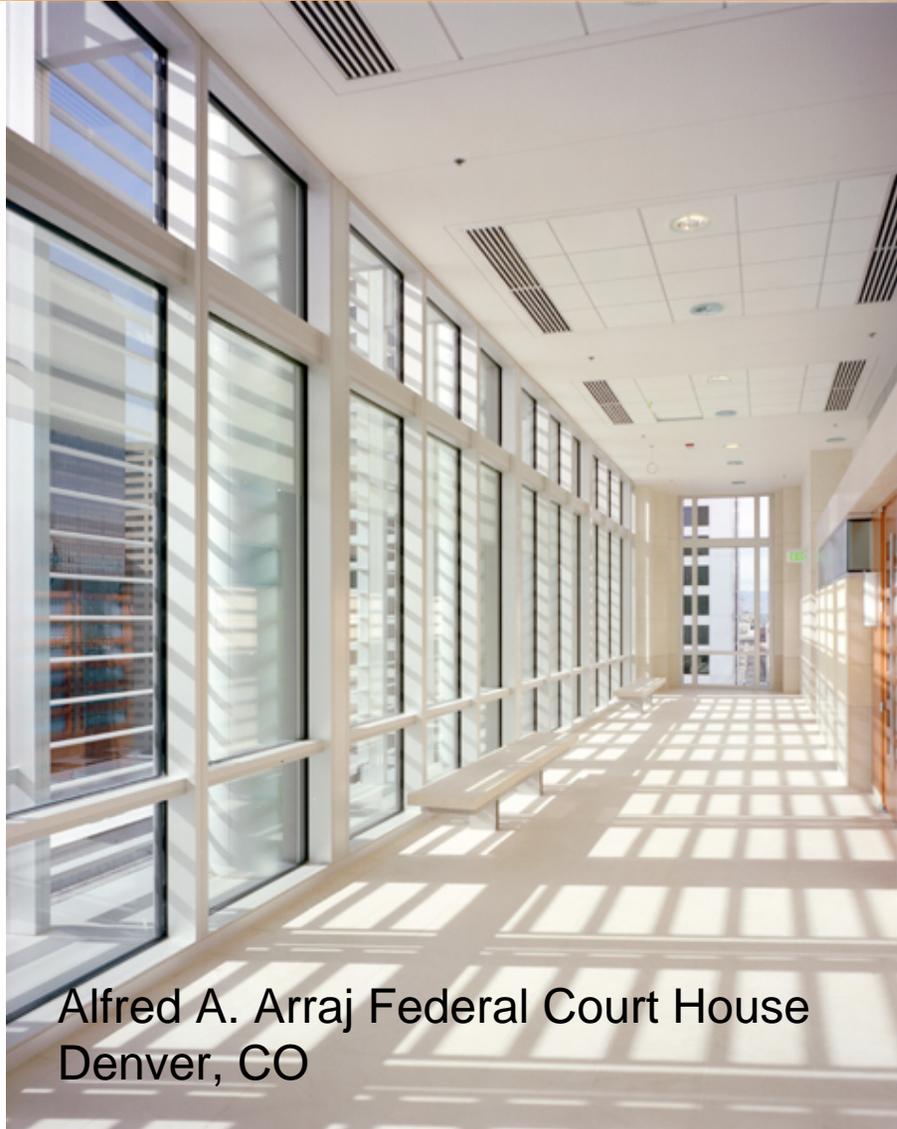
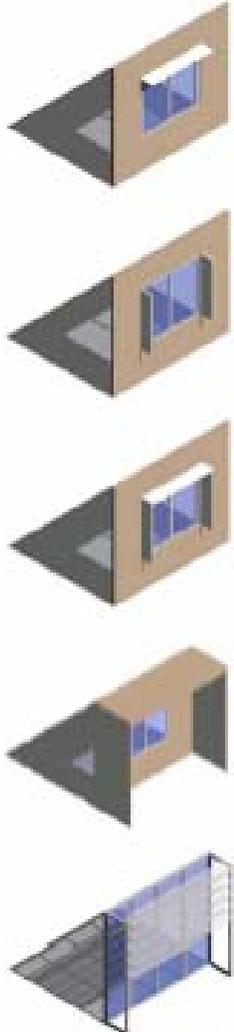
Alfred A. Arraj Federal Court House
Denver, CO



