DOE Challenge Home

- Tech Training Webinar Series

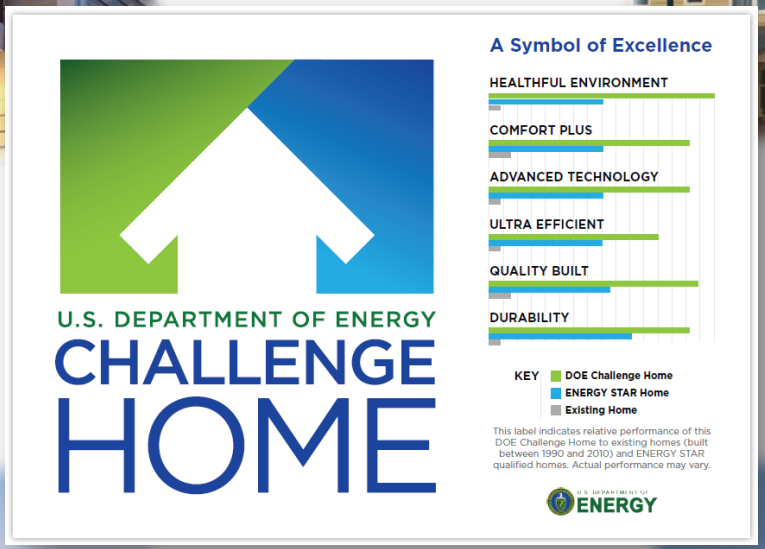
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Comprehensive Building Science

U.S. DEPARTMENT OF ENERGY CHALLENGE HOME

The Home of the Future….Today

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

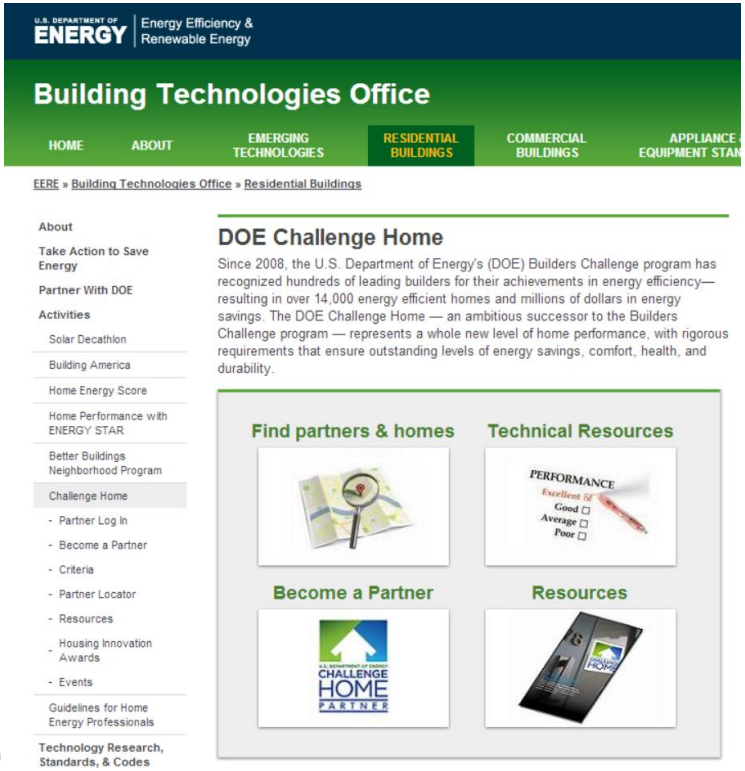


DOE Challenge Home Resources

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Website

- www.buildings.energy.gov/challenge/
- Events:
  - Upcoming in-person ZERH Training
  - Technical Training webinars
  - Conference Presentations
- Partner Locator
- Program Specifications
- Webinar Recordings (coming soon)



Building America Solution Center

- http://basc.pnnl.gov/

Thank You

For More Information:

www.buildings.energy.gov/challenge/

Email:

doechallengehome@newportpartnersllc.com

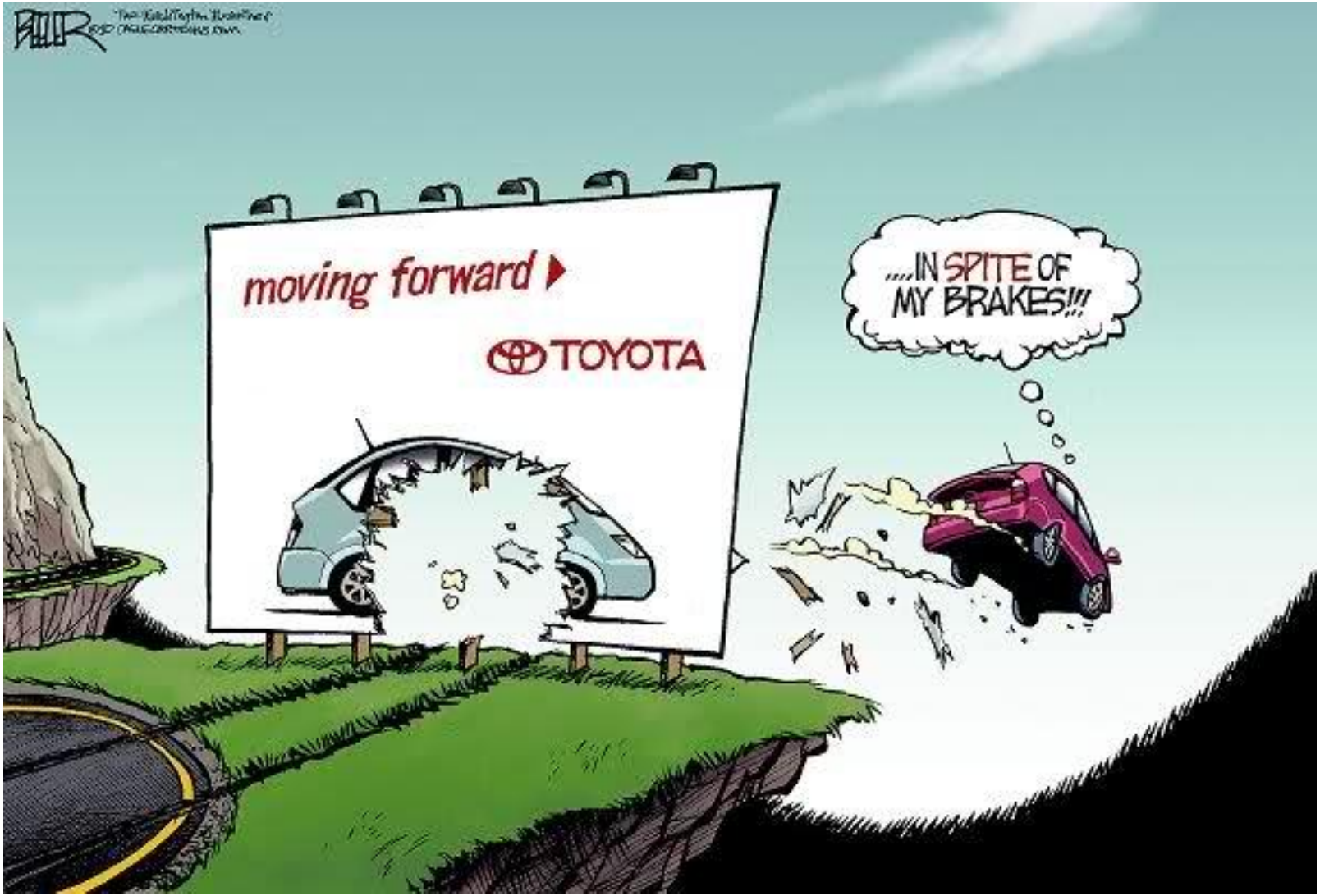
The Building Science Basics Behind ENERGY STAR

March 26, 2014

Dean Gamble

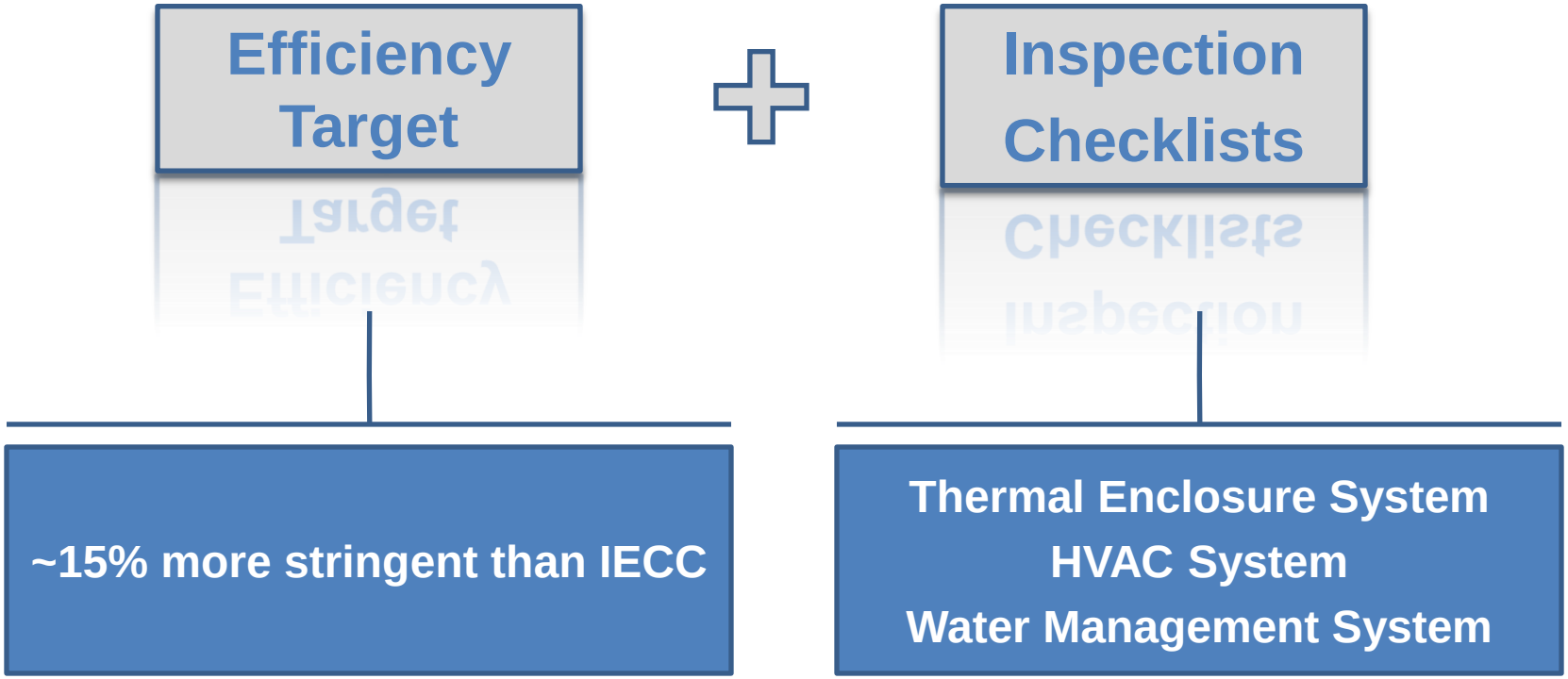
Mix & match…

.. versus systems approach



Key components of ENERGY STAR Certified Homes

- Two key components to program requirements:



Poll question #1

- Which of the following programs do you have experience certifying homes under?
  A. ENERGY STAR v3
  B. Challenge Home
  C. PHIUS+

