

Part B:

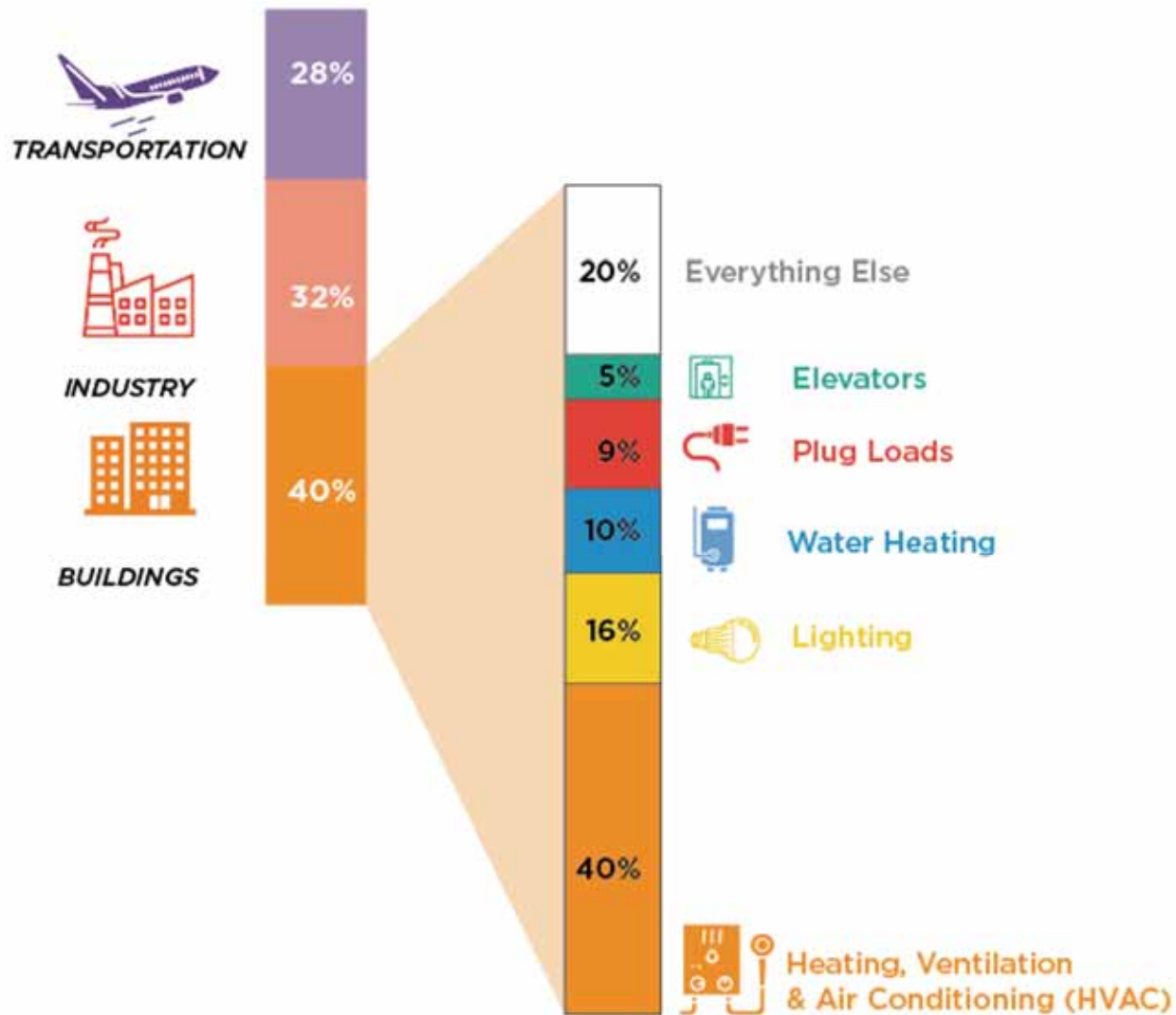
GREEN BUILDING PRACTICES

**Integrated Systems are Key
to High Performance**

CHAPTER 6:

**SMALL CHANGES,
HUGE IMPACT**

Which Building Systems Use the Most Energy?



Data: Commercial Buildings, U.S.

POP QUIZ: Focus on Energy-Consuming Systems to Reduce Carbon Emissions

Which system is missing?

#1



Building Envelope
(Walls, Roof, Slab, Windows, Doors)

#2



Heating, Ventilation and Air Conditioning
(HVAC)

#3



Lighting

#4



Water Heating

These **8** building strategies have a huge impact on building performance



1. **Envelope:** Seal and insulate building exterior
2. **HVAC:** Properly sized heating, cooling and ventilation systems
3. **Water:** Strategies to conserve water
4. **Lighting:** Efficient electrical and lighting systems
5. **IAQ:** Healthy indoor air quality
6. **Materials:** Use environmentally friendly materials
7. **Testing:** Test and commission systems to ensure performance
8. **Sustainable Building Operations:** Ensure continuous performance

CHAPTER 7:
TIGHT BUILDING
ENVELOPE

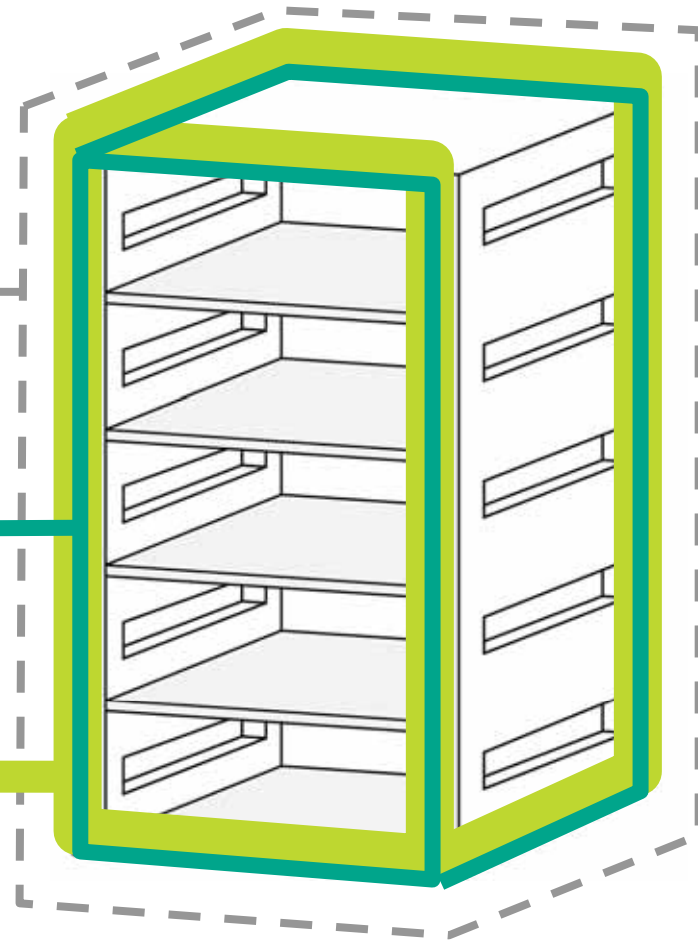
The Job of the Building Envelope

Factors that determine a building's energy use:

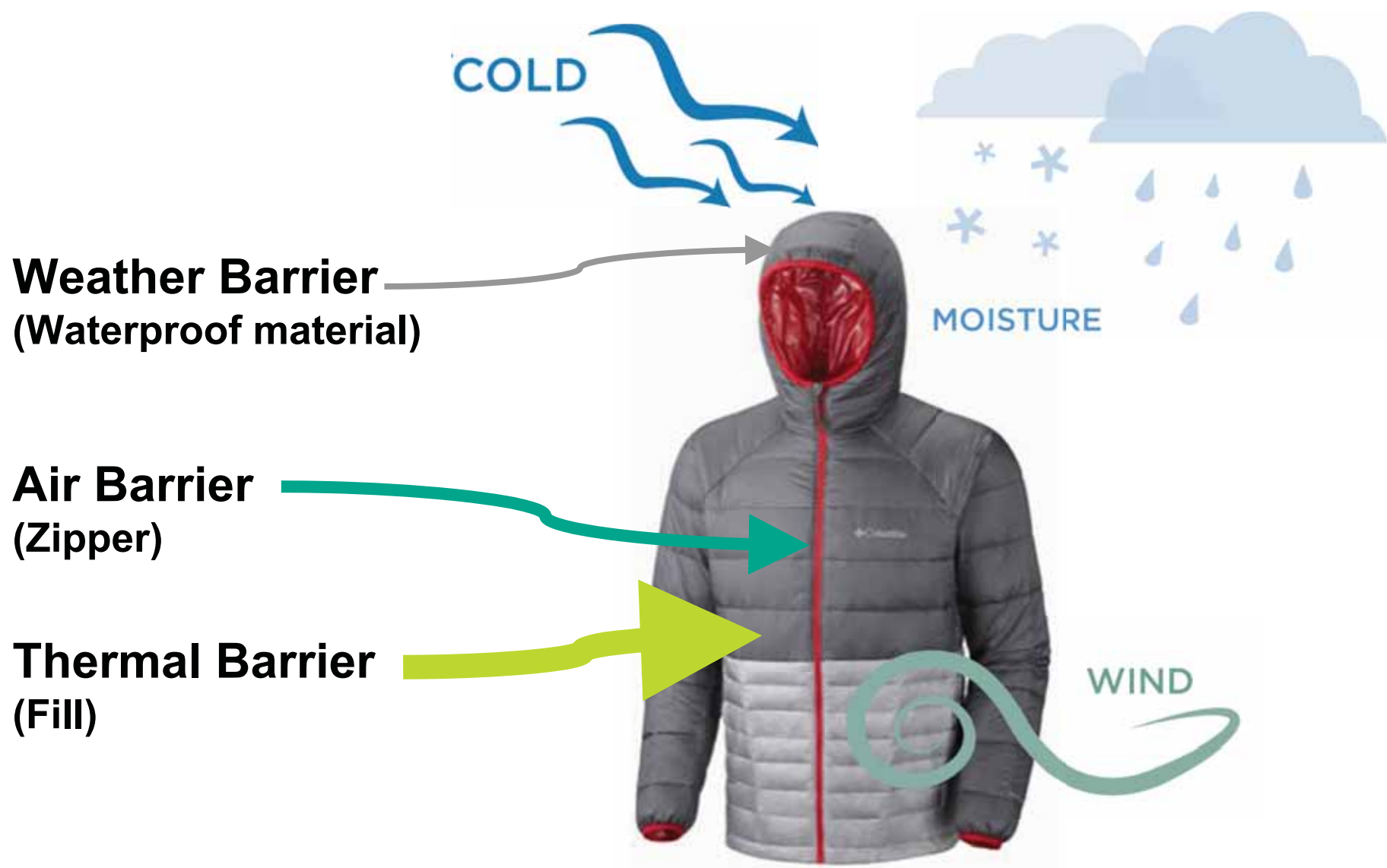
Weather Barrier
(Protects from rain, leaks)