Exterior shades

Provide the
**most
effective
shading**

Interior Shades
and blinds are
less effective
but more
common



Alfred A. Arraj Federal Court House
Denver, CO

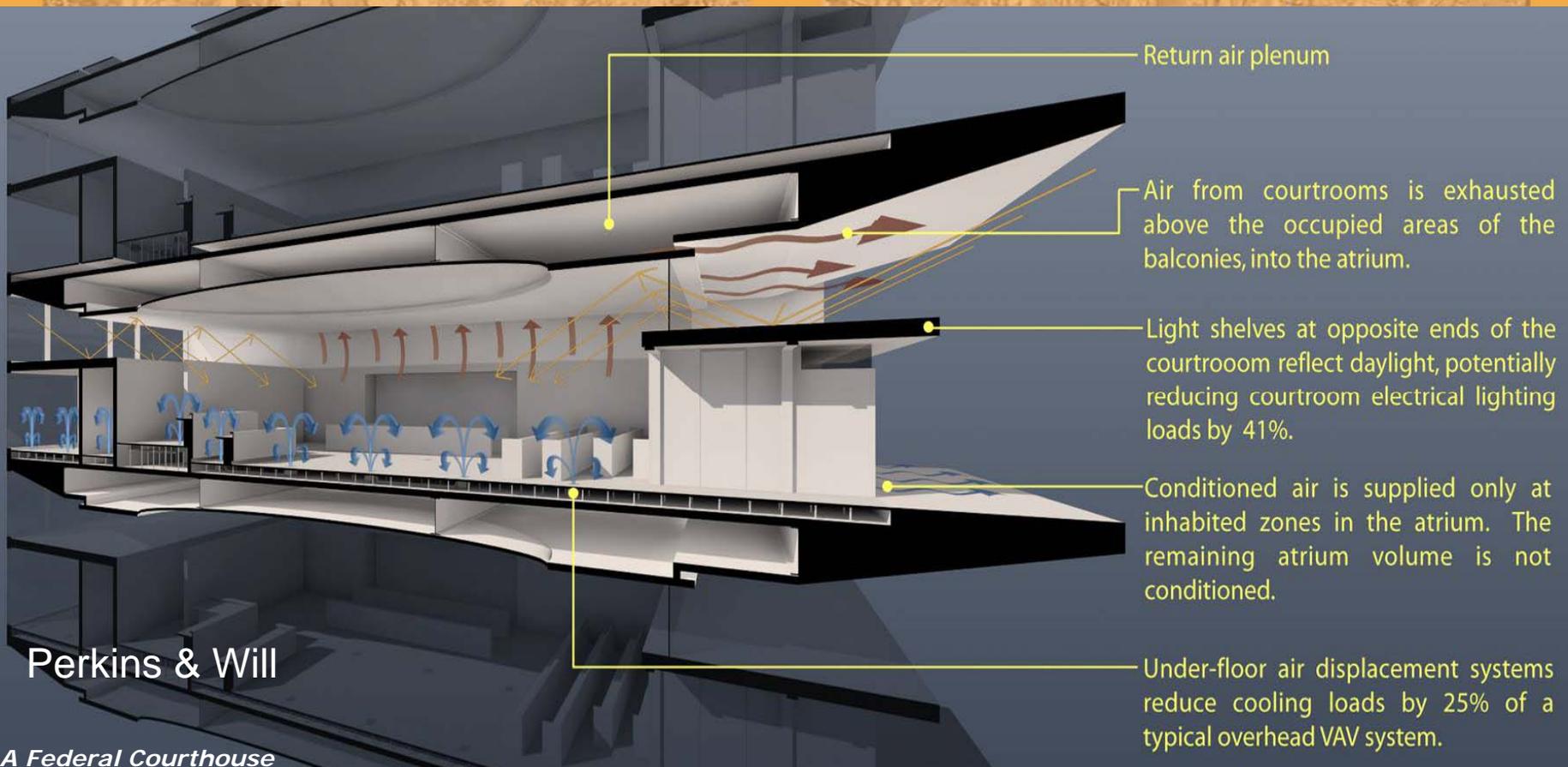
Ventilation

- Naturally ventilated buildings-
a design challenge but opportunity to optimize



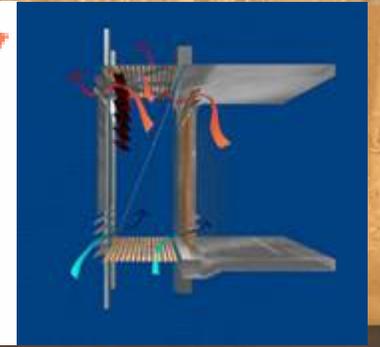
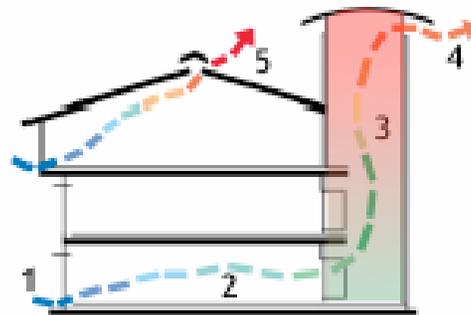
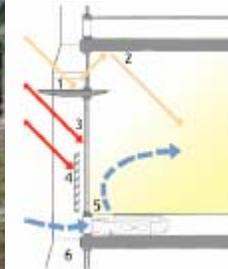
Caltrans District 7 Headquarters
Los Angeles, CA