System 1:
Thermal enclosure system

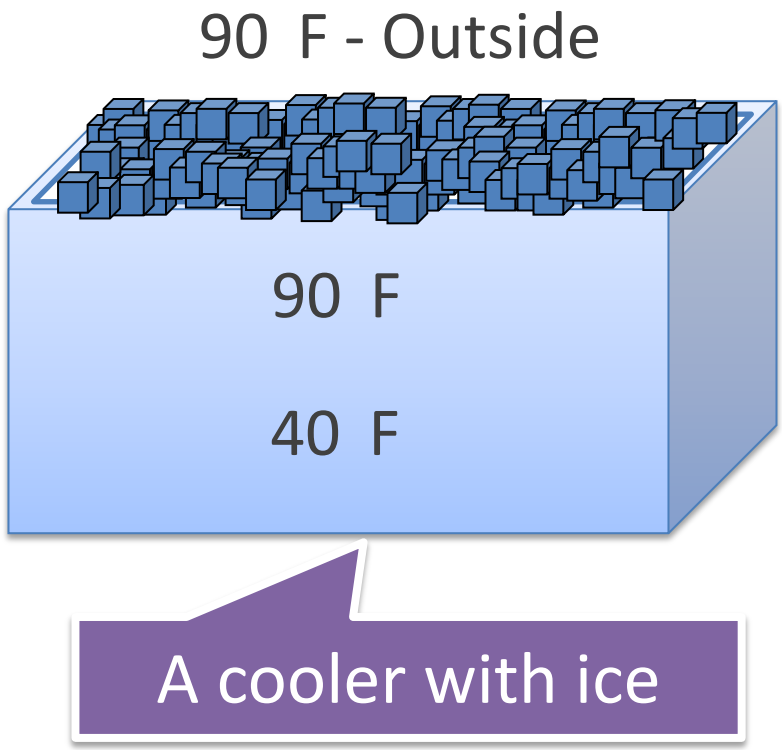
1

Thermal Enclosure System

- A well-insulated and air-sealed home, with good windows and doors, reduces the amount of energy needed to keep the home comfortable.

Thermal enclosure system: Building science concepts

1. Energy moves from more to less.



Thermal enclosure system: Building science concepts

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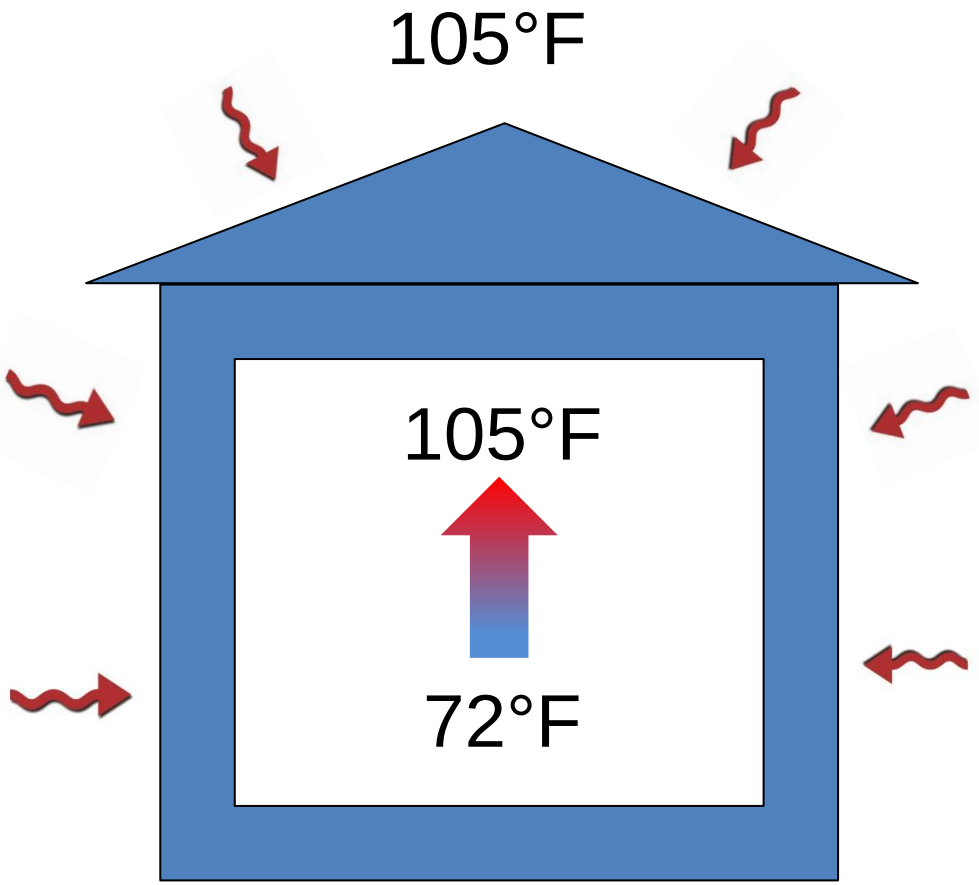
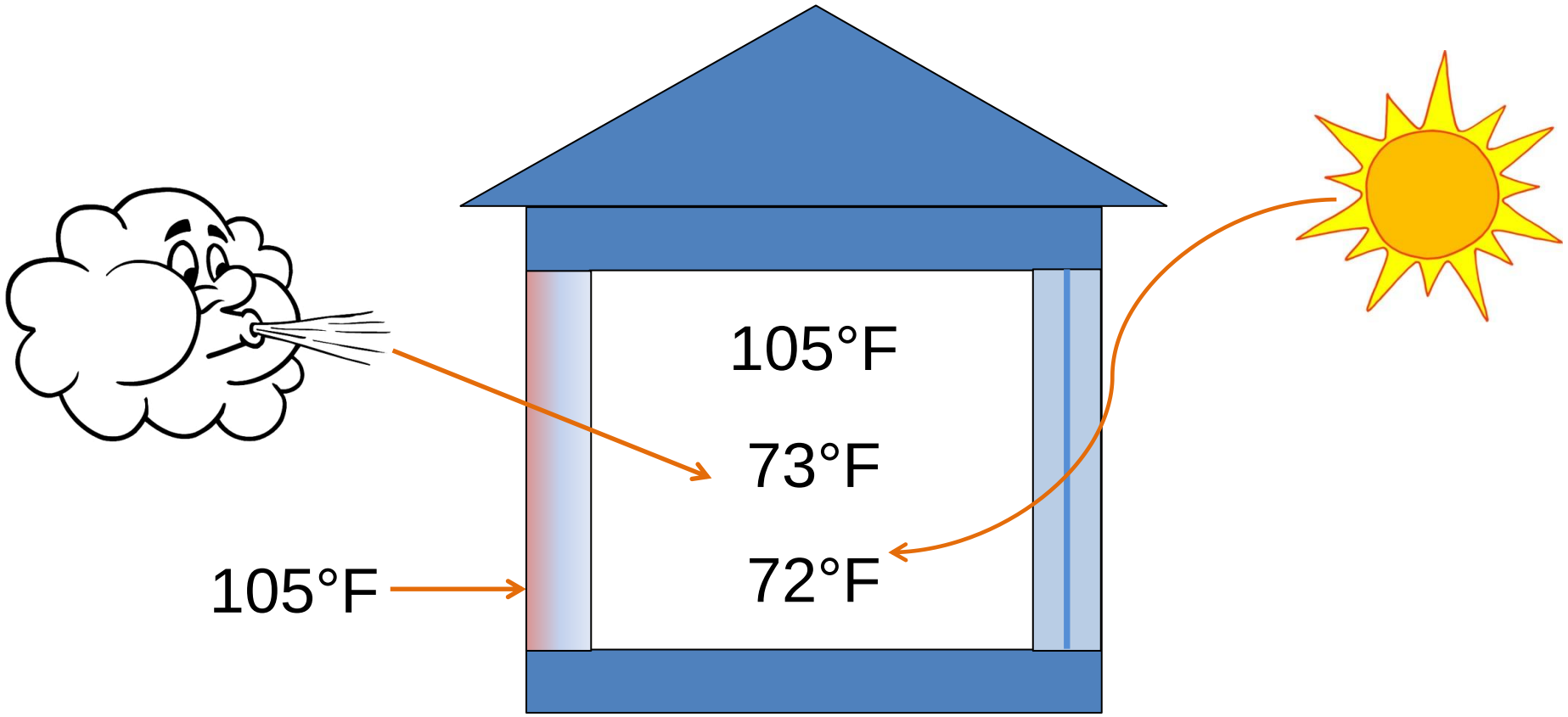


Thermal enclosure system: Building science concepts

- Heat transfer can be quantified in British Thermal Units (Btu's).
- 1 Btu is approximately equal to the energy in a single match.

Thermal enclosure system: Building science concepts

- Heat transfer occurs via conduction, convection, & radiation.



Thermal Enclosure System Rater Checklist

- Section 1: High-performance fenestration.
- Section 2: Quality-installed insulation.
- Section 3: Fully-aligned air barriers.
- Section 4: Reduced thermal bridging.
- Section 5: Air sealing.

System 2: HVAC system

2

Heating, Cooling, & Ventilation System

- Heating and cooling equipment that is:
  - High efficiency
  - Properly designed and installed
  - Combined with a duct system that's insulated, sealed, and balanced

  … maintains comfort with less energy.
- Ventilation systems that remove low-quality air, provide outdoor air, and filter contaminants to improve indoor air quality.

HVAC system:
Building science concepts

Design:

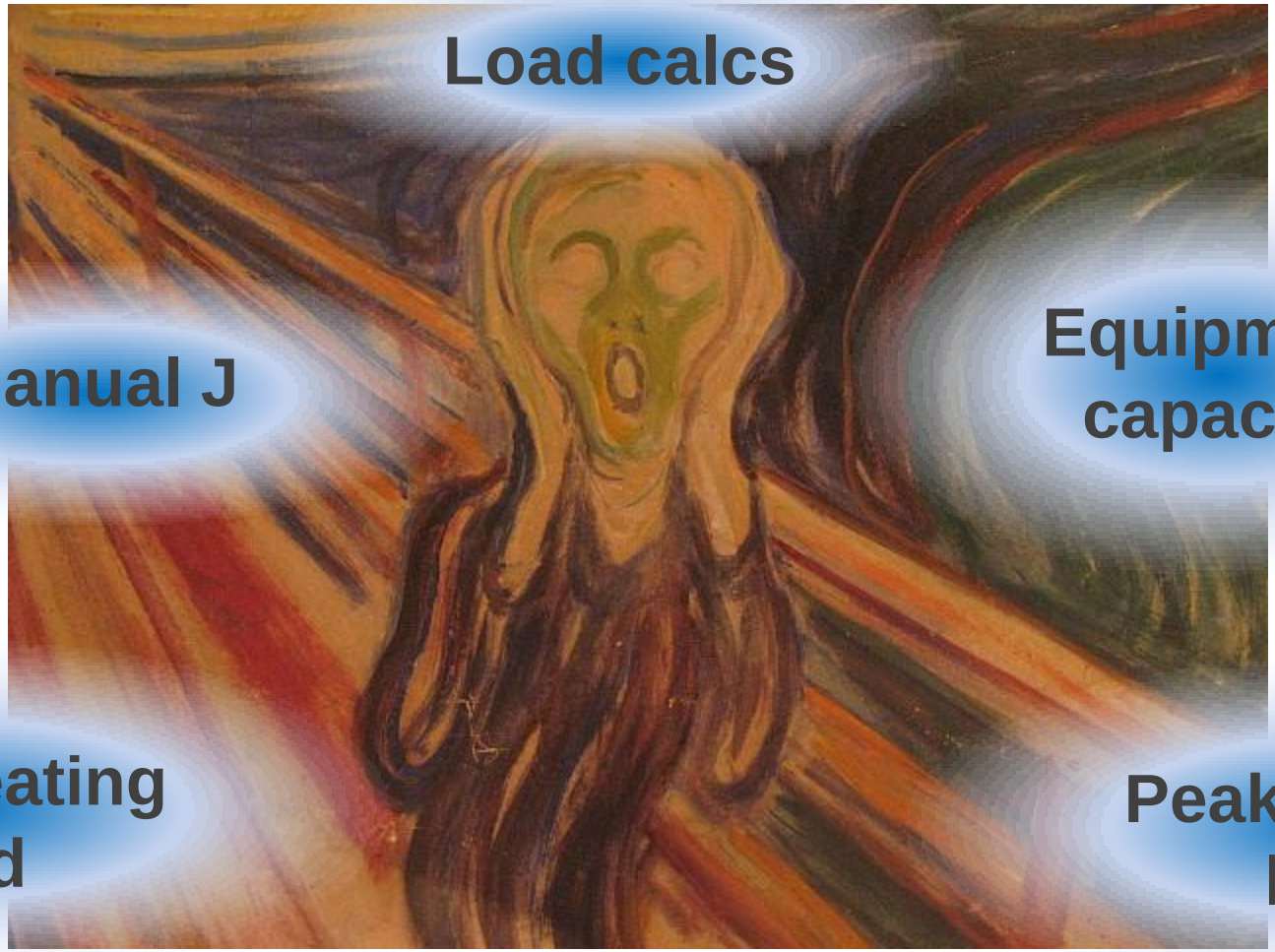
1. Calculate the heating and cooling loads.
2. Select equipment that meets those loads.
3. Design a duct system that gets air from the equipment to the rooms in the house, and back.