Air Barrier
(Prevents air leakage)

Thermal Barrier
(Insulation)



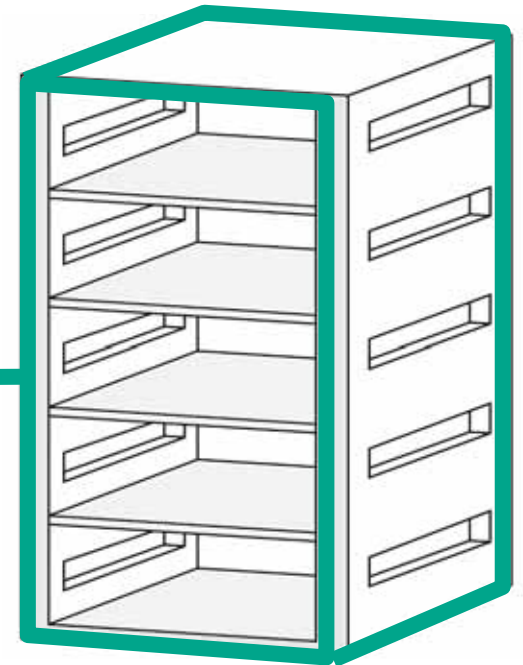
Same As How We Protect Our Bodies from Cold



BUILDING ENVELOPE

Air Barrier

Air Barrier



Air Sealing Materials

Air sealing materials can be simple:

- Caulk or tape at all joints and seams
- Liquid applied membrane at exterior



Air sealing with caulk



Liquid applied air barrier

All Trades Responsible for Integrity of Air Barrier

On projects, take care at exterior walls:

- Screws
- Holes
- Pipe penetrations
- Duct penetrations
- Electrical boxes
- Window installations

AIRTIGHT BUILDING


NO DRILLING
AIRTIGHT
CONSTRUCTION


NO CUTTING
AIRTIGHT
MEMBRANES

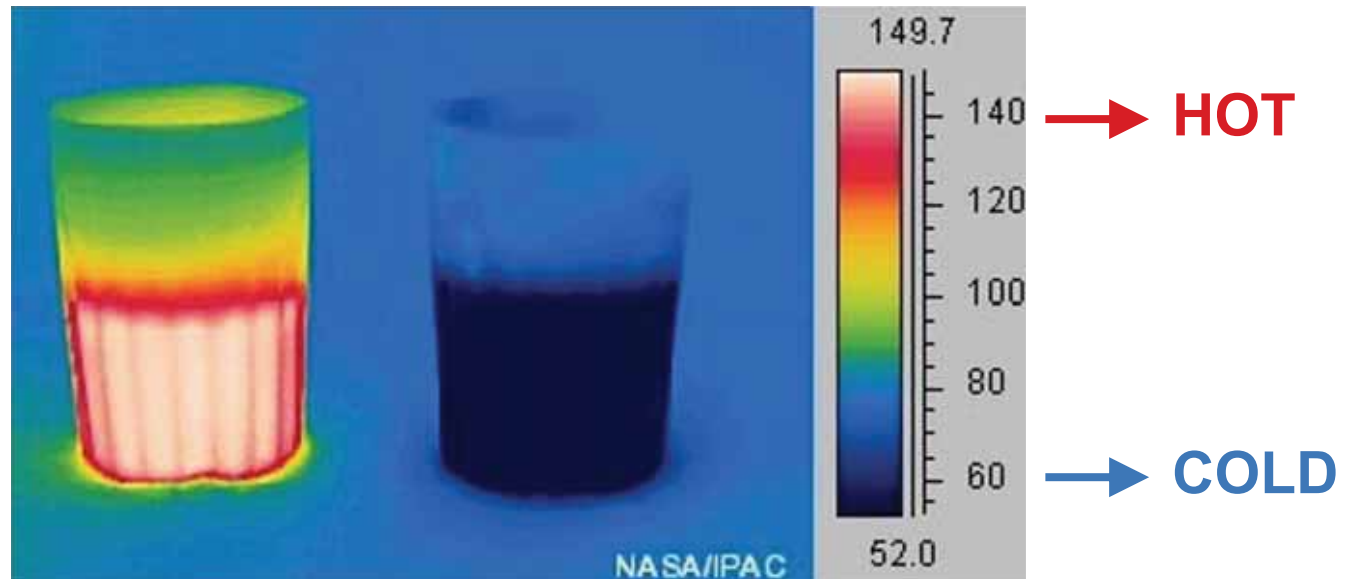
REPORT ALL PENETRATIONS TO SUPERVISOR

The sign features a dark blue header with the text 'AIRTIGHT BUILDING' in white. Below this, a white background contains two red prohibition symbols. The first symbol shows a blue power drill with a red diagonal line through it, with the text 'NO DRILLING AIRTIGHT CONSTRUCTION' below. The second symbol shows a blue utility knife with a red diagonal line through it, with the text 'NO CUTTING AIRTIGHT MEMBRANES' below. A vertical dashed line separates the two symbols. At the bottom, a red banner contains the text 'REPORT ALL PENETRATIONS TO SUPERVISOR' in white.

Many Trades Get Information from Infrared Cameras

Infrared cameras produce **thermal images** to detect temperature

Which cup contains hot water?



Test Before Inspections

Infrared (IR) cameras can capture visual images of common areas of air leakage such as:

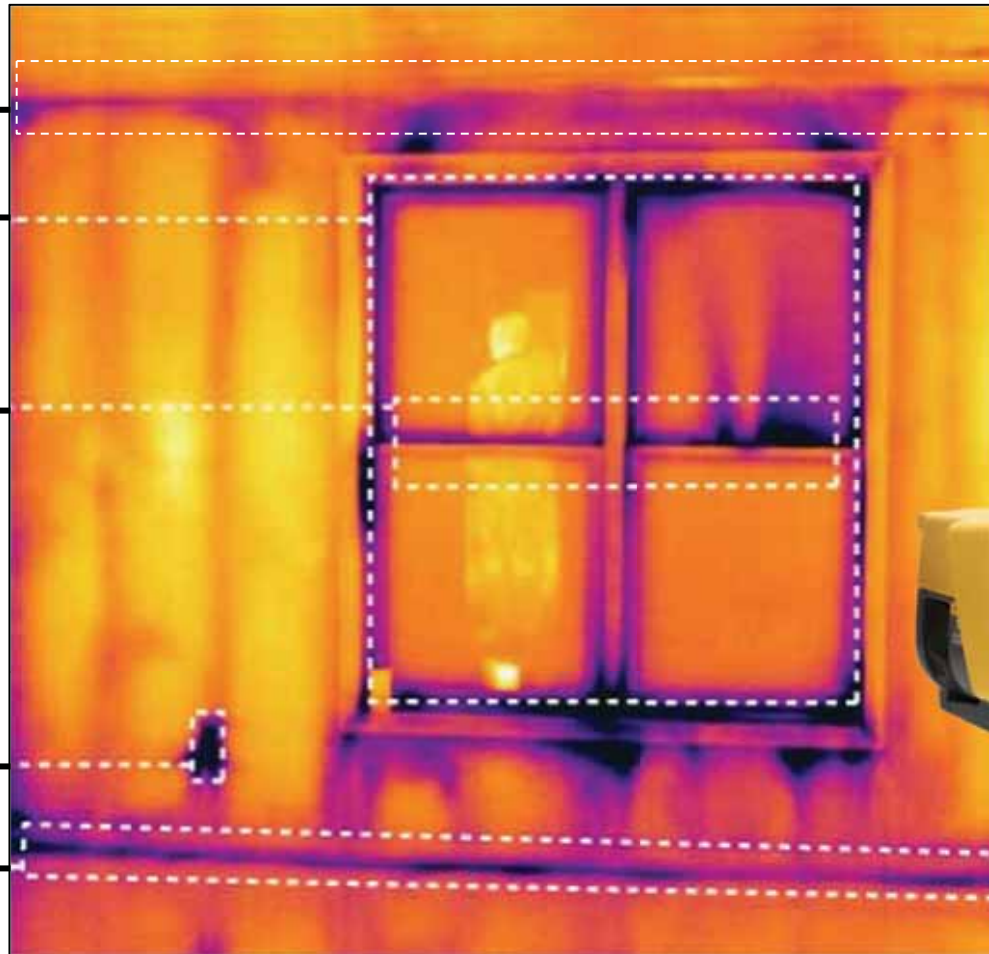
Ceilings

Window frame

Window sash

Electrical outlet

Floors



Blower Door Tests



BUILDING ENVELOPE

Thermal Barrier

Thermal Barrier



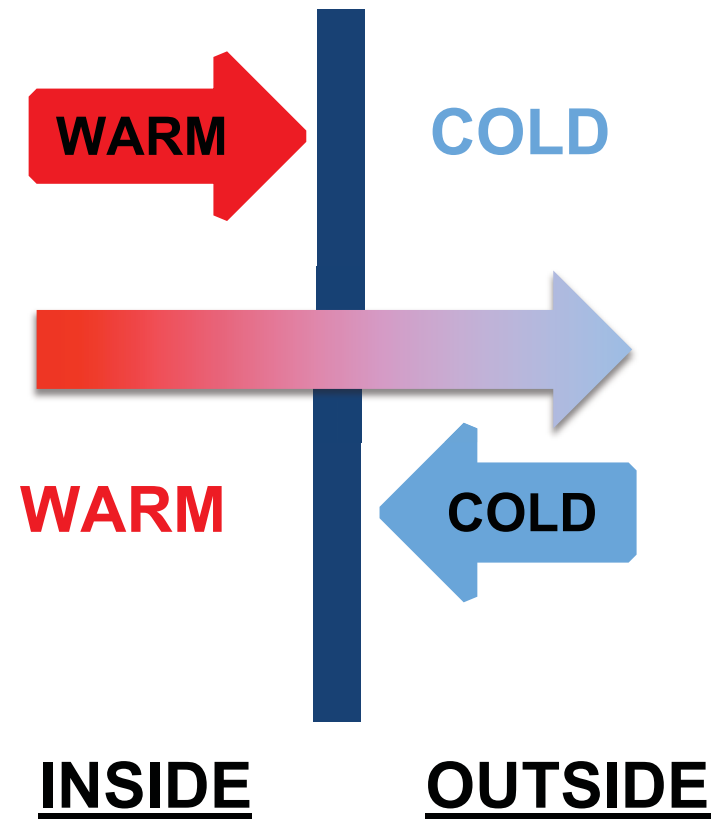
POP QUIZ: HOW DOES HEAT FLOW IN BUILDINGS

In **cold** weather, which way does heat flow through the wall?