Interior Ventilation



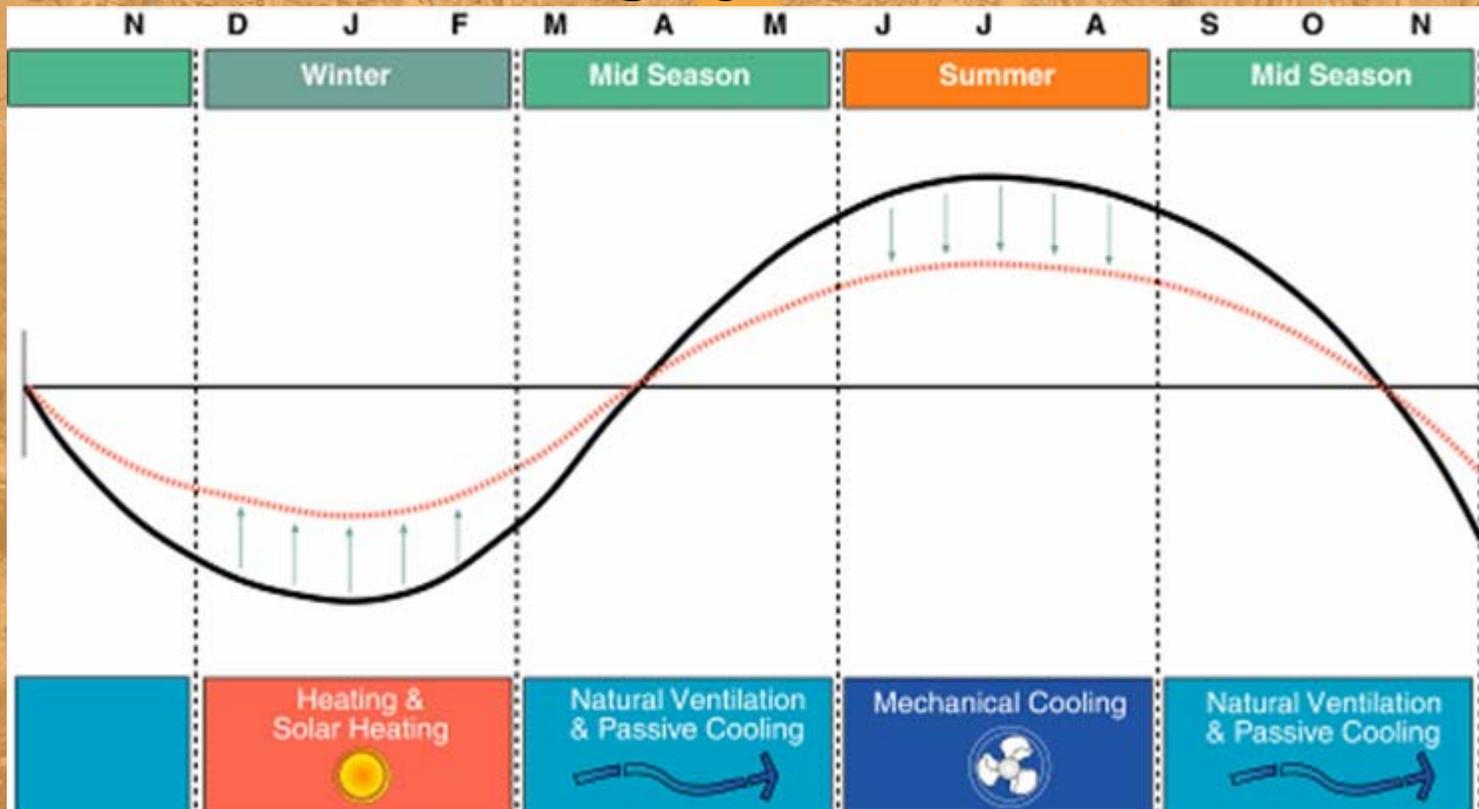
ASHRAE

- says maximum airspeed is 160 ft/min.
- Standard 55
 - predicts that air moving at 100 fpm can offset temperatures of 2°F to 4°F above the normal comfort zone, and an air velocity of 250 fpm can offset temperature increases of 4°F to 10°F. *R*



Last option

- Only when passive and low energy options have been exhausted should conventional mechanical cooling systems be considered.