Commission:

A. Check airflow at air handler.
B. Check refrigerant charge.
C. Measure airflow at registers.

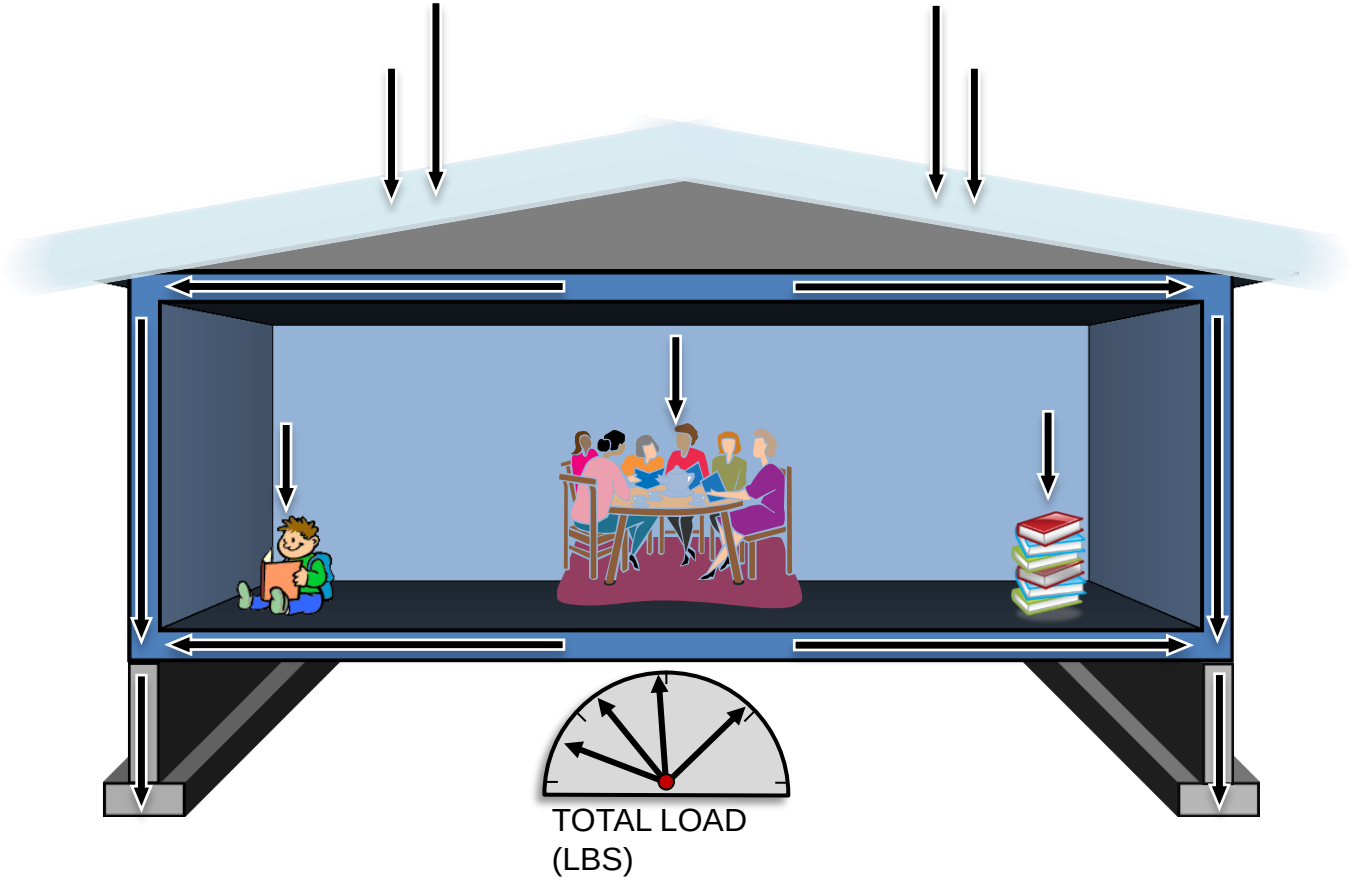
HVAC design step 1:
Calculate heating & cooling loads

HVAC design step 1: Building science concepts



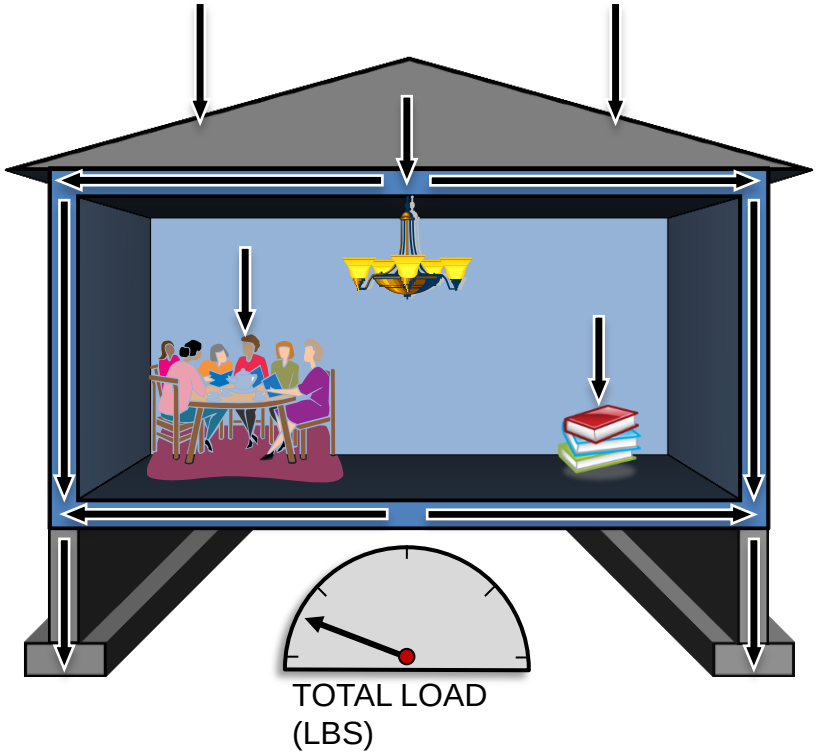
HVAC design step 1: Building science concepts

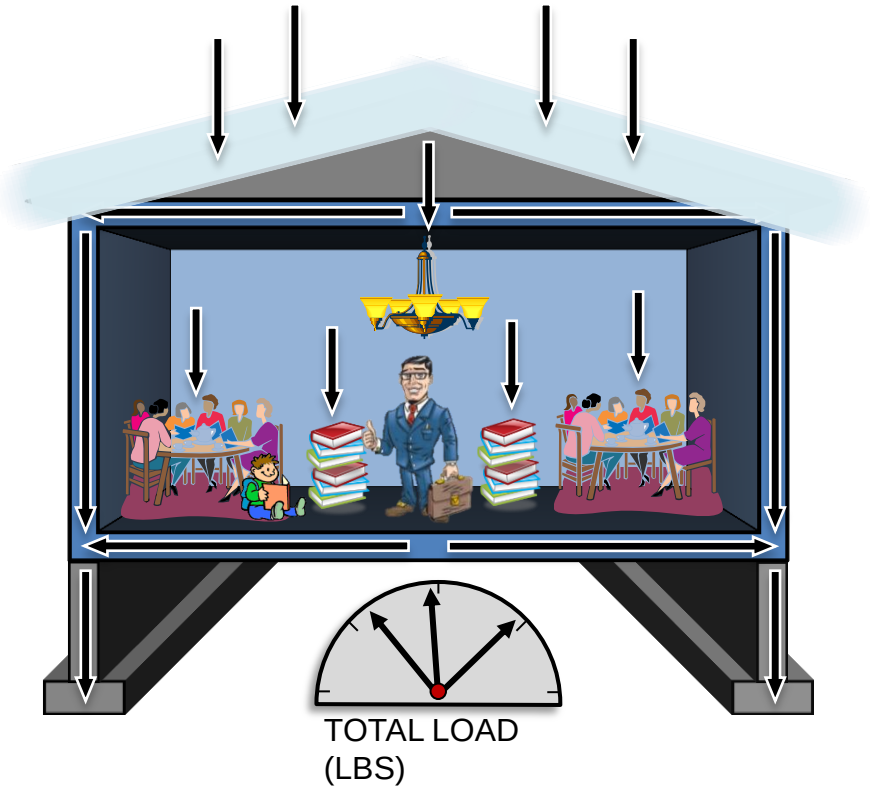
- Structural Load: The weight that must be supported by a foundation at any particular time.



HVAC design step 1: Building science concepts

- Structural Load varies for each hour of the year.
- Structural Peak Load: The maximum weight that must be supported by a foundation.