Is the warm air trying to get out?

Is the cold air trying to get in?

Why?



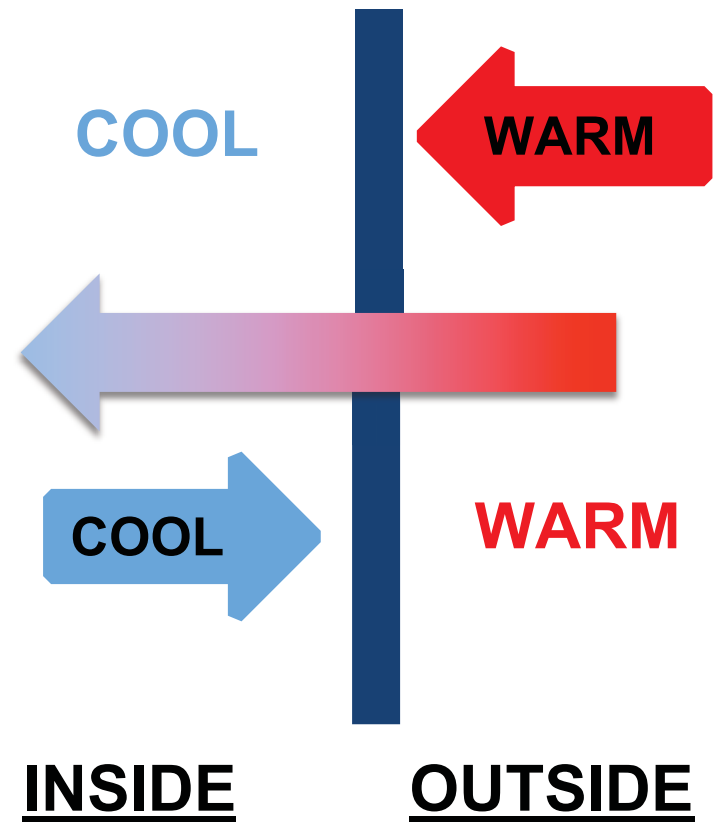
POP QUIZ: HOW DOES HEAT FLOW IN BUILDINGS

How about in **hot** weather?

Is the warm air trying to get in?

Is the cool air trying to get out?

Why?



POP QUIZ:

HOW DOES HEAT FLOW IN BUILDINGS

Heat always moves from a **hotter** to a **colder** object until they reach the same temperature.

You can force heat to flow in the other direction — as with refrigerators or air conditioners — but what do you have to add?

ANSWER: ENERGY

Insulation is a Material that Slows Heat Transfer



Gloves protect your hands from the cold

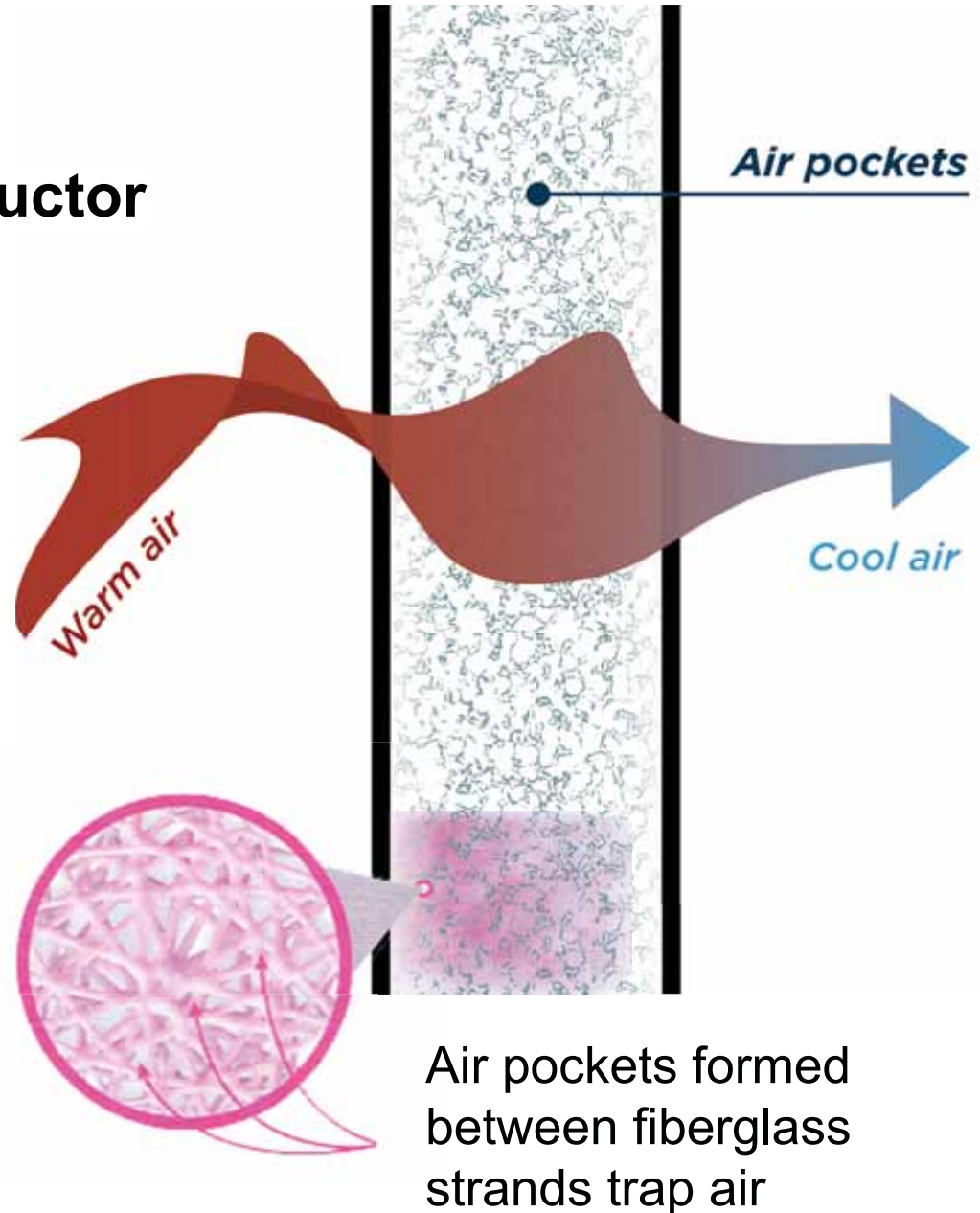


Oven mitts protect your hands from heat

How Insulation Works

Trapped air is a **poor conductor** of heat

Lightweight, bulky materials that trap a lot of small air pockets are good insulators because they can substantially reduce the **rate** of heat transfer



CASE STUDY: U.S. Army Saves Lives and Billions of Dollars Insulating Tents

Issues:

- Difficult to air condition tents in the desert
- Required huge amounts of fuel for air conditioning

Solution:

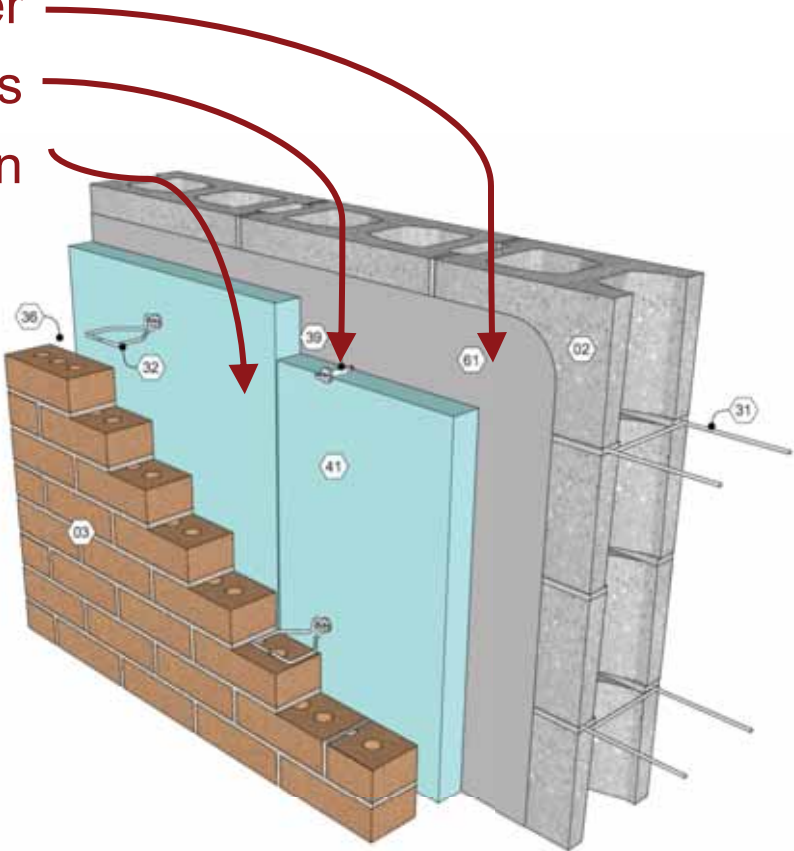
- Insulated structural spray foam on tents dramatically reduced energy use and required many fewer supply convoys



Spray Foam Insulation, Iraq

Trades Learn New Techniques for Continuous Insulation

Air/moisture/vapor barrier
Thermally-broken wall ties
Continuous rigid insulation