Switch to Kim Fowler



AC System

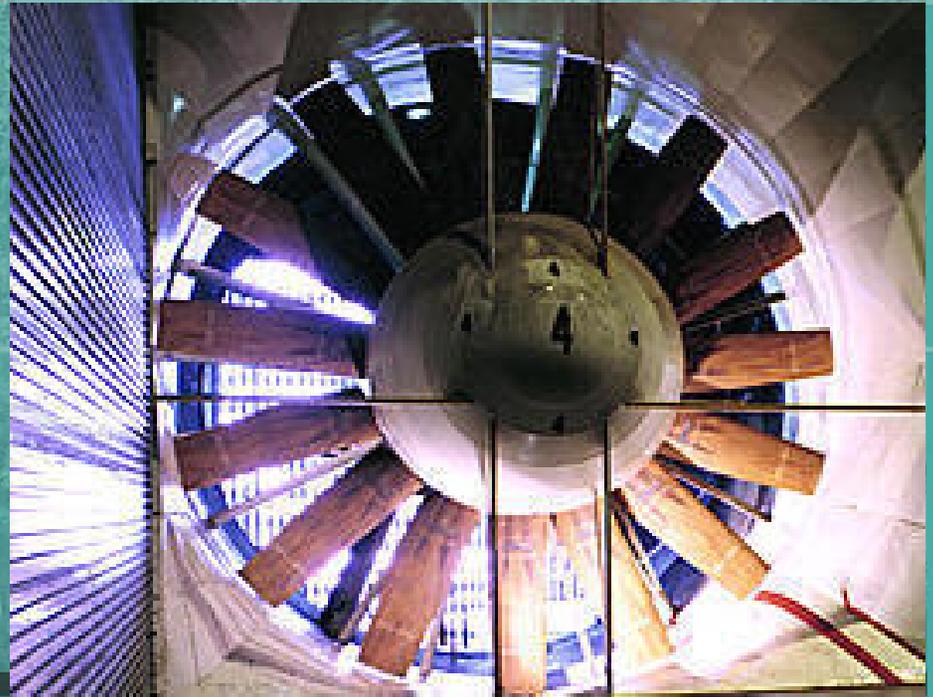
- **AC is a technical solution and requires nonrenewable energy. Designers are ethically responsible to reduce power through design and management.**

The thumbs do not rule

- 350 to 400 square feet per ton of cooling.
- Over 400 sq feet and engineers get nervous.
- 2 – 3 watts for lights
- 10 watts for plug loads

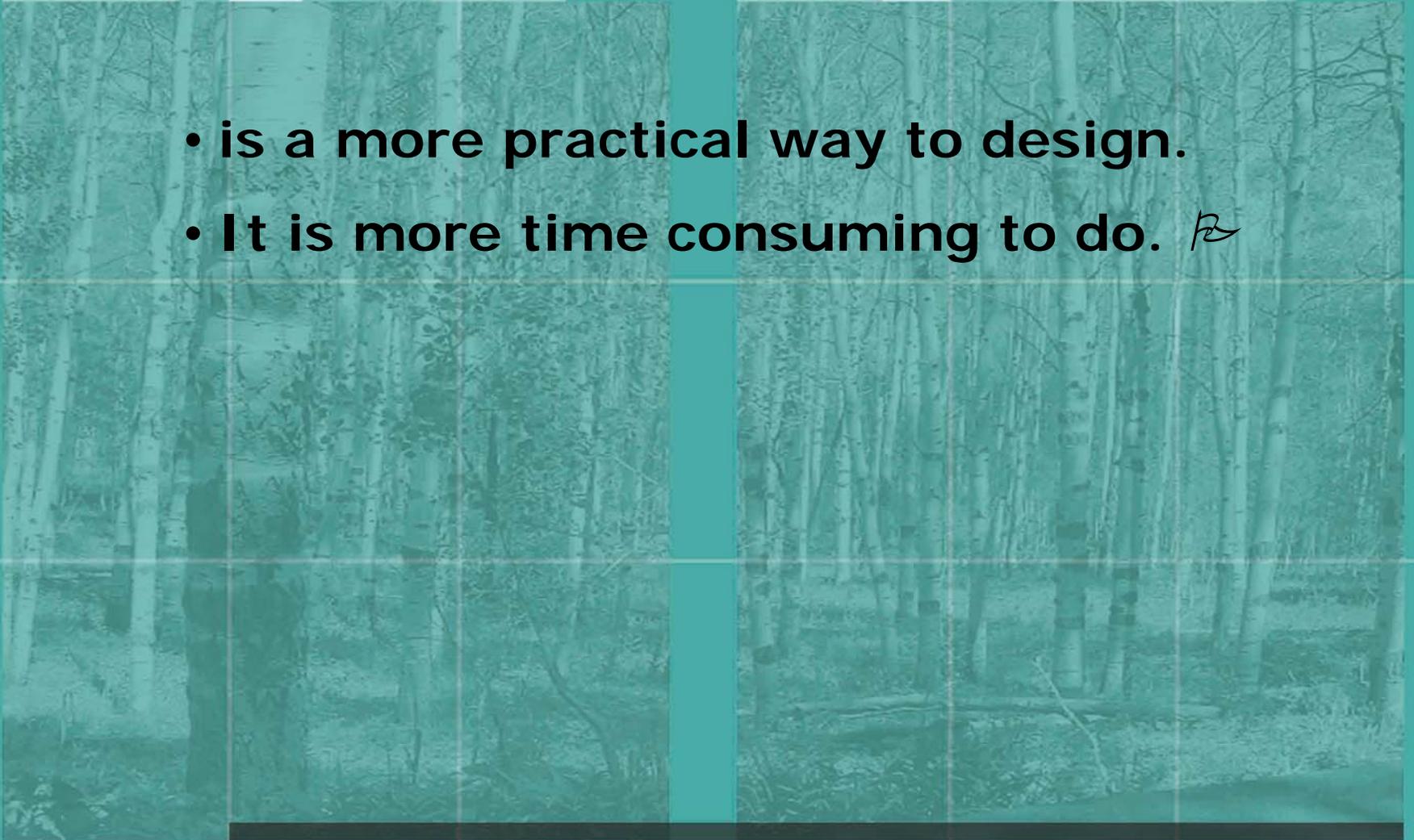
Design cooling load

- is the worst case scenario for keeping the building cool. *R*
- Can contain huge safety factors