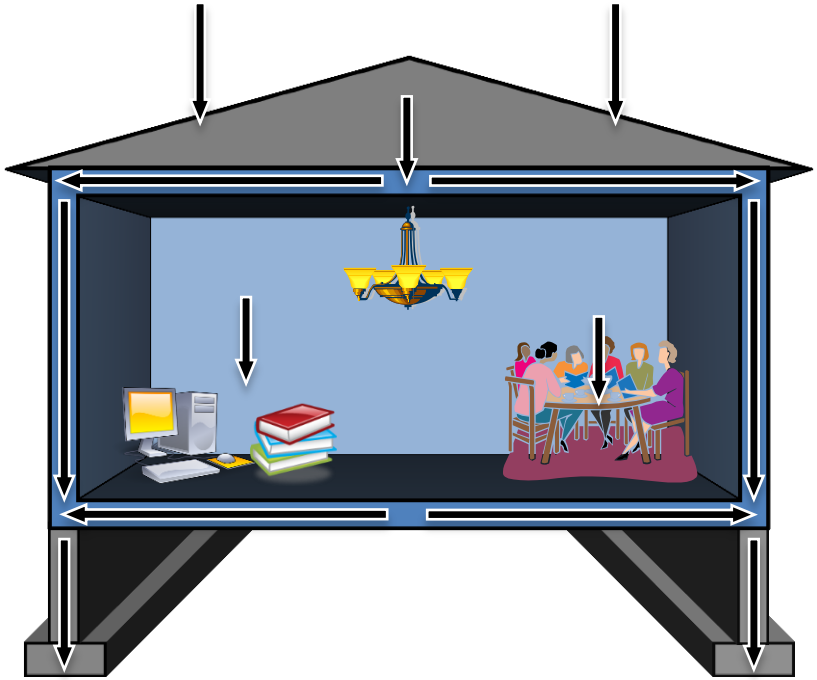


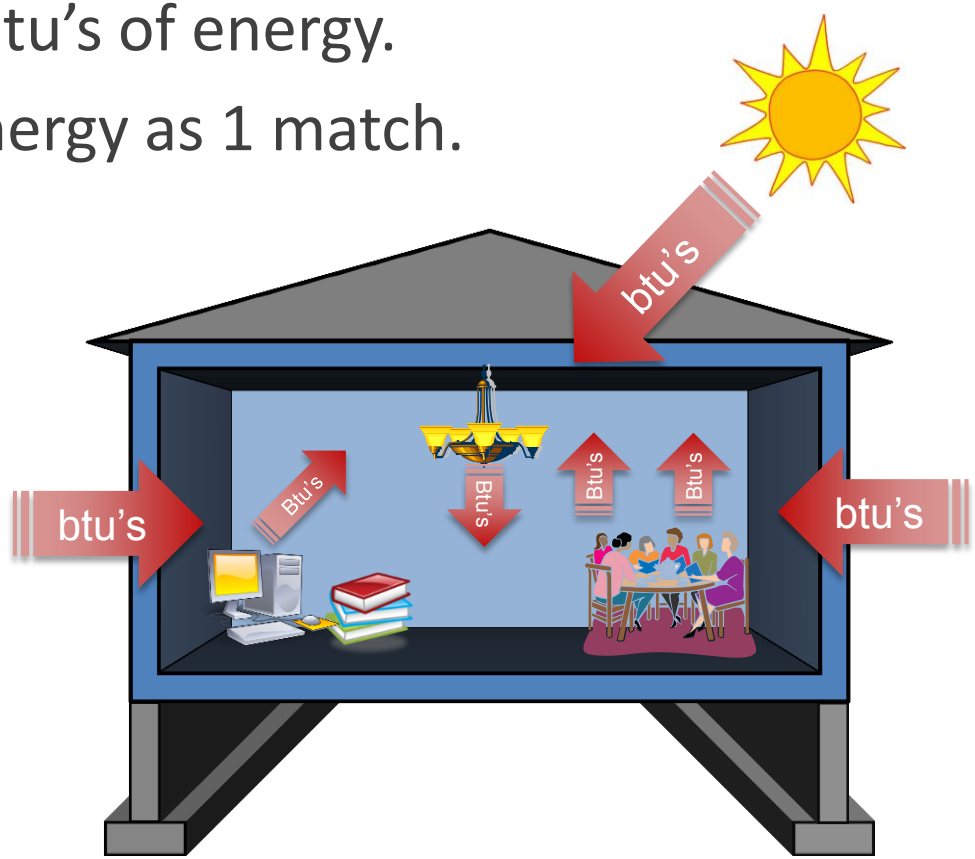


HVAC design step 1: Building science concepts

- Structural load measured in pounds of weight..

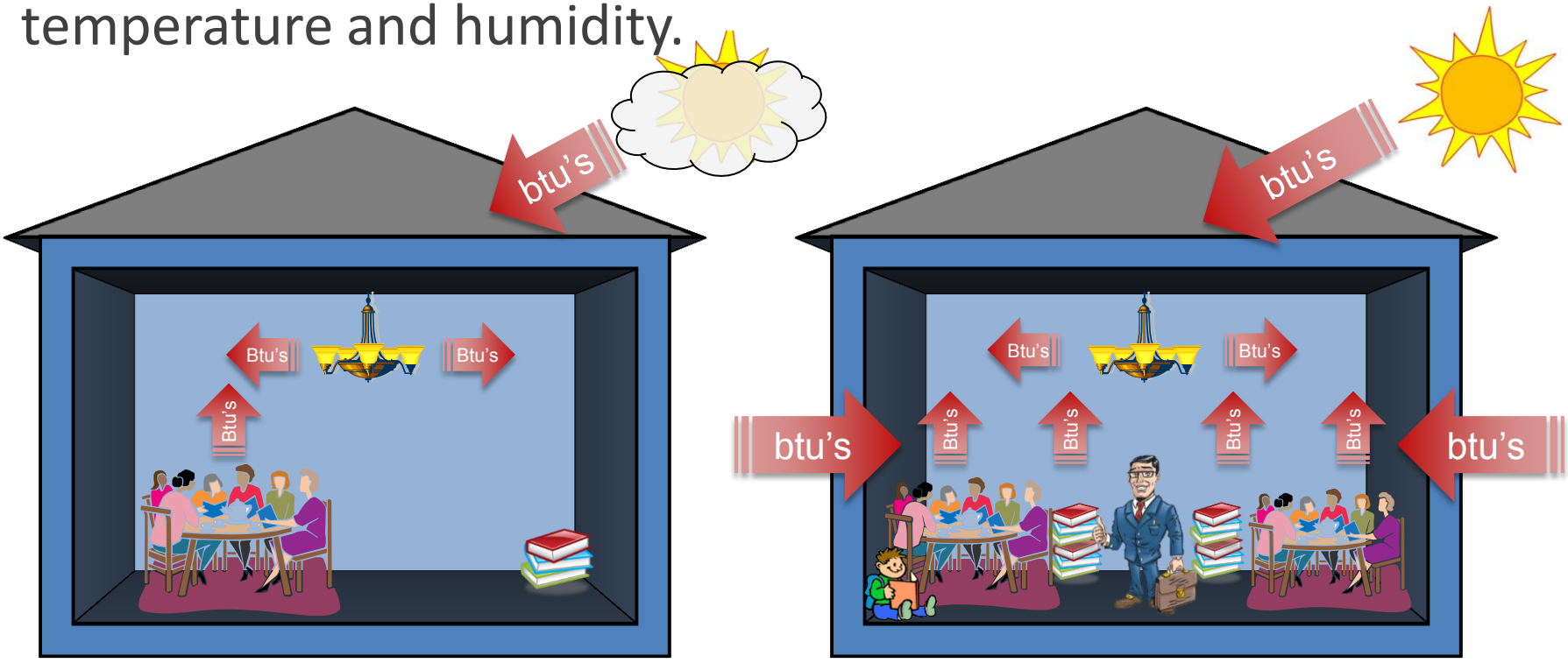
  ..Cooling load measured in btu's of energy.
- 1 btu has about the same energy as 1 match.





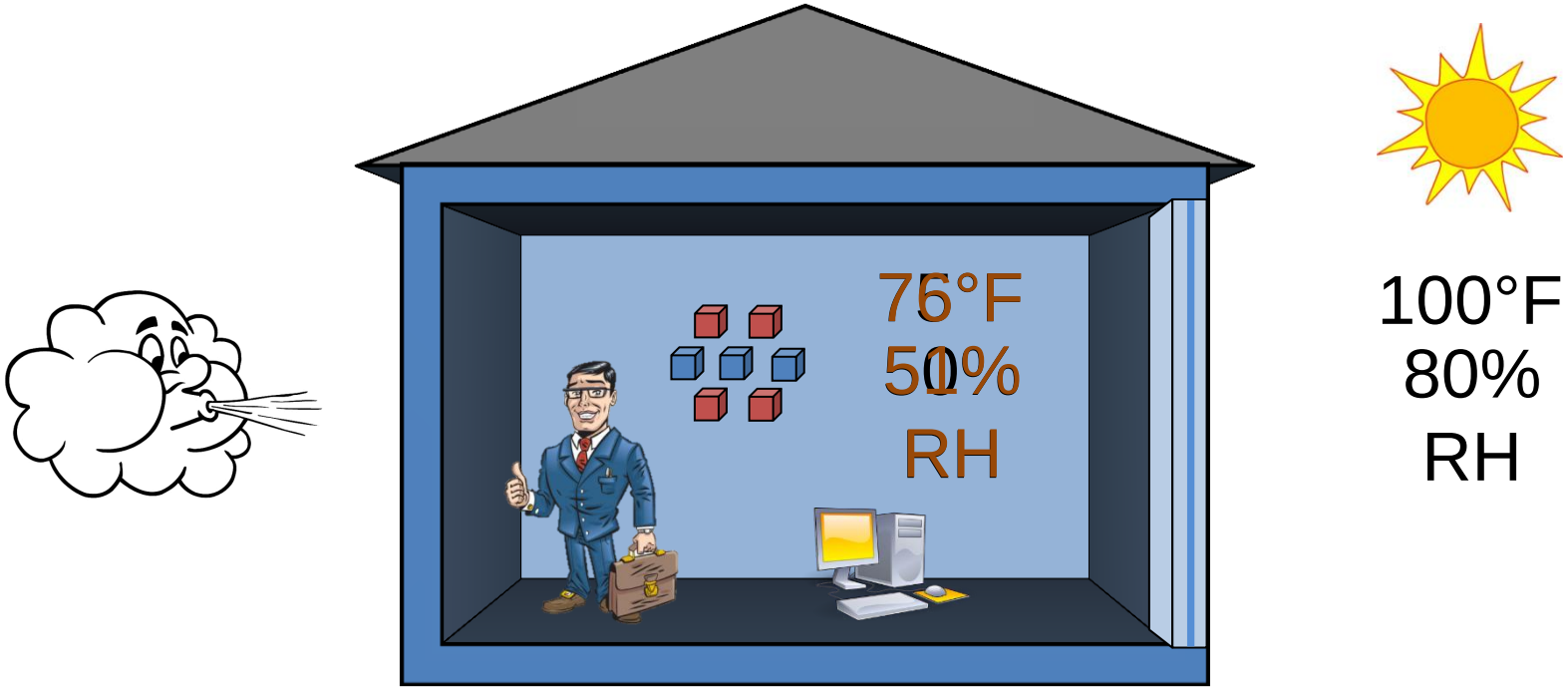
HVAC design step 1: Building science concepts

- Cooling Load varies for each hour of the year.
- Cooling Peak Load: The maximum energy that's added to the home in a single hour, and must be removed to maintain temperature and humidity.