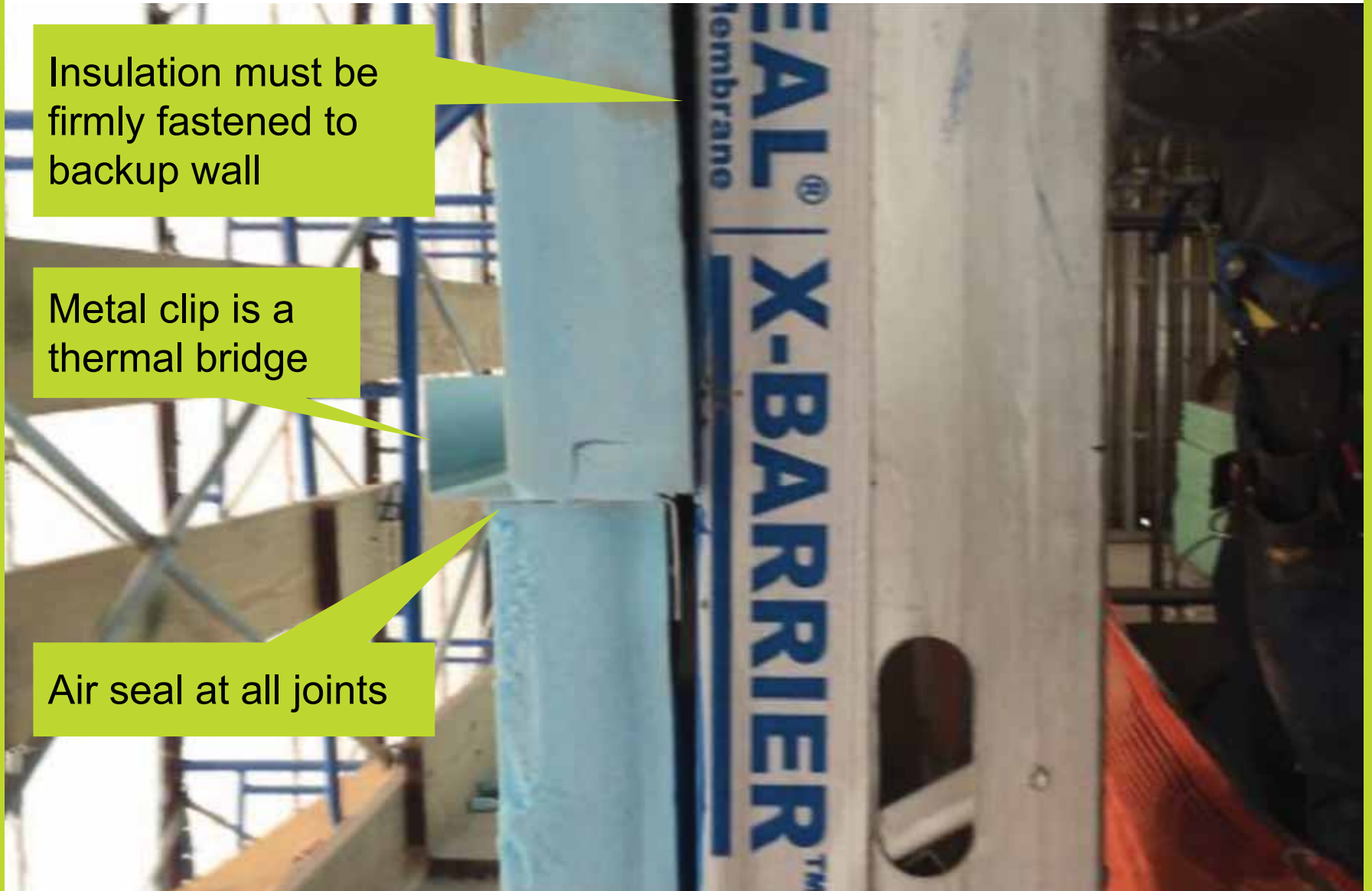


What's Wrong with this Installation?

Insulation must be firmly fastened to backup wall

Metal clip is a thermal bridge

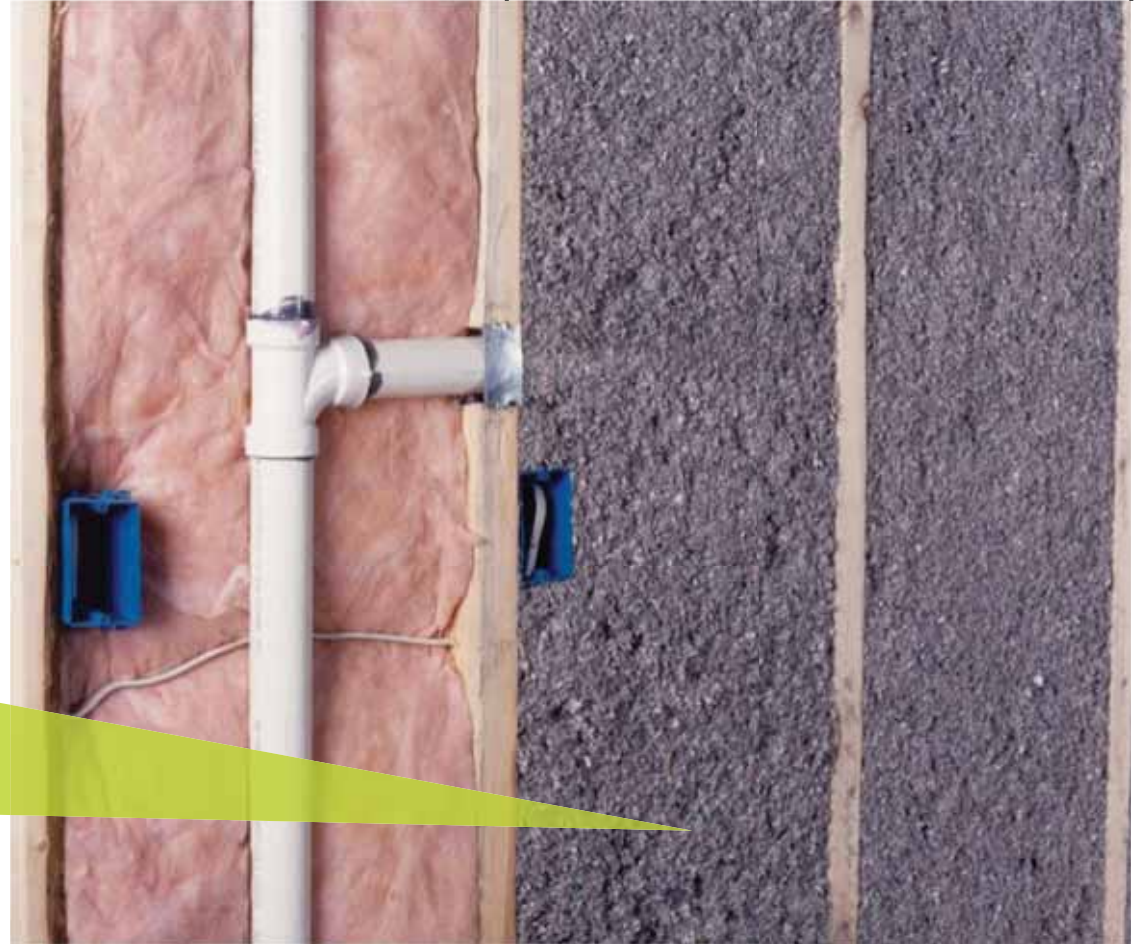
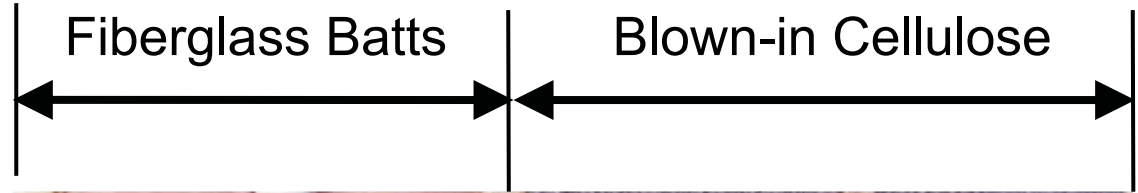
Air seal at all joints



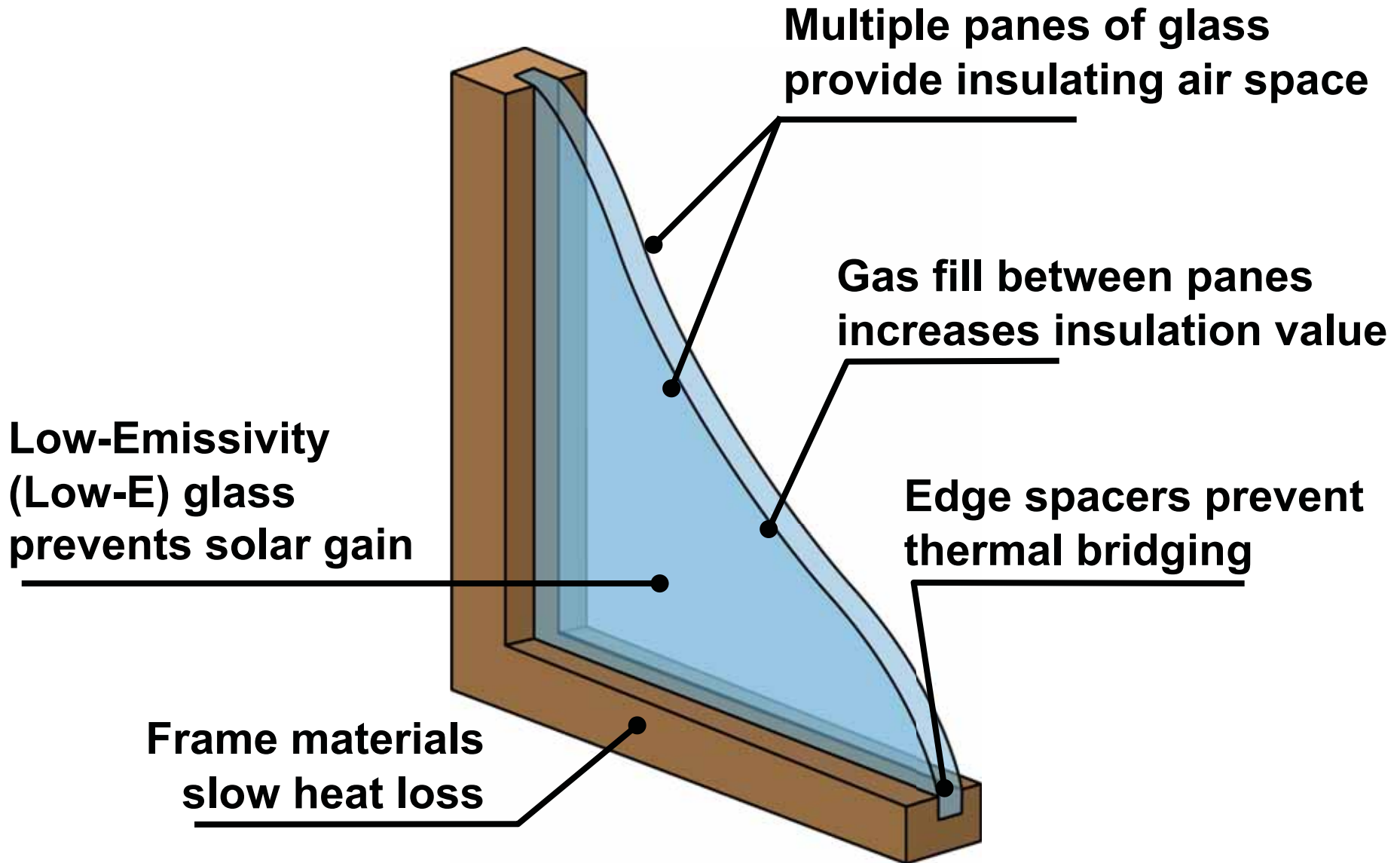
Which of these shows a better installation?