Actual operating load

- is a more practical way to design.
- It is more time consuming to do. *R*



Lighting Plug loads

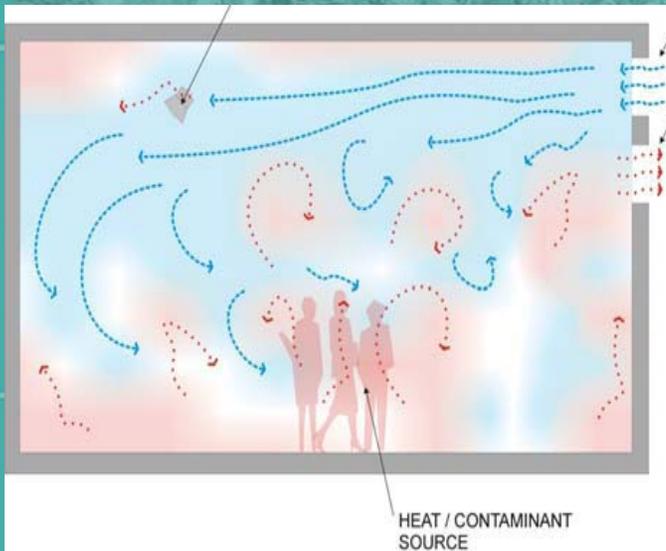
- Heat from lights must be removed by the cooling system.
- New construction - .5 to 1.5 watts/sf
- Daylighting reduces operating loads but not the connected load because the building must be operated at night. *B*

Plug loads

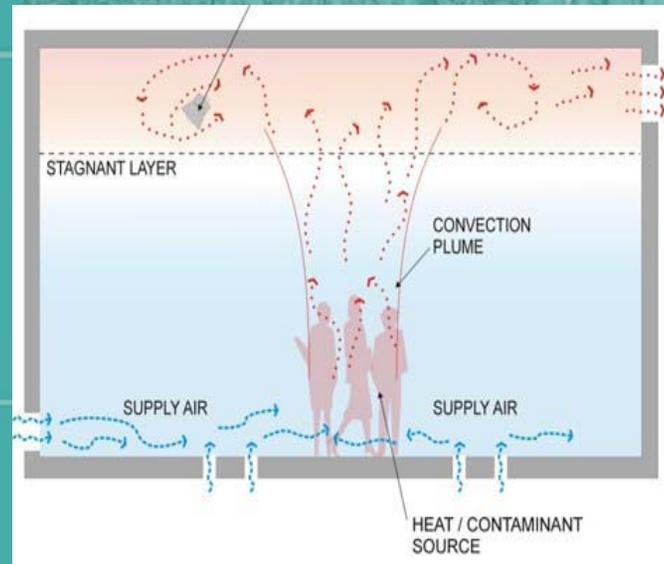
- are a mystical area and can equate to large amounts of safety factors.
- An ASHRAE study showed that plug loads are typically less than 1 watt per square foot. This is due to efficient machines that are not in operation all day.