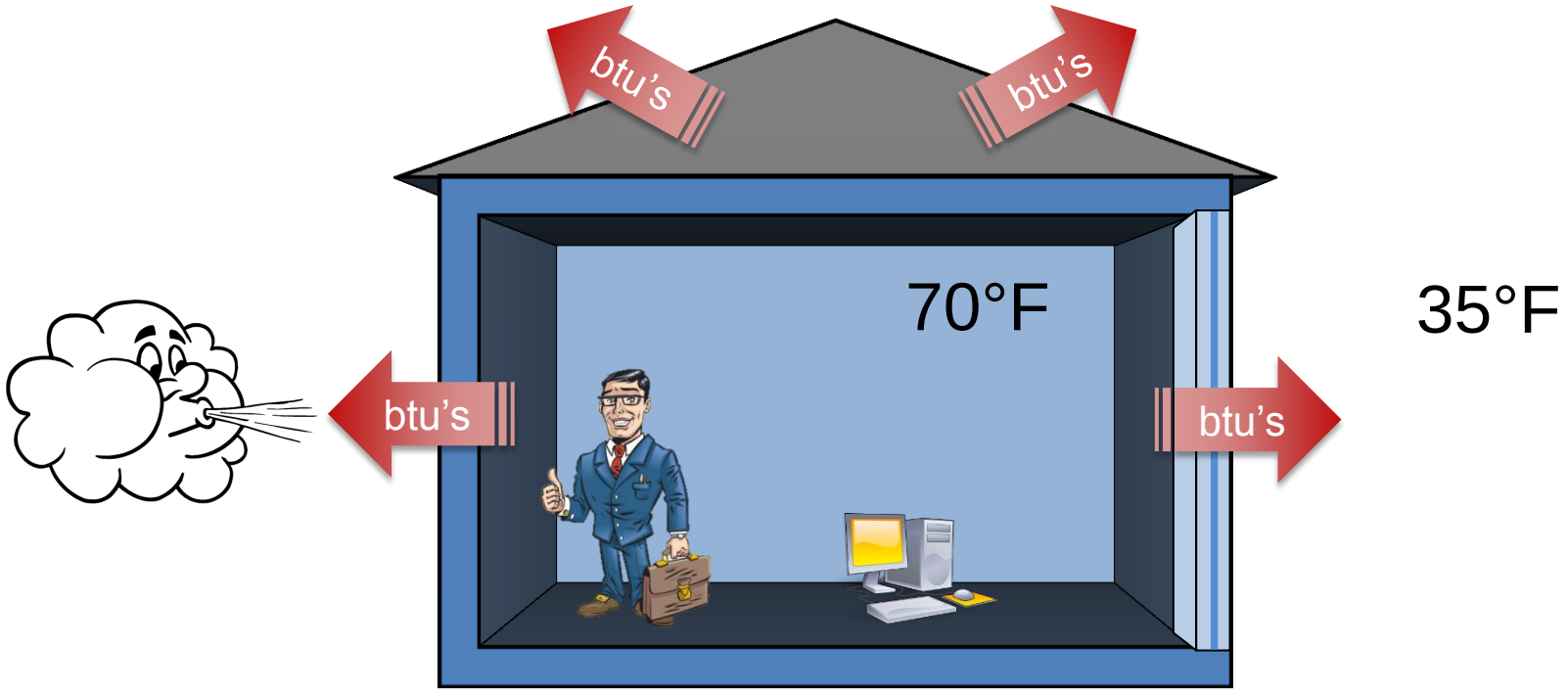
HVAC design step 1: Building science concepts

- Sensible Cooling Load: Btu's added to the home that increase temperature.
- Latent Cooling Load: Btu's added to the home that increase relative humidity.



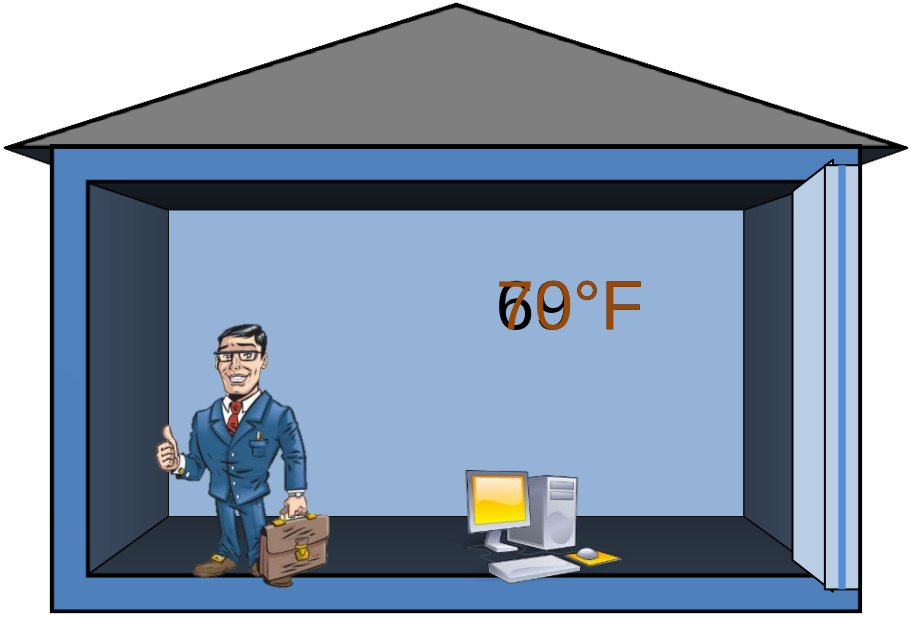
HVAC design step 1: Building science concepts

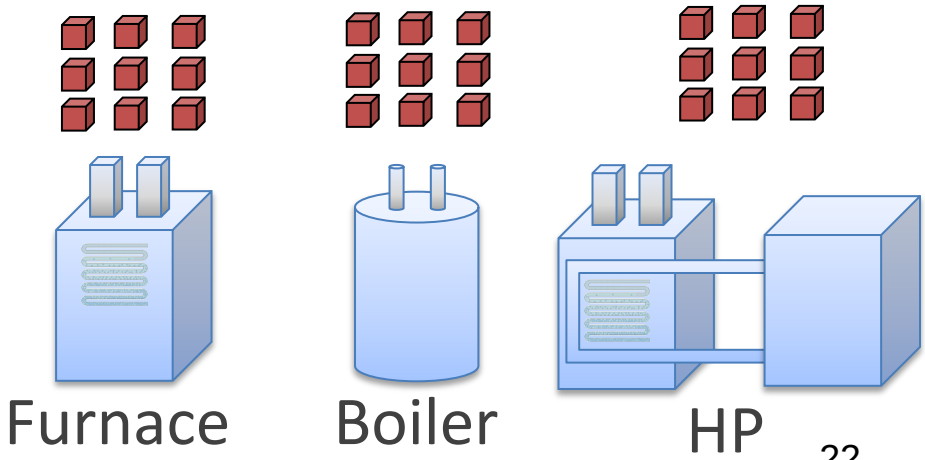
- Heating Load varies for each hour of the year.
- Heating Peak Load: The maximum energy that lost from the home in a single hour, which must be added back to maintain temperature.



HVAC design step 1: Building science concepts

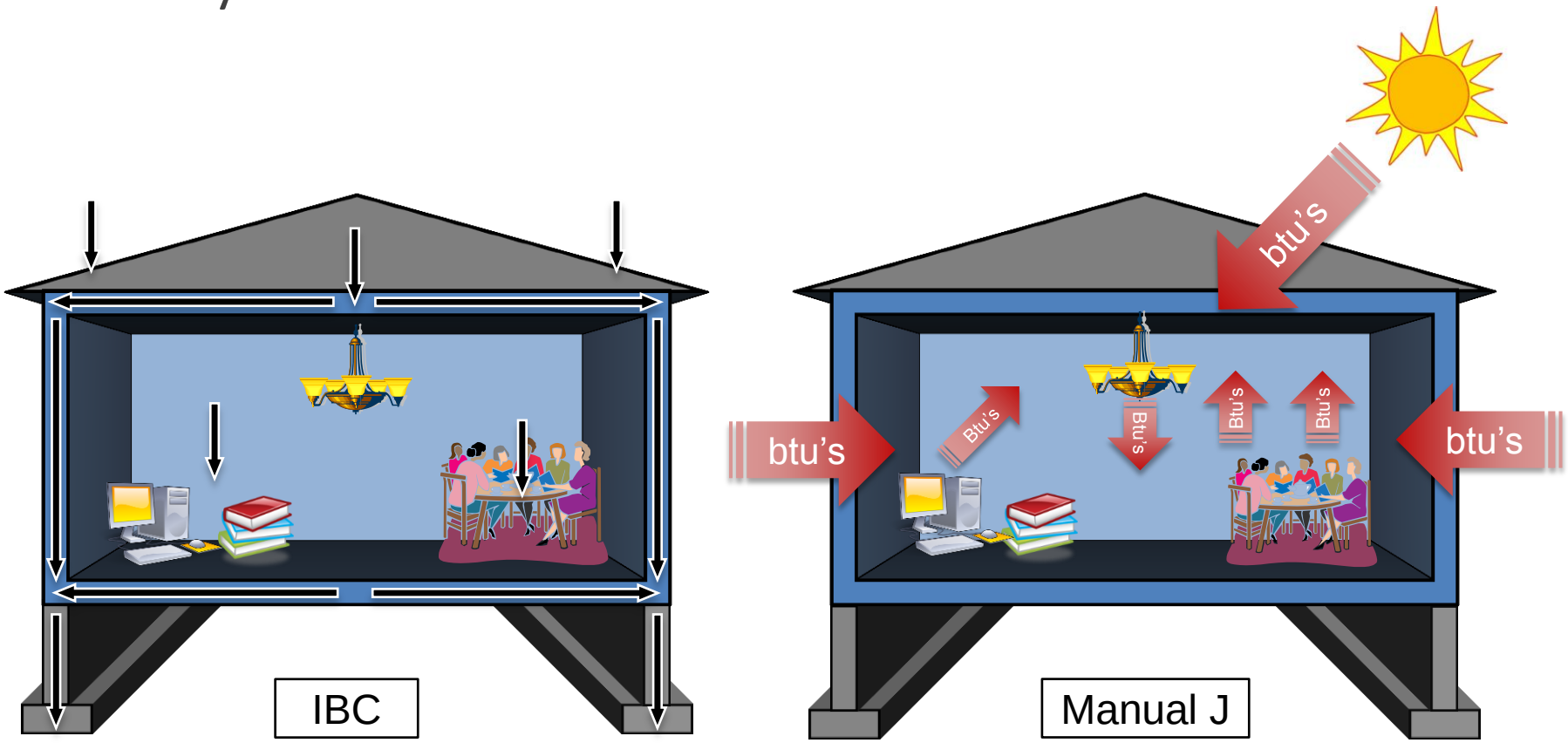
- Cooling & heating equipment are “btu machines” that add or remove btu’s to offset the load.
- The cooling and heating load tell you how many btu’s the equipment has to be capable of removing or adding.
- Load is independent of the *type* of equipment that will be used.





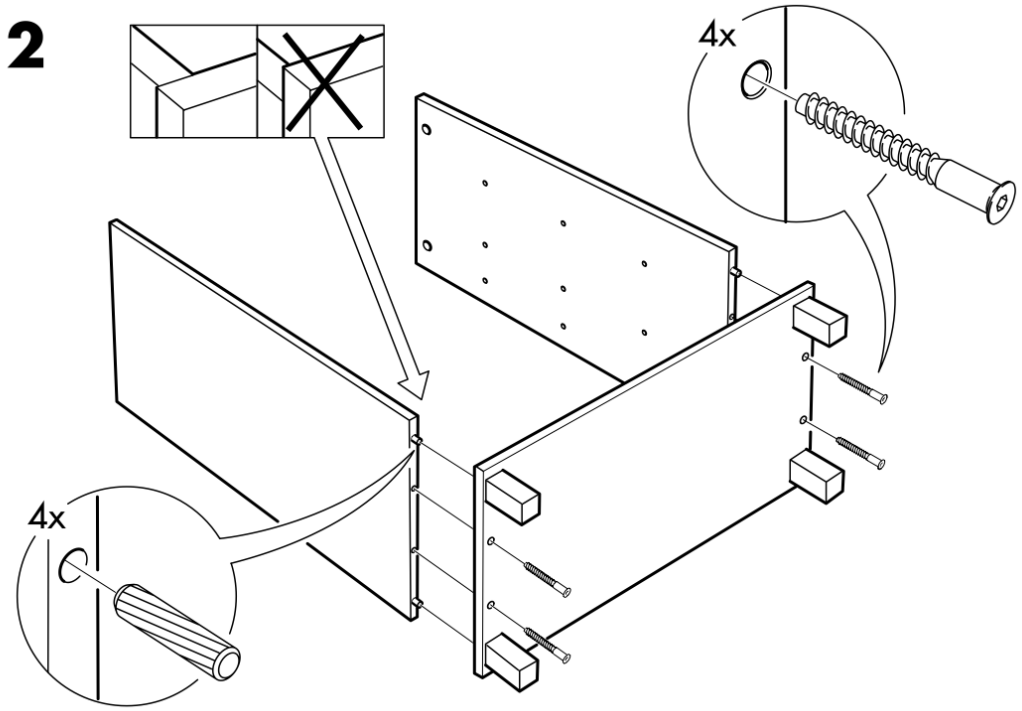
HVAC design step 1: Building science concepts

- Cooling & heating loads are calculated using a standard process – usually ACCA's Manual J.