Why?

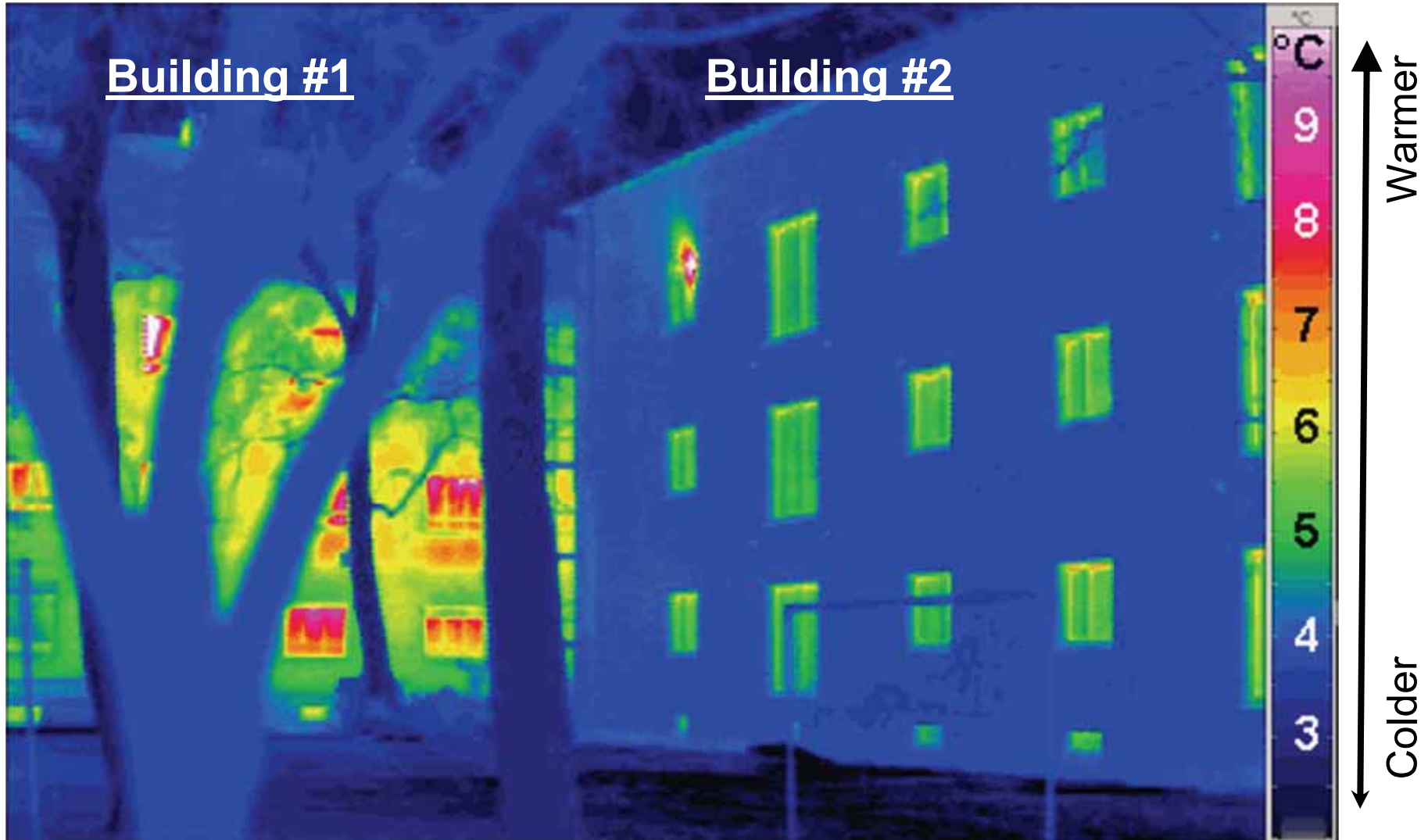
This installation is better because insulation is not compressed at edges or at electrical box



High Performance Windows Transfer Less Heat



Which Building has a Better Building Envelope?



Building 2 is better built.

In cold weather, less heat escapes through the envelope.

Envelope Technology is Changing Quickly



**Tozzer Anthropology Building Cambridge, Massachusetts
LEED Gold 2009**

CASE STUDY: PNC Plaza, Pittsburgh, PA



LEED Platinum
skyscraper

Innovative, high
performing building
envelope

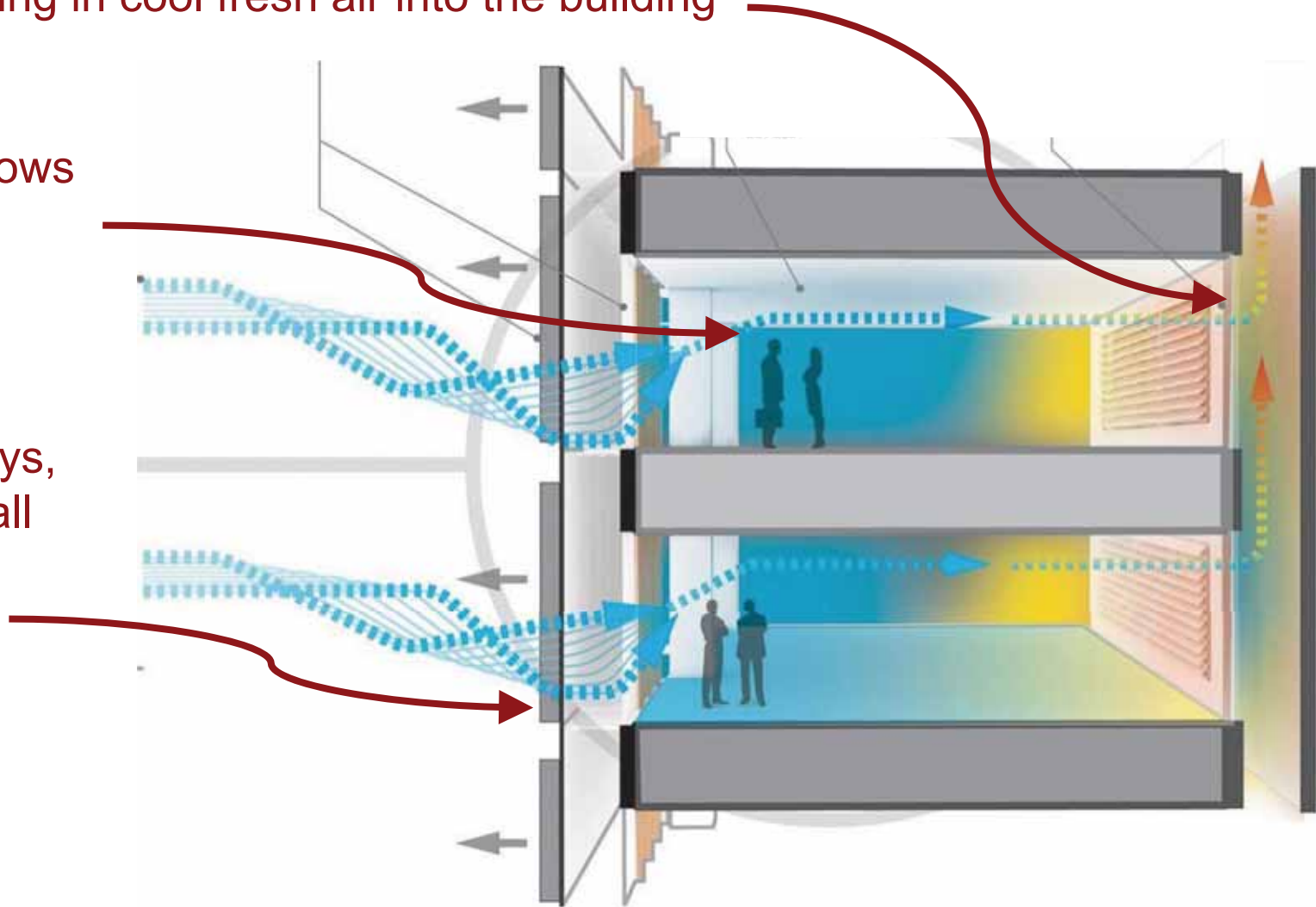
Members of Local 3 Ironworkers during
façade installation