Priorities

- Hot air rises

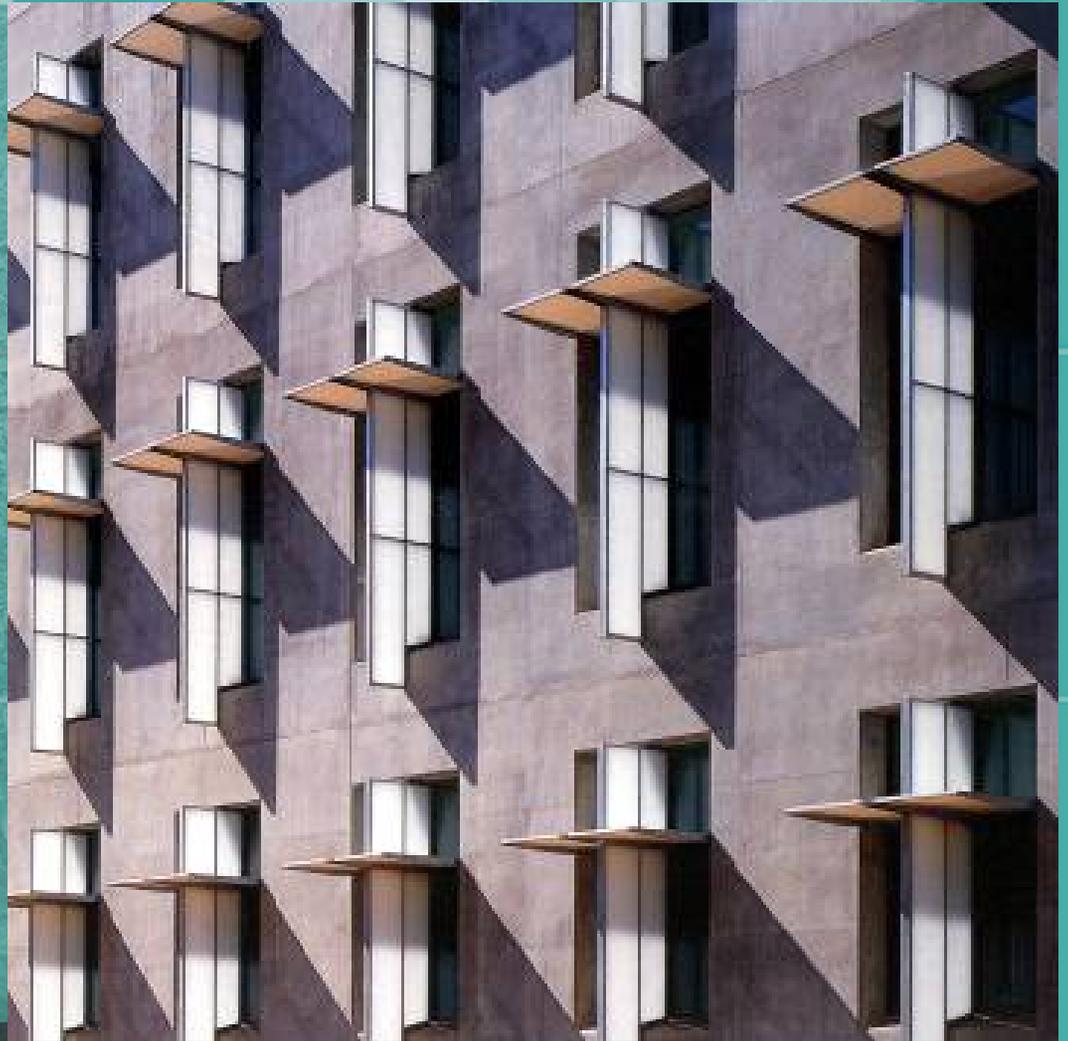


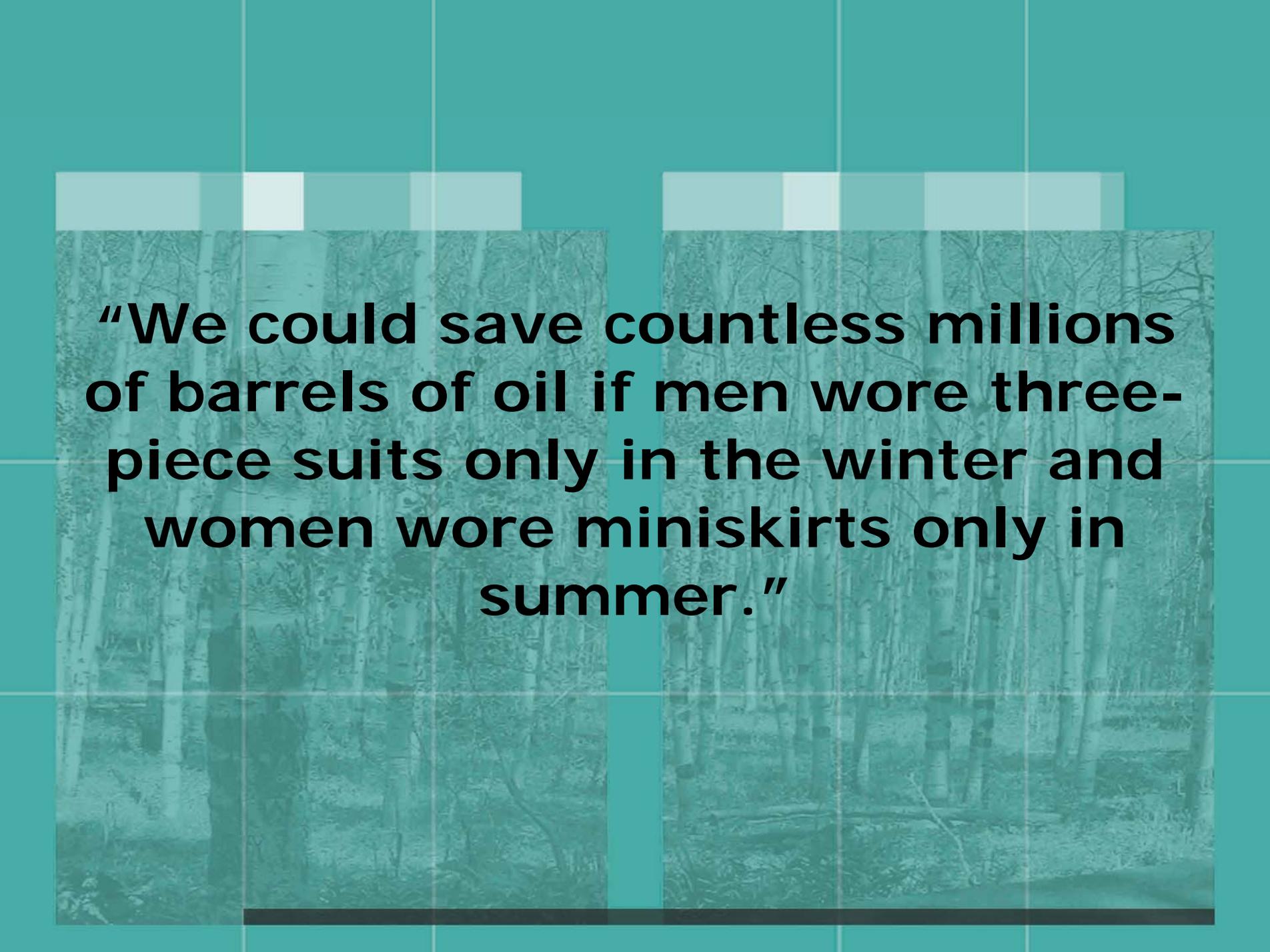
- Strategy – contain cold air in floor plan and draft hot air