HVAC design step 1: Building science concepts

- Process is able to be repeated by someone else.
- ACCA recognized Manual J programs:
  - www.acca.org/industry/system-design/software



Poll question #2

- What program do you most often use, or see HVAC designers use, to calculate loads?
  A. Wrightsoft's Right-J.
  B. Elite Software's RHVAC.
  C. FSEC's EnergyGauge.
  D. Other

HVAC design step 1:
Summary of building science concepts

- *Structural load* = # pounds that foundation must support..

.. *Cooling load* = # btu's that equipment must remove.

- Structural *peak* load = the max. weight..

.. Cooling *peak* load = the max. btu's / hr equipment must remove.

- ACCA Manual J is the most commonly used standard for calculating cooling and heating loads.

HVAC design step 2:
Select equipment that meets loads

HVAC design step 2: Building science concepts

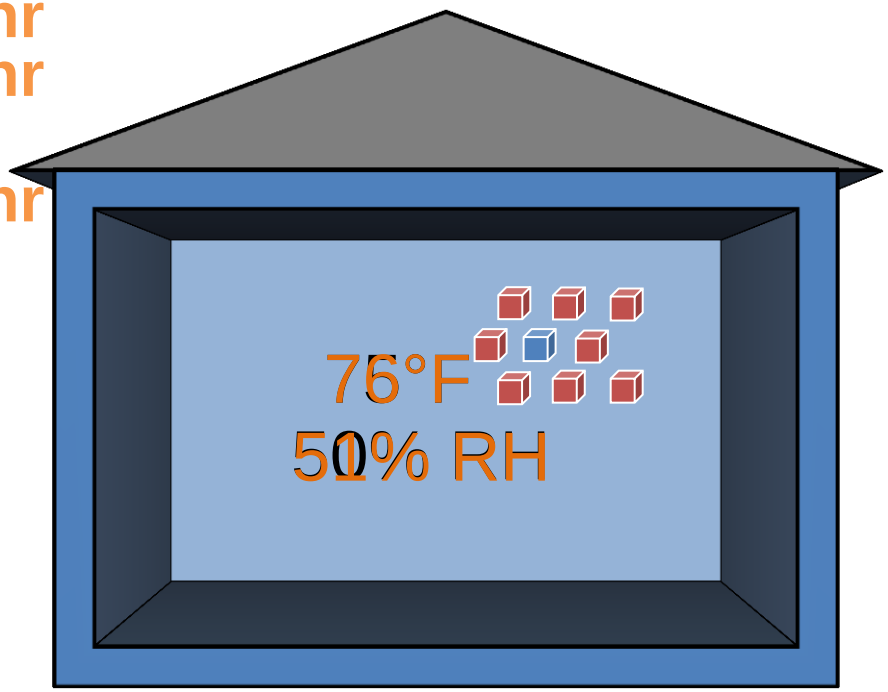
- Step 1: Calculate heating and cooling load. 
- Step 2: Select heating and cooling equipment.
- Step 3: Design the duct system.

HVAC design step 2: Building science concepts

- Cooling Capacity: BTU's per hour that equipment can remove.

49,400 BTU/hr
35,000 BTU/hr

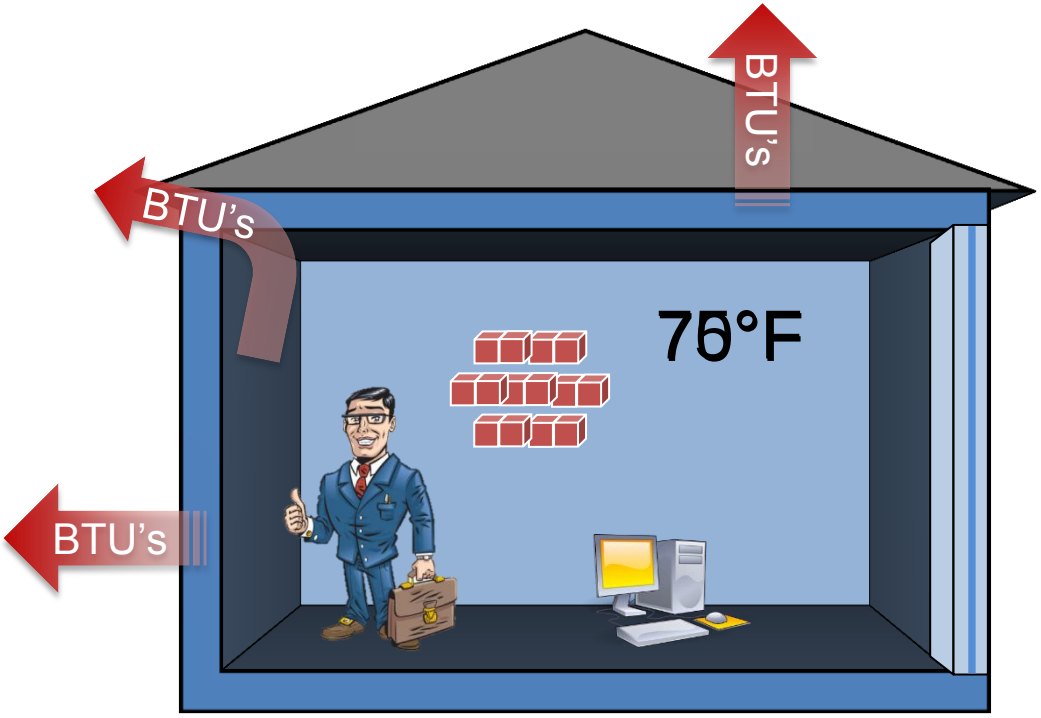
22,100 BTU/hr



100°F
80% RH

HVAC design step 2: Building science concepts

- Heating capacity: BTU's per hour that equipment can add.



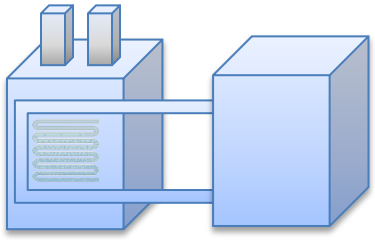
51,300 BTU/hr

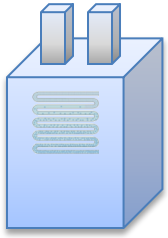
HVAC design step 2: Building science concepts

Super-Simple Equipment Selection Goal

Capacity (in BTU's per hour)	=	**Load** (in BTU's per hour)

Sample ACCA Manual S Sizing Limits

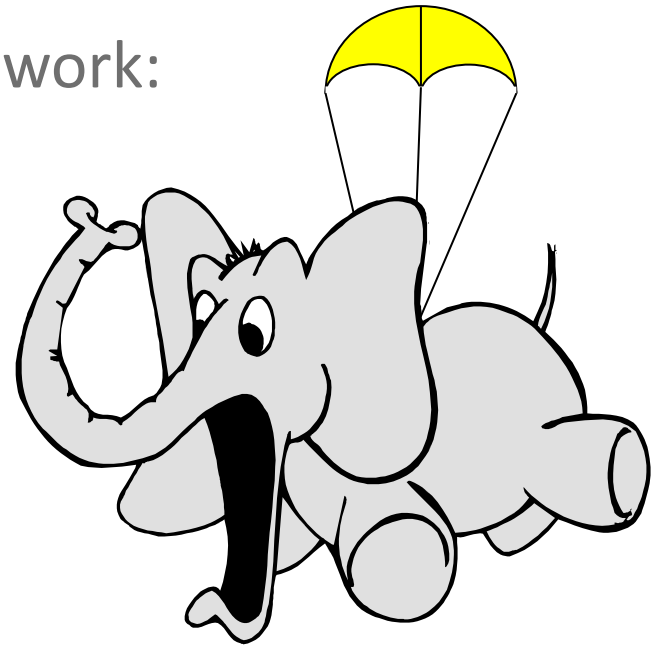
AC  Total Capacity = 95-115% of Load

Furnace  Total Capacity = 100-140% of Load

HVAC design step 2: Building science concepts

- Load calculations and equipment selection go hand in hand.
- Both need to be right for the system to work:

Measured Weight		Parachute Rating	
1,000 lbs	+	1,000 lbs	= ✗
8,000 lbs	+	1,000 lbs	= ✗
8,000 lbs	+	8,000 lbs	= ✓



HVAC design step 2: Summary of building science concepts

- Design Step 2: Select equipment using those loads.
- Cooling Capacity: BTU's per hour that equipment can remove.
- Heating Capacity: BTU's per hour that equipment can add.
- ACCA Manual S helps standardize this process.
- Equipment that's based on an *undersized load* won't keep up.
- Equipment that's based on an *oversized load* will cycle on & off.
- Equipment that's based on an *accurate load* will best achieve comfort, efficiency, and durability.

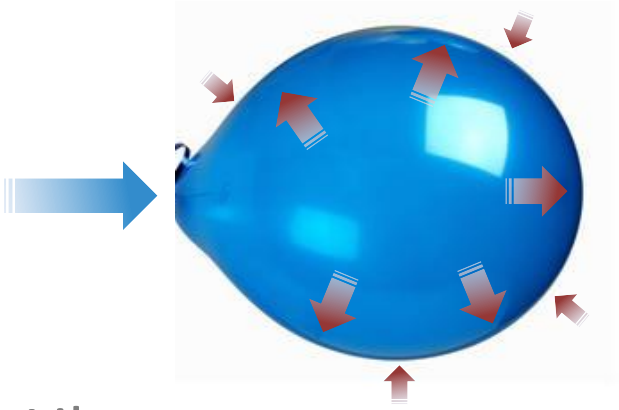
HVAC design step 3:
Design duct system to get air from equipment to rooms & back

HVAC design step 3: Building science concepts

- Step 1: Calculate heating and cooling load. 
- Step 2: Select heating and cooling equipment. 
- Step 3: Design the duct system.

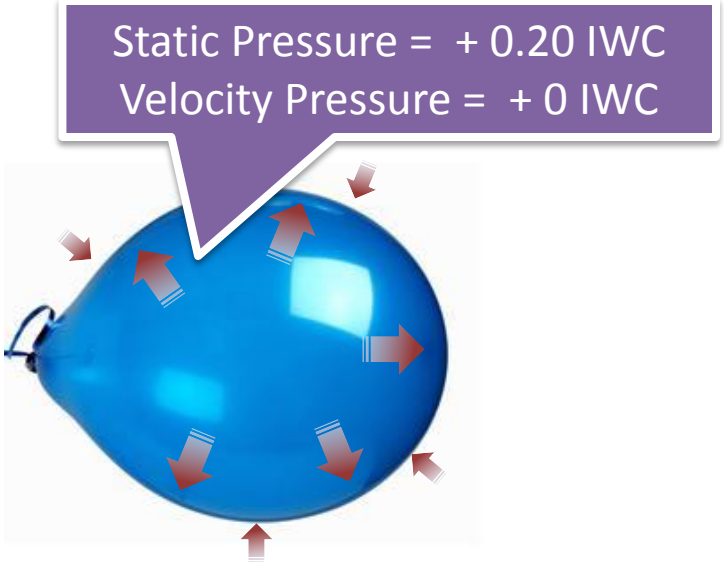
HVAC design step 3:
Building science concepts