Modern Envelopes Let In Fresh Air: Spring and Fall

3. The warmed stale air is drawn into the chimney, pulling in cool fresh air into the building

1. Fresh air flows through the workspace

2. On mild days, the double wall facade lets in fresh air



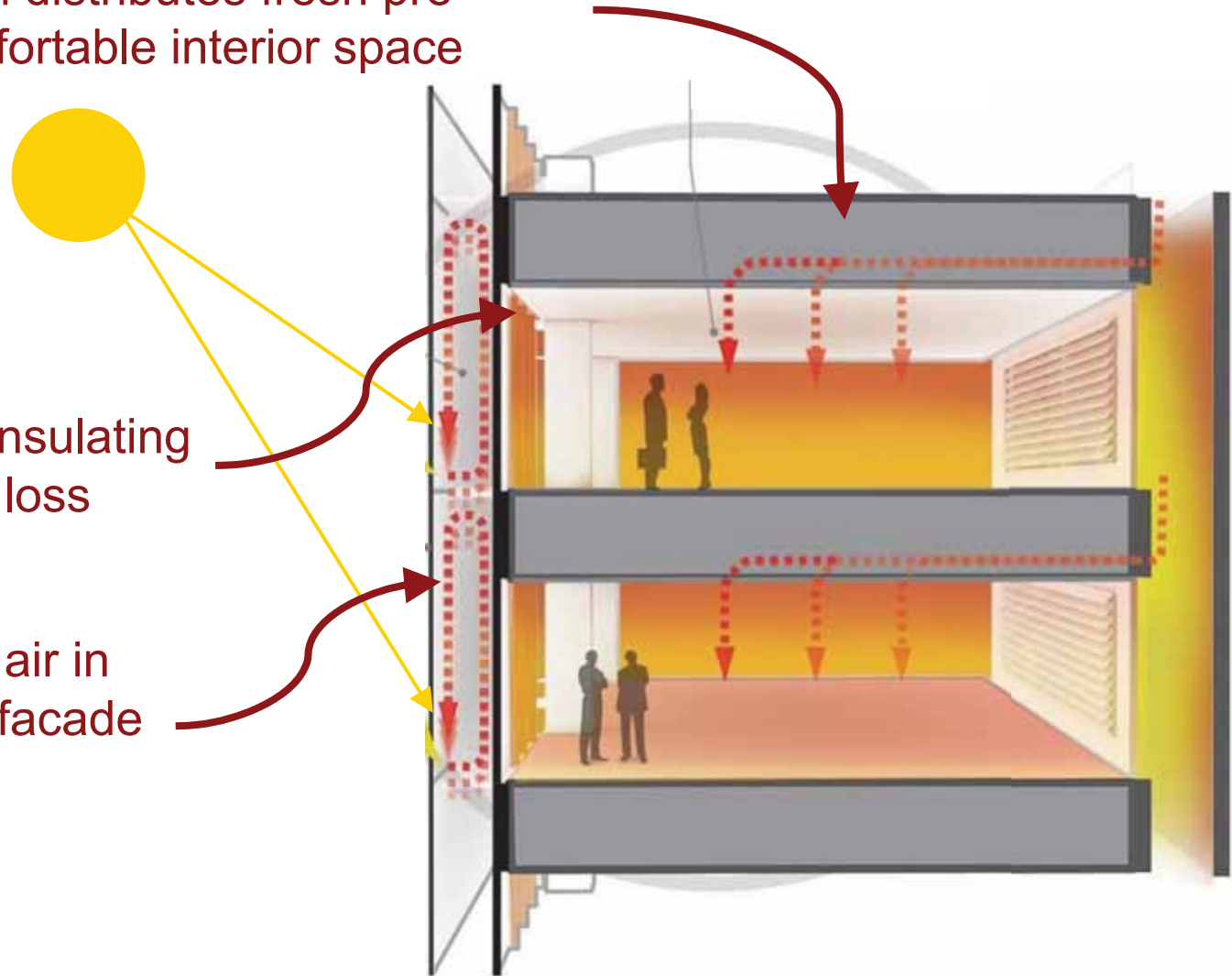
The Tower at PNC Plaza, Pittsburgh, PA

...And Insulates and Pre-Heats Winter Air

3. Ventilation system distributes fresh pre-heated air for a comfortable interior space

2. Warm air creates insulating layer to prevent heat loss

1. Sun heats up cold air in cavity of double wall facade



The Tower at PNC Plaza, Pittsburgh, PA

POP QUIZ:

With a tight, well-sealed building envelope, does the building still need mechanical heating, ventilation and air-conditioning systems?

Why?

Yes.

Mechanical Systems:

- Provide clean, fresh air and remove stale air
- Keep temperature/humidity comfortable and consistent

CHAPTER 8:

RIGHT-SIZED HVAC

Right-Sized and Efficient Mechanical Systems

Air sealed and insulated envelope = smaller heating and cooling loads, leading to lower energy use.



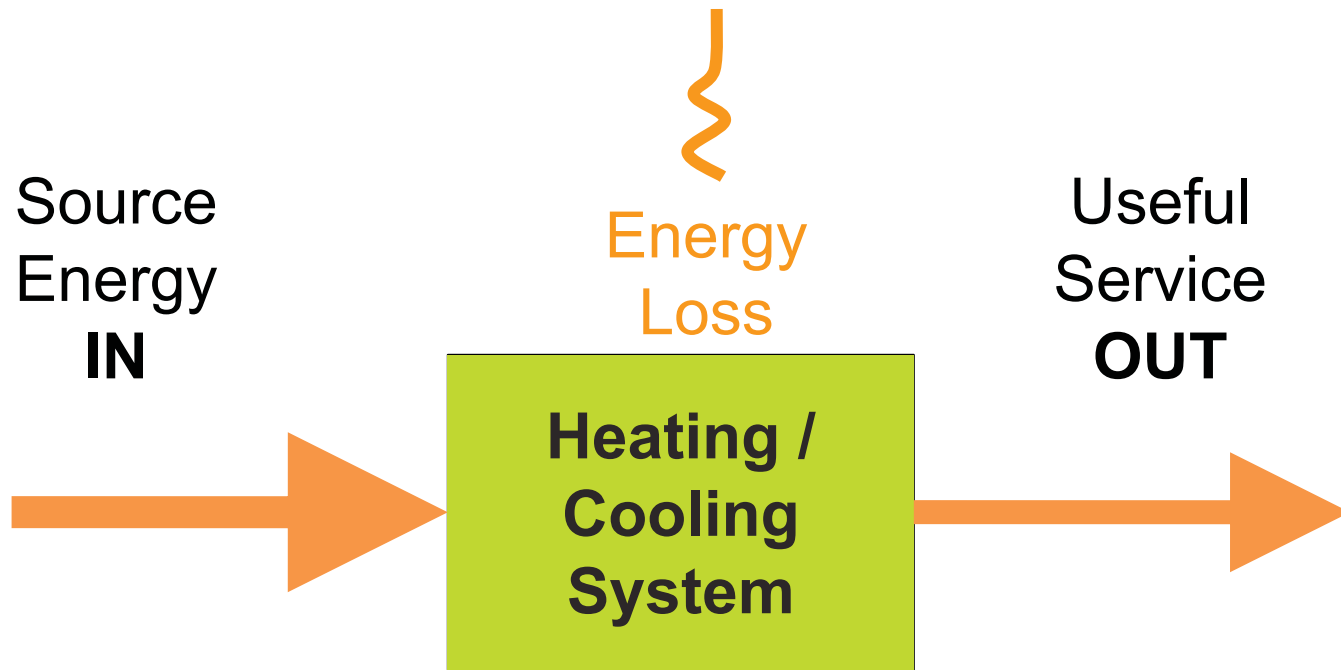
Leaky, poorly insulated envelope = Larger heating & cooling loads



Tighter envelope = Smaller heating & cooling loads

Efficiency Means...

...minimize energy losses to get more “service” out without putting more fuel in



Less in, More out

Seal and Insulate Ducts to Ensure Conditioned Air Delivered Without Wasting Energy

Prevent loss of energy by sealing and insulating entire distribution system



Tightly seal all joints at ducts



Insulate all pipes and ducts

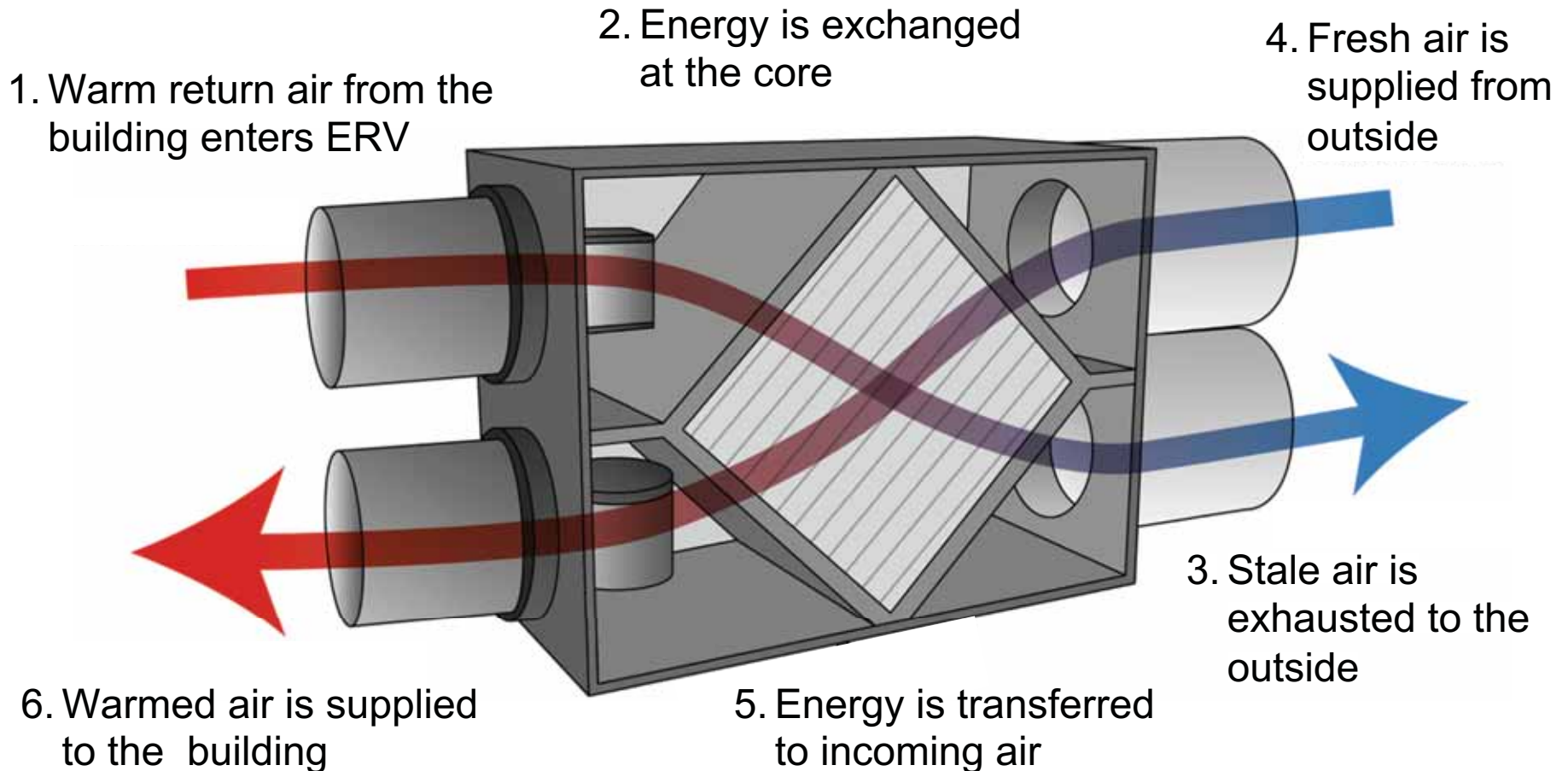
Seal it Tight, Ventilate Right

Ventilation is necessary for a healthy indoor environment. Old buildings bring in dirty air through wall cavities. Tight buildings bring in clean, filtered air through mechanical ventilation.