Priorities

- High levels of solar radiation mean heat load
- Strategy – orientation and shading, reflective surfaces.





“We could save countless millions of barrels of oil if men wore three-piece suits only in the winter and women wore miniskirts only in summer.”

Thermal comfort

- I can't define it, you might say, but I know it when I feel it
- ASHRAE, thermal comfort is "the condition of mind that expresses satisfaction with the thermal environment."
- 85°F (29°C) feels fine outdoors, in the shade, with a breeze blowing, but miserable in a sealed office building.

1966, ASHRAE Standard 55

- has defined thermal comfort in the U.S. and Canada. It applies to most buildings—residential and commercial, new and existing—in which occupants are engaged in “light, primarily sedentary activity.”
- Though it’s not part of any building code, it often provides both leasing guidelines and legal cover

Adaptive comfort

- **ASHRAE's Standard 55 now recognizes adaptability; the 2004 version includes an expanded comfort zone for optional use in naturally ventilated spaces.**

Alison Kwok

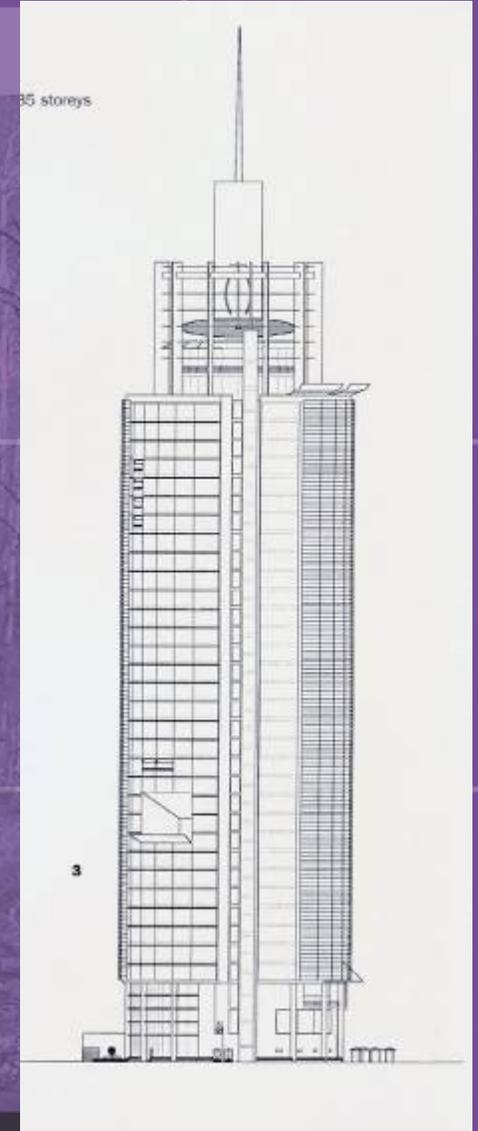
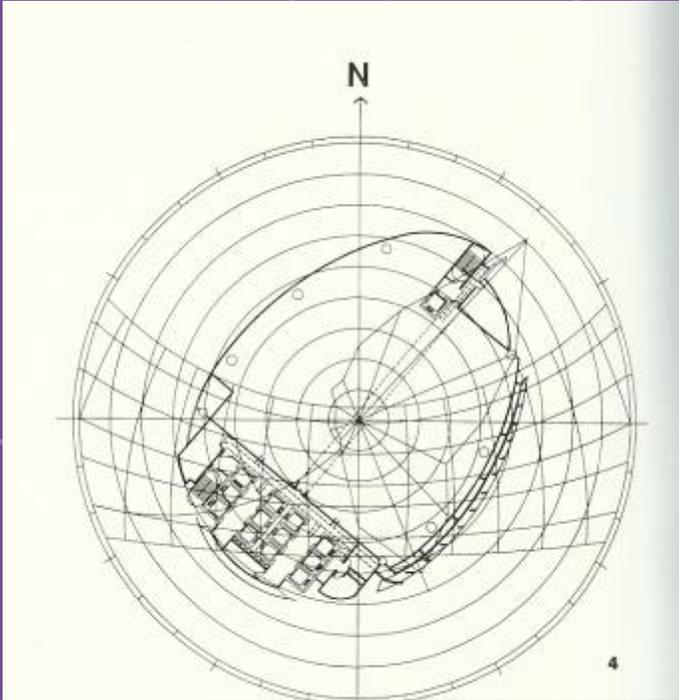
- of the University of Oregon, put the problem more directly:

“This is the HVAC industry defining comfort in naturally ventilated buildings—see the irony?”