A fan uses energy to push air

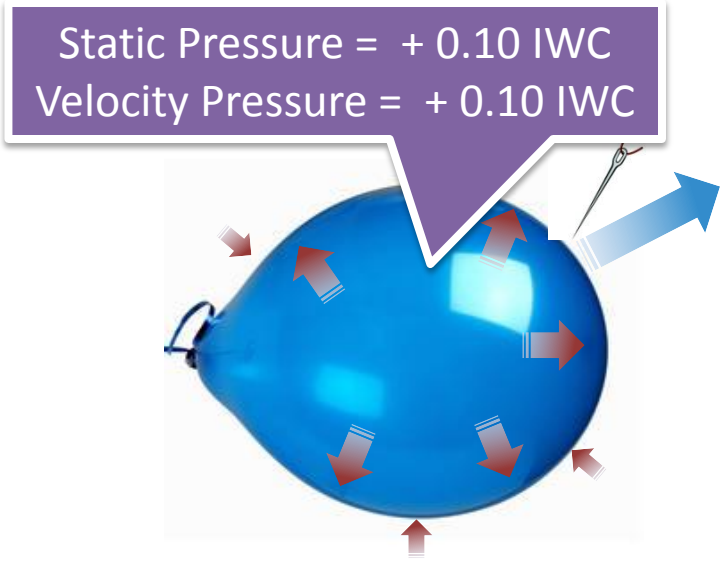


Like we use energy to
push air into a balloon

HVAC design step 3: Building science concepts



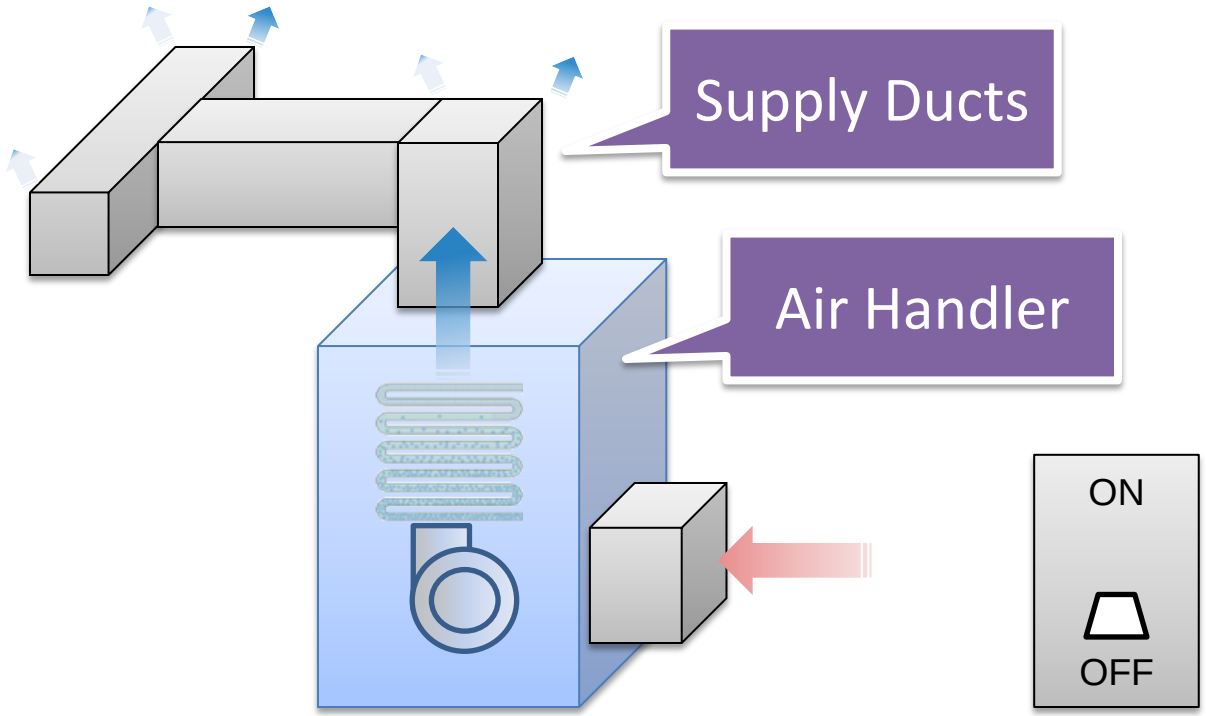
The pressure inside the inflated balloon is the Static Pressure



If the balloon has a leak, the pressure of that moving air is the Velocity Pressure

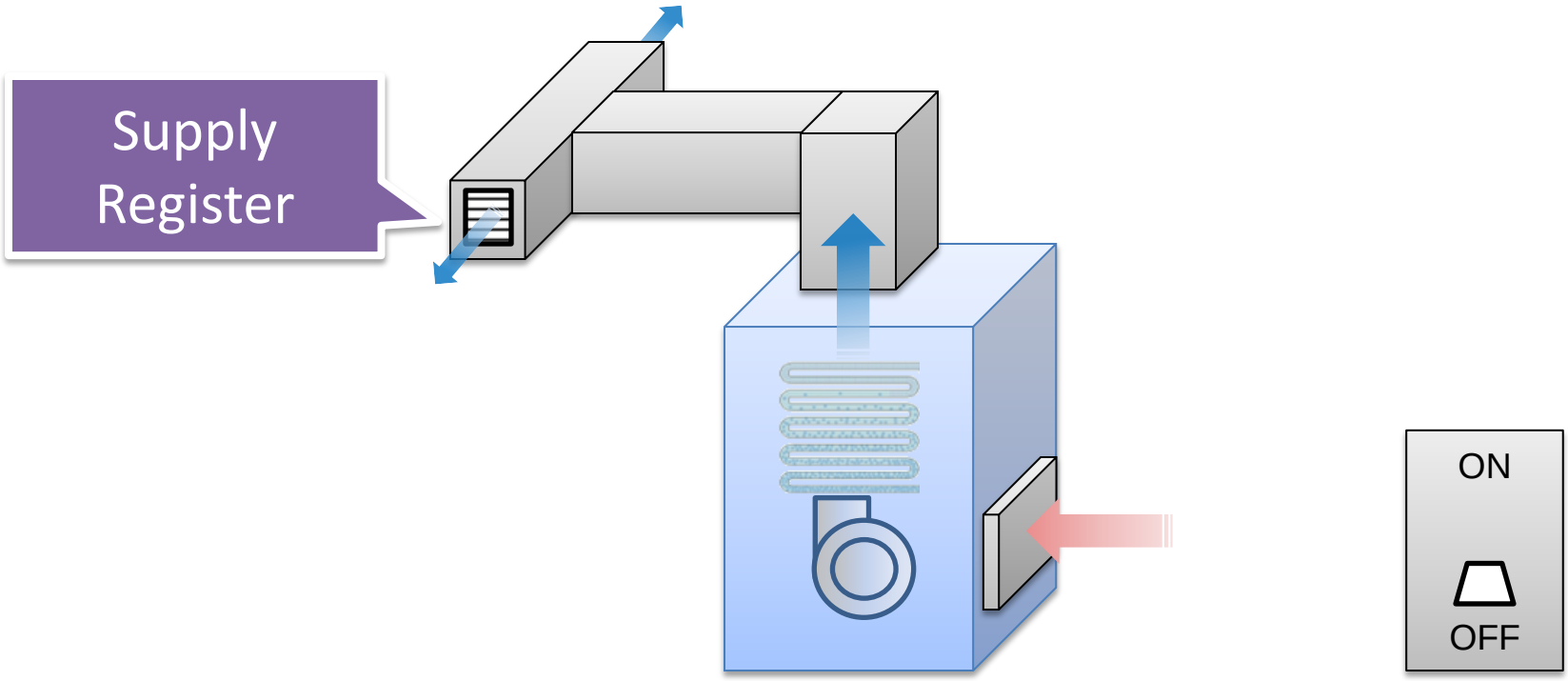
HVAC design step 3: Building science concepts

- Example: Duct system without registers and sealed tightly.



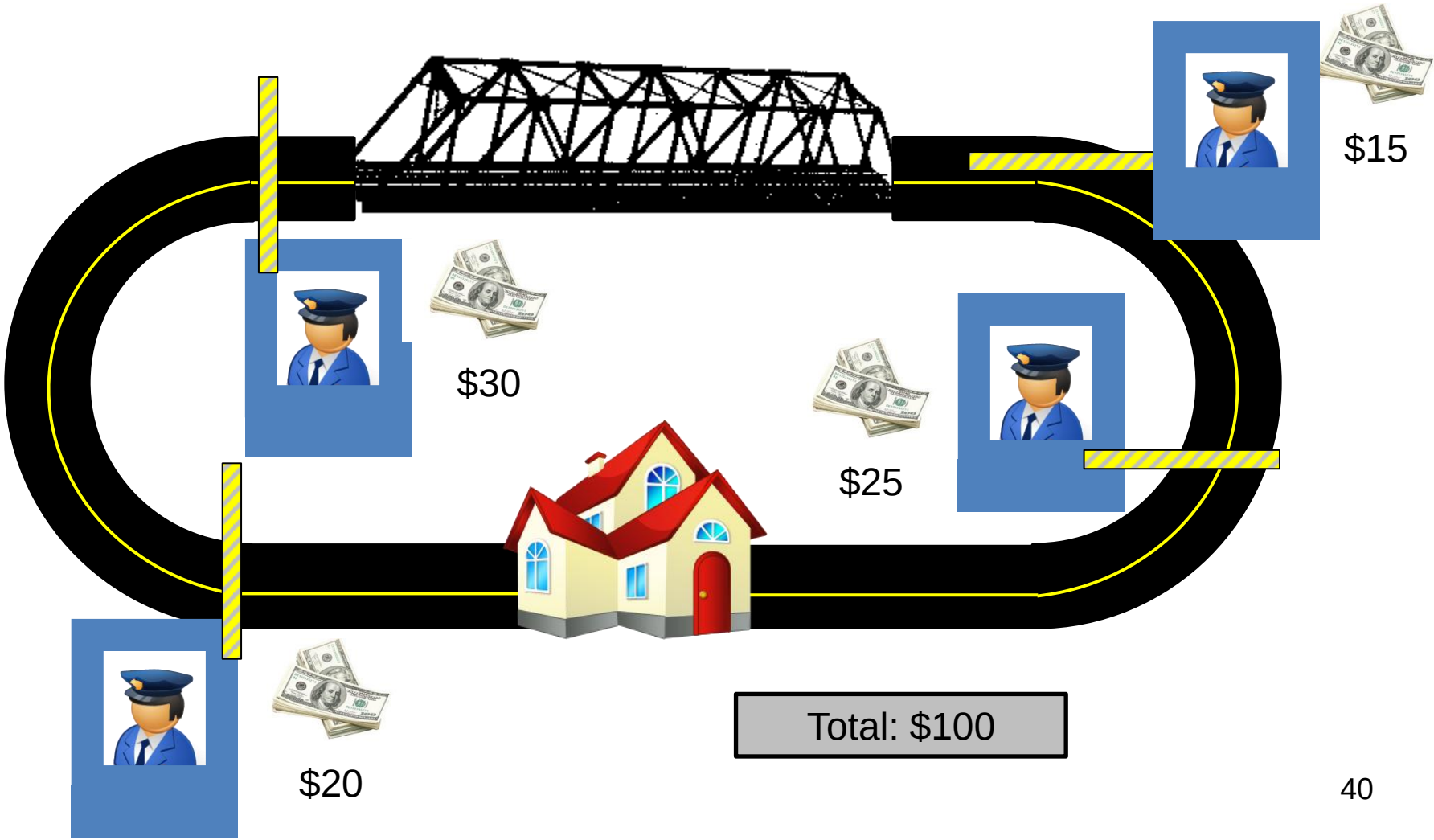
HVAC design step 3: Building science concepts

- Example: Supply registers added to duct system.



HVAC design step 3: Building science concepts

- Designer must meet a static pressure ‘budget’.