Where Ventilation and Efficiency Meet

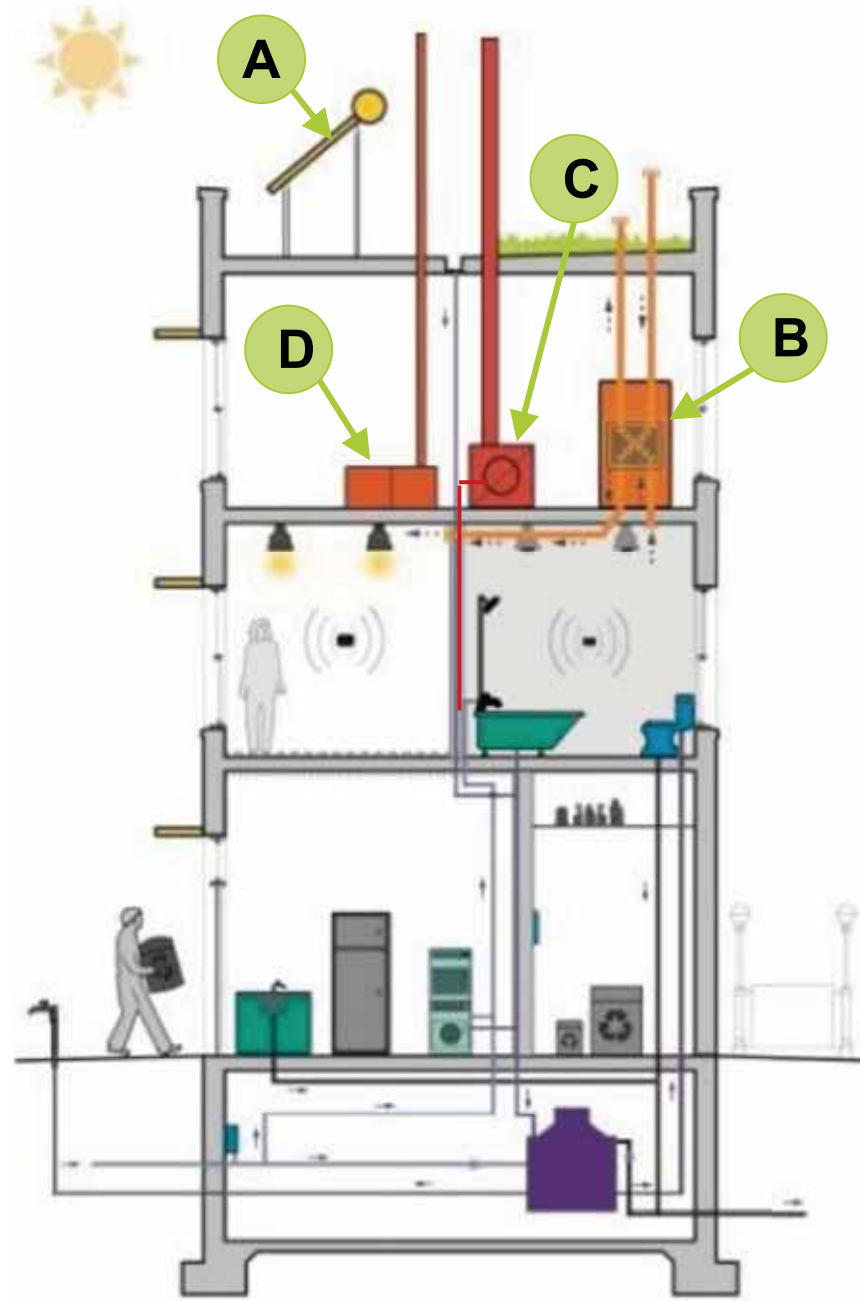
Ventilation can use a lot of energy. Energy Recovery Ventilators (ERV) capture heat from exhaust air to help heat fresh air.



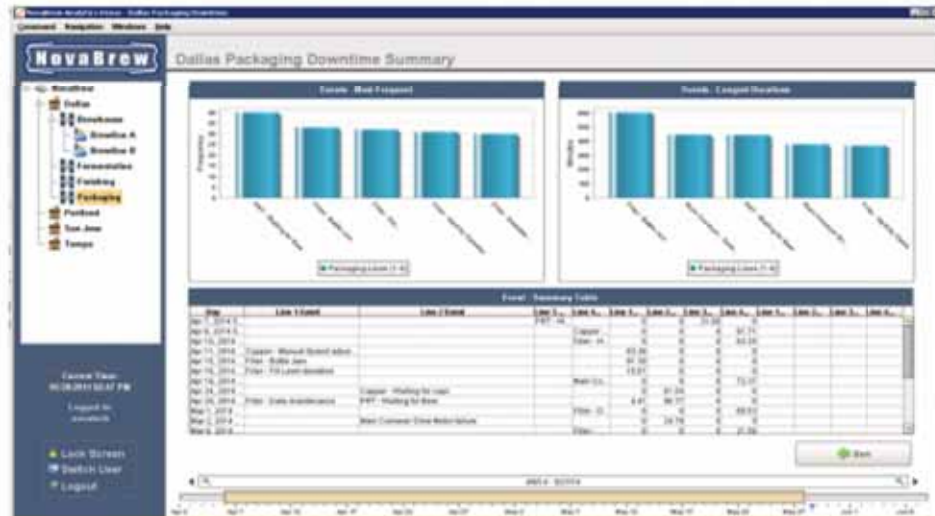
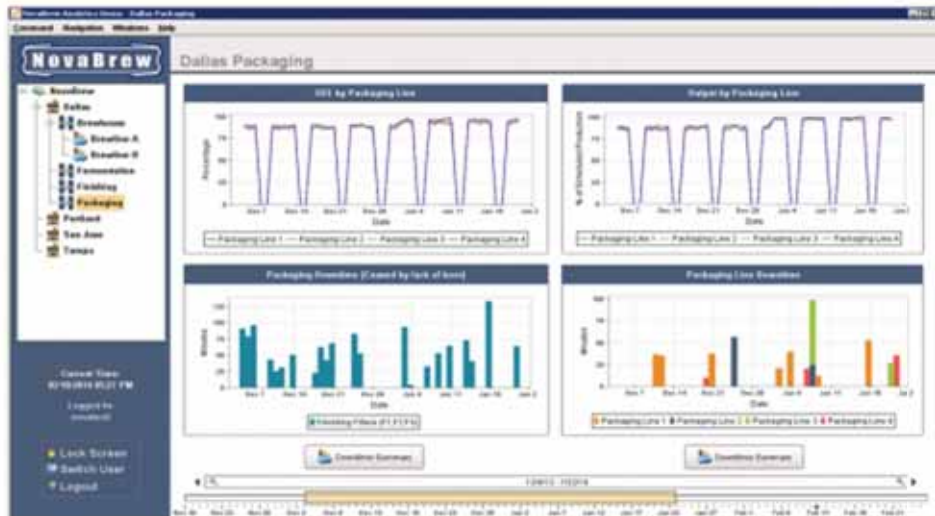
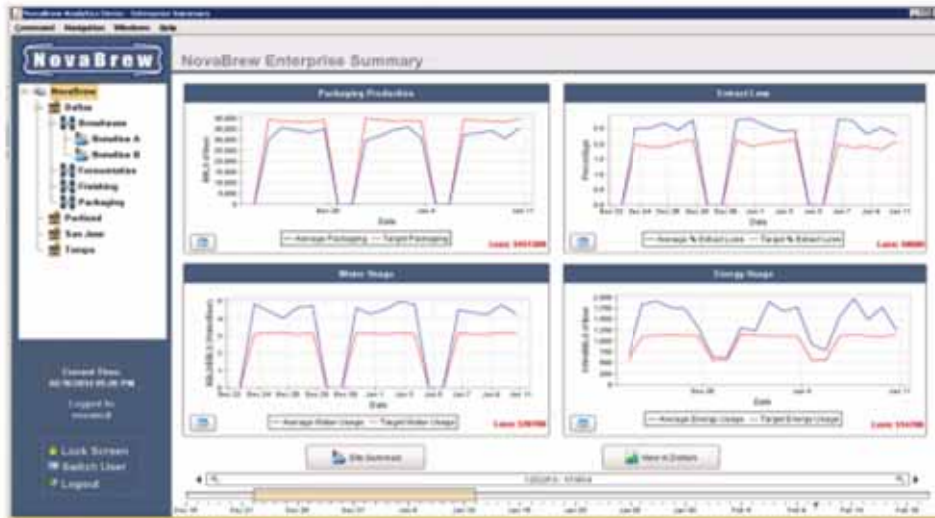
Energy Recovery Ventilators save energy while bringing in fresh air

New Technologies Found in High Performance Buildings

- Solar thermal system (A)
- Energy recovery ventilation (B)
- High performance boilers and furnaces (C)
- Cogeneration system (D)
- Heat pumps
- Variable speed drives on fans and pumps



New Innovations in Smart Buildings



BMS (Building Management Systems) and EMS (Energy Management Systems) along with automatic temperature controls help operators meet occupant needs while saving energy.