Brager and de Dear

- Found that occupants of mechanically ventilated buildings were twice as sensitive to temperature changes as those in naturally ventilated buildings. *RB*
- In other words, we can become addicted to air conditioning. *RB*

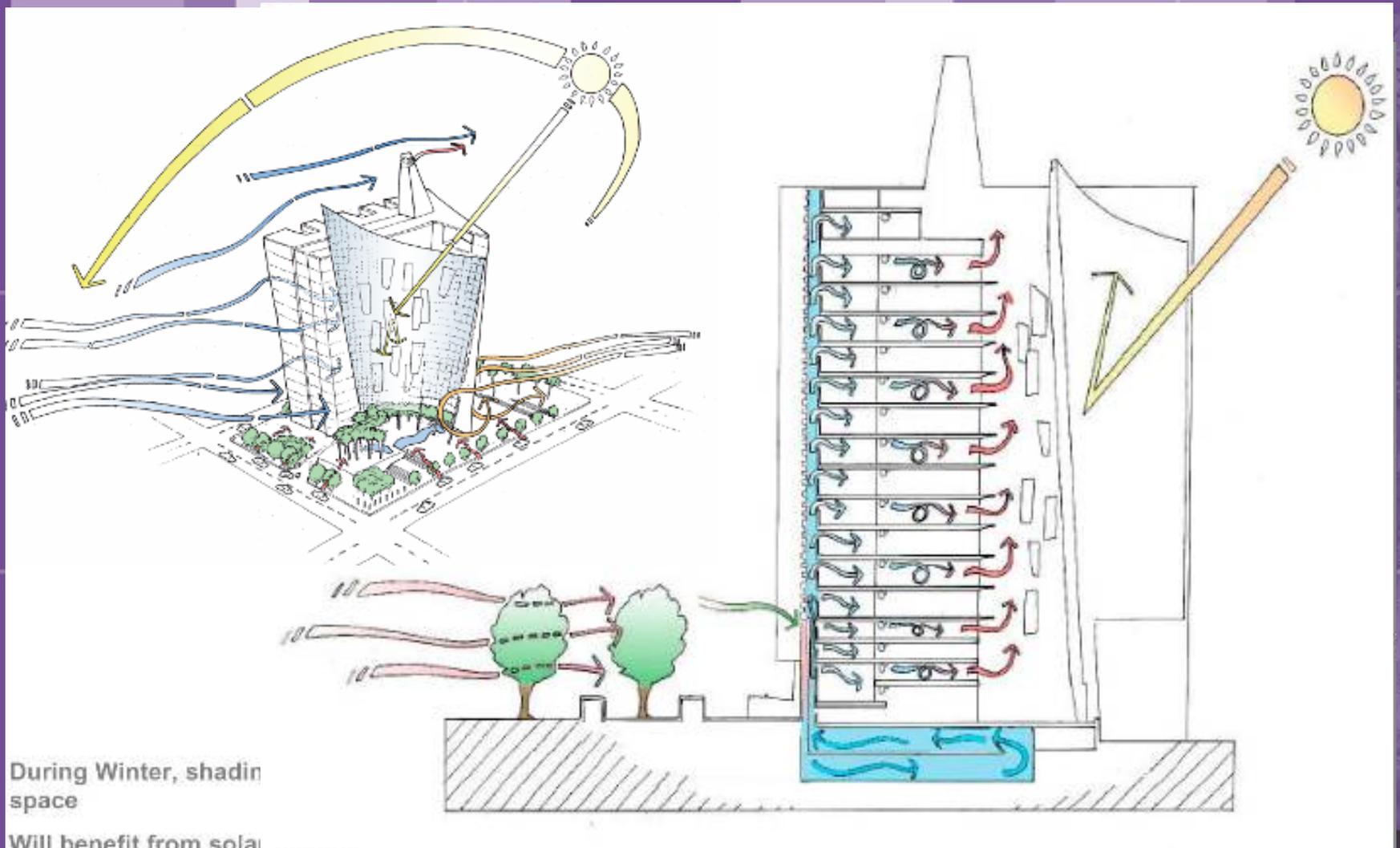
Examples from Ken Yeang



Examples from Ken Yeang



Examples from Guy Battle



Examples from Guy Battle



Other examples



Allow for adaptive comfort

If you can design for occupants to effectively cool or warm themselves in 'adaptive' ways, people will do so. This can lead to tremendous operational cost savings and energy savings in addition to greater occupant comfort.

Thank you.



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