CHAPTER 9:

WATER CONSERVATION

POP QUIZ:

Water/Energy Waste

How does conserving water also conserve energy?

- Using less hot water means conserving energy used to heat it
- Using less water means conserving energy used for moving water around
- Less wastewater means less energy to treat it

Low-Flow Fixtures are Law and Conserve Water and Energy

Low flow showerheads and on-demand heaters waste less water



Certified fixtures & appliances use 20% less water

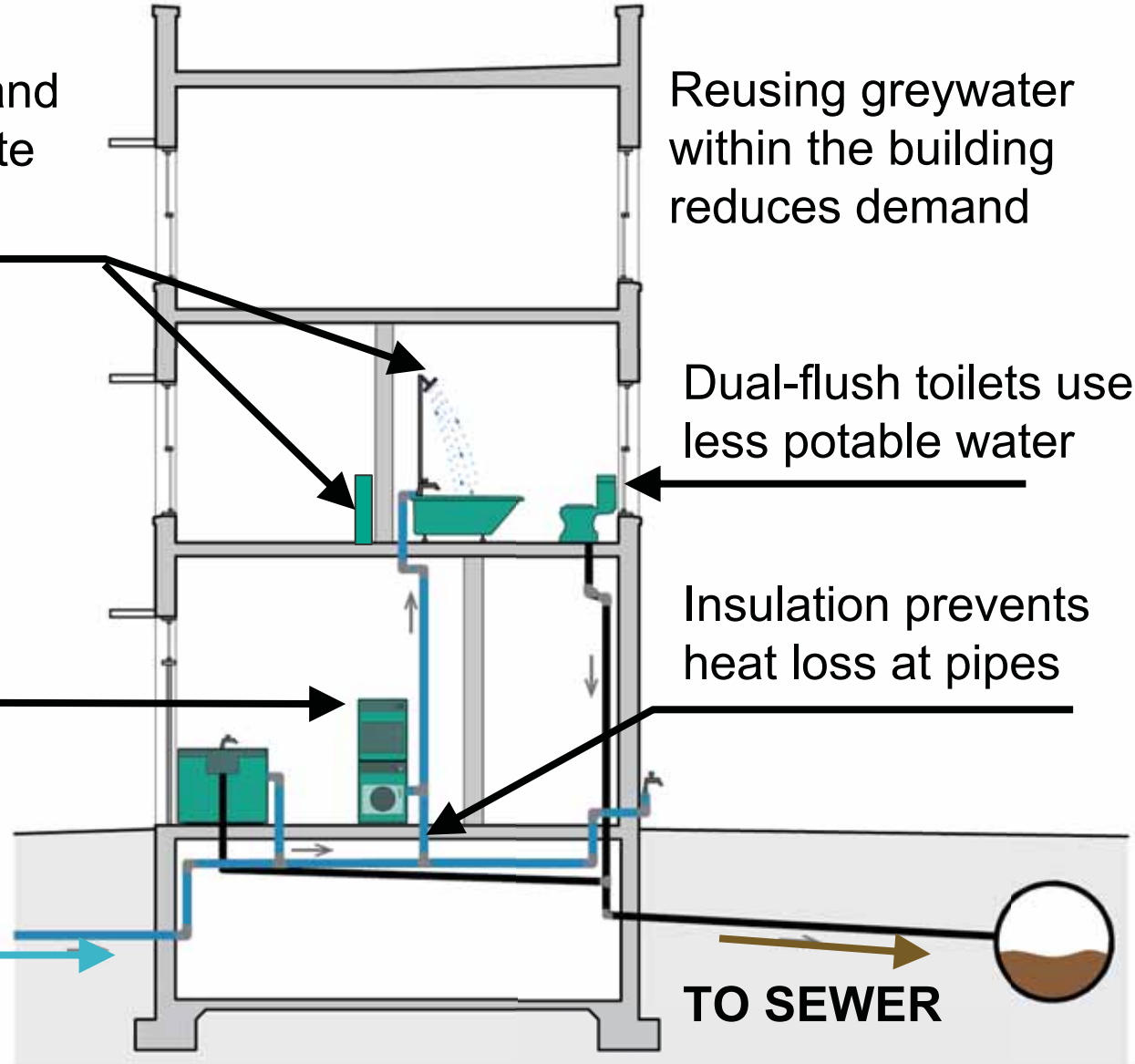
Reusing greywater within the building reduces demand

Dual-flush toilets use less potable water

Insulation prevents heat loss at pipes

POTABLE WATER IN

TO SEWER



Water Reuse & Alternative Wastewater Systems

Areas of opportunity for green plumbers:

Harvested Water: Captures and reuses rainwater for non-potable uses such as toilet flushing and irrigation

Alternative water sources:
Treats greywater and blackwater and converts used water from a nuisance to a re-usable benefit



Use Renewable Energy to Heat Water

Solar thermal energy systems harvest solar energy to heat domestic water.



Flat-plate solar collectors

Reduce Water Use on Construction Sites

- Clean tools with buckets of water
- When cleaning, use brooms, squeegees, vacuums first. If water is necessary, use water brooms or trigger guns attached to hoses



Avoid using water to clean sites

O&M Strategies To Conserve Water

- Monitor water usage to detect changes in water use
- Fix leaks immediately and survey previous fixture leakage periodically. An unaddressed leak can be a significant and expensive waste of water
- Don't wash sidewalks with potable water
- Insulate all hot and cold plumbing pipes



CASE STUDY: 1 World Trade Center

Portable composting toilets used during construction:

- Used almost no water
- Smelled better
- Easier for workers to use and maintain
- Easier to move on-site



One World Trade Center, NYC

CHAPTER 10:
EFFICIENT LIGHTING
AND ELECTRICAL
SYSTEMS

Lighting Energy Depends On Two Factors

POWER
(kW)



X

TIME
(hours)



= Energy Consumption (kWh)

Question: What are two ways reduce lighting energy?

Lighting Energy Depends On Two Factors

POWER
(kW)



X

TIME
(hours)



= Energy Consumption (kWh)

Reduce lighting power by
using more efficient bulbs

Reduce the amount of time
that lights are on with
controls and sensors

Lightbulbs Much More Efficient Now than 10 Years Ago

Assume 800 lumens:



Incandescent: 60W



CFL: 13-18W



LED: 7-10W

Lighting Controls & Sensors

- Lights should be on only when needed
- Take advantage of daylight

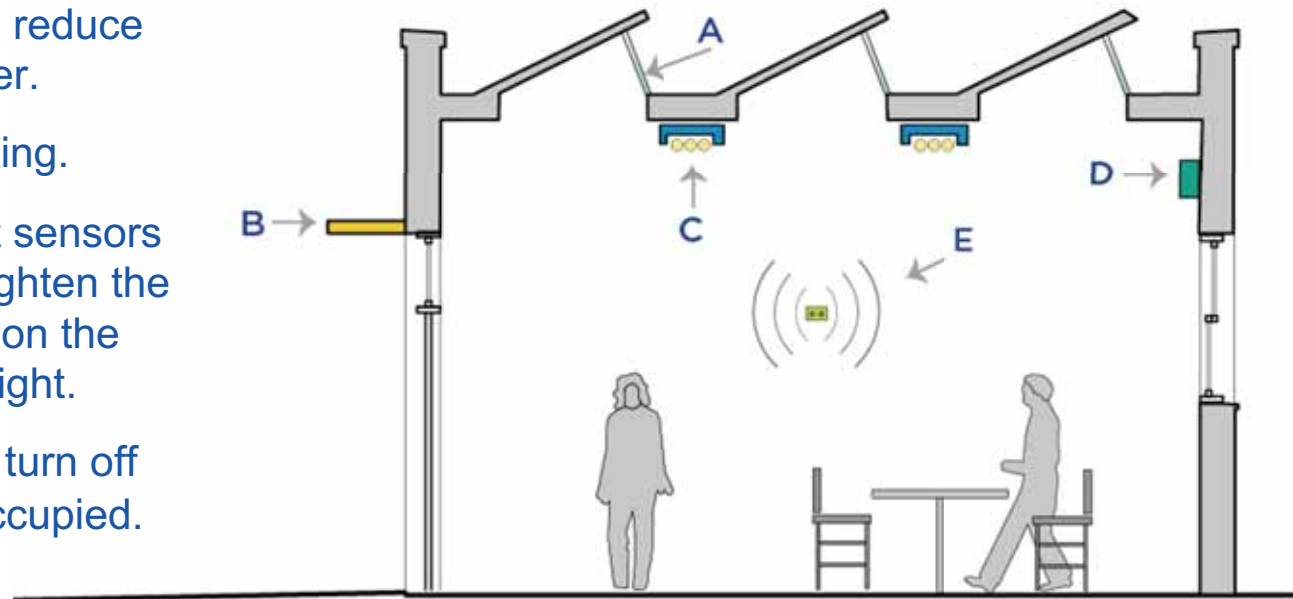


Efficient Lighting Design Saves Energy and Money

Daylighting (sensors that turn off lighting when sufficient daylight is available) is now required in many energy codes.



- A. Skylights provide Northern, indirect daylighting.
- B. Exterior shading devices reduce solar heat gain in summer.
- C. High-efficiency LED lighting.
- D. Daylight-responsive light sensors and controls dim and brighten the interior lights depending on the amount of available sunlight.
- E. Vacancy sensors dim or turn off lights when room is unoccupied.



POP QUIZ: Can we build a building that uses zero energy?

So far we discussed ways to reduce building energy...

1. Tightly sealed and insulated envelope
2. Efficient heating and cooling systems
3. Water-conserving fixtures and heating systems
4. Energy saving lighting systems with sensors and controls

We probably can't reduce energy consumption to zero but...

We can generate energy on site for **Net Zero Energy**

What Is a Net Zero Energy Building (NZE)?



(Start with an energy efficient building)

What Is a Net Zero Energy Building (NZE)?

Add enough renewable energy to offset energy used in building

Solar photovoltaic (PV) system

Solar thermal hot water system



(Net Zero Building)

Generate Energy From Renewable Sources

Energy generated from renewable sources is carbon-free

Building mounted:



Solar photovoltaic panel



Solar thermal collector

Utility scale:



Wind turbines