HVAC design step 3: Building science concepts

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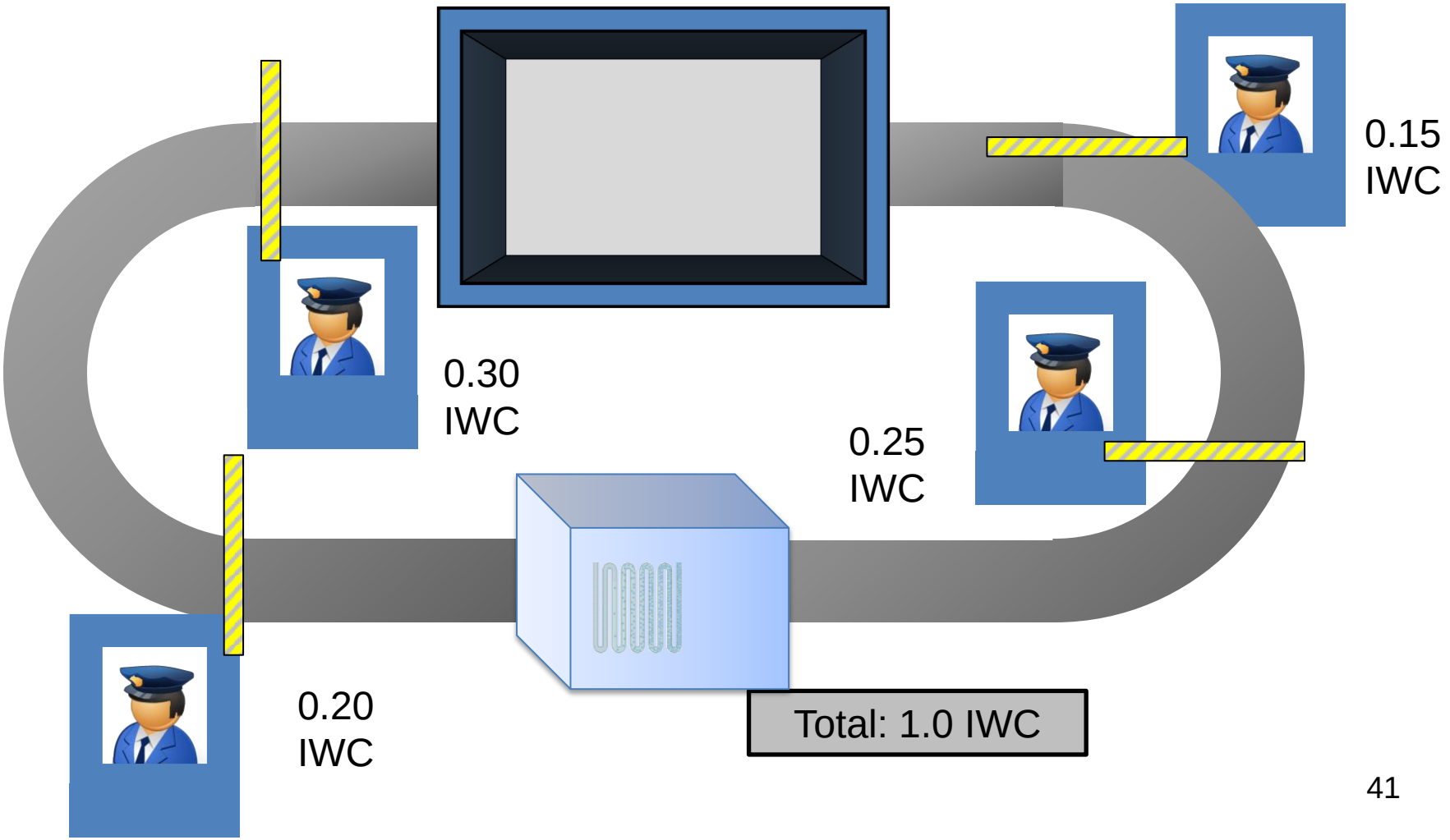

HVAC design step 3: Building science concepts

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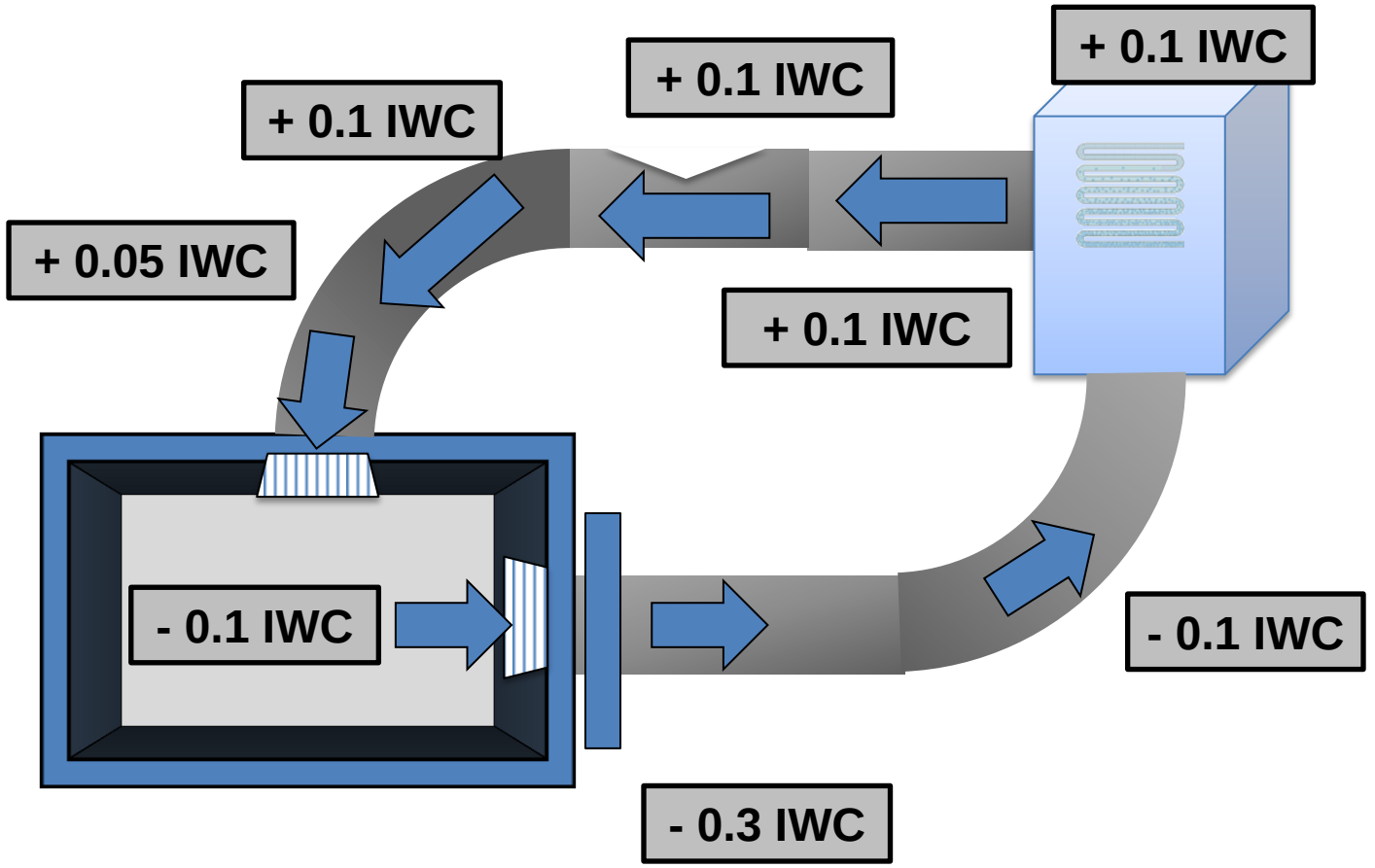
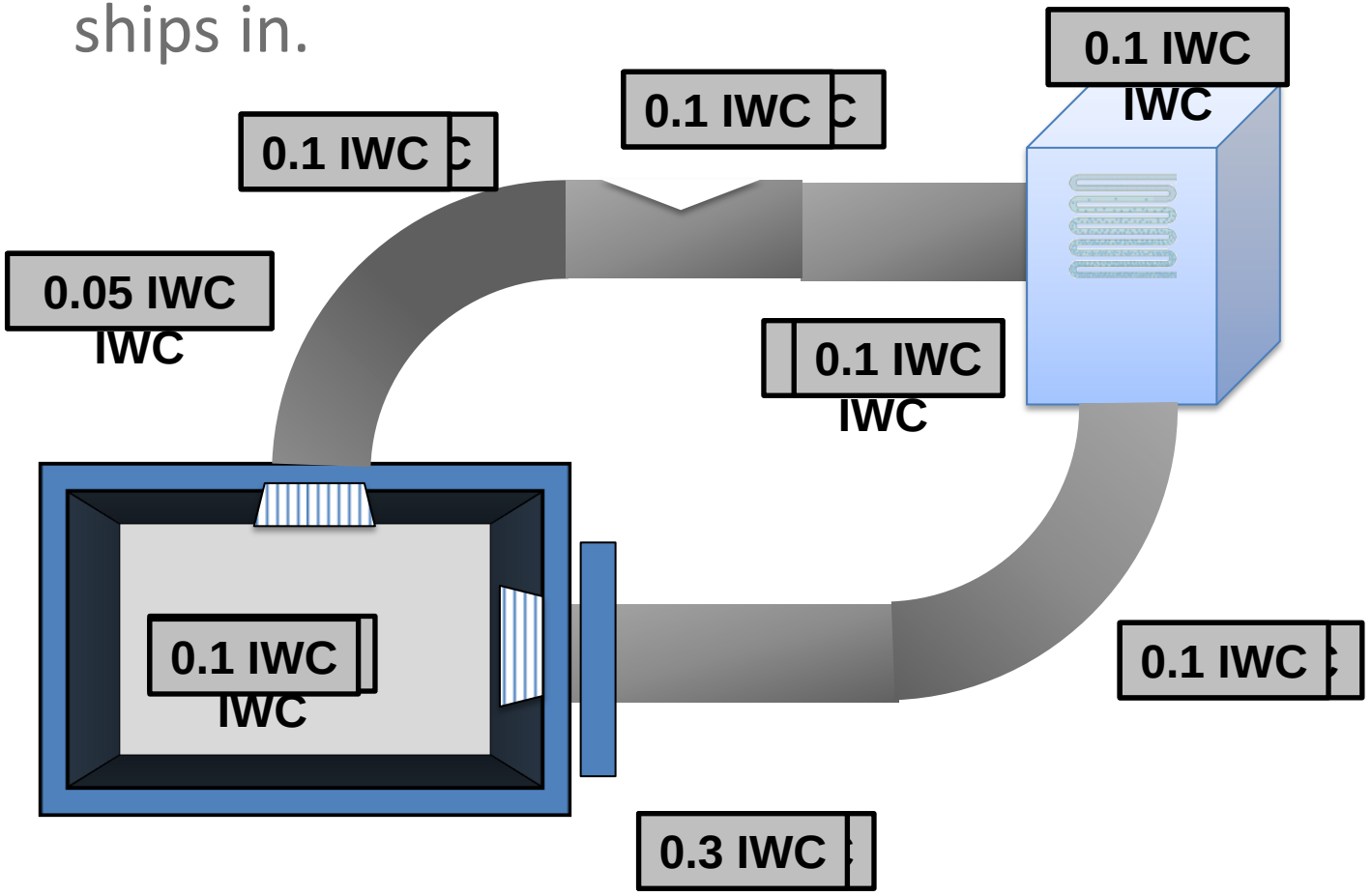


HVAC design step 3: Building science concepts

- Total External Static Pressure – The sum of the static pressure that is *external* to the equipment that the fan ships in.



#	IWC
~~1~~	~~0.1~~
2	0.1
3	0.1
4	0.1
5	0.05
6	0.1
7	0.3
8	0.1
Total	0.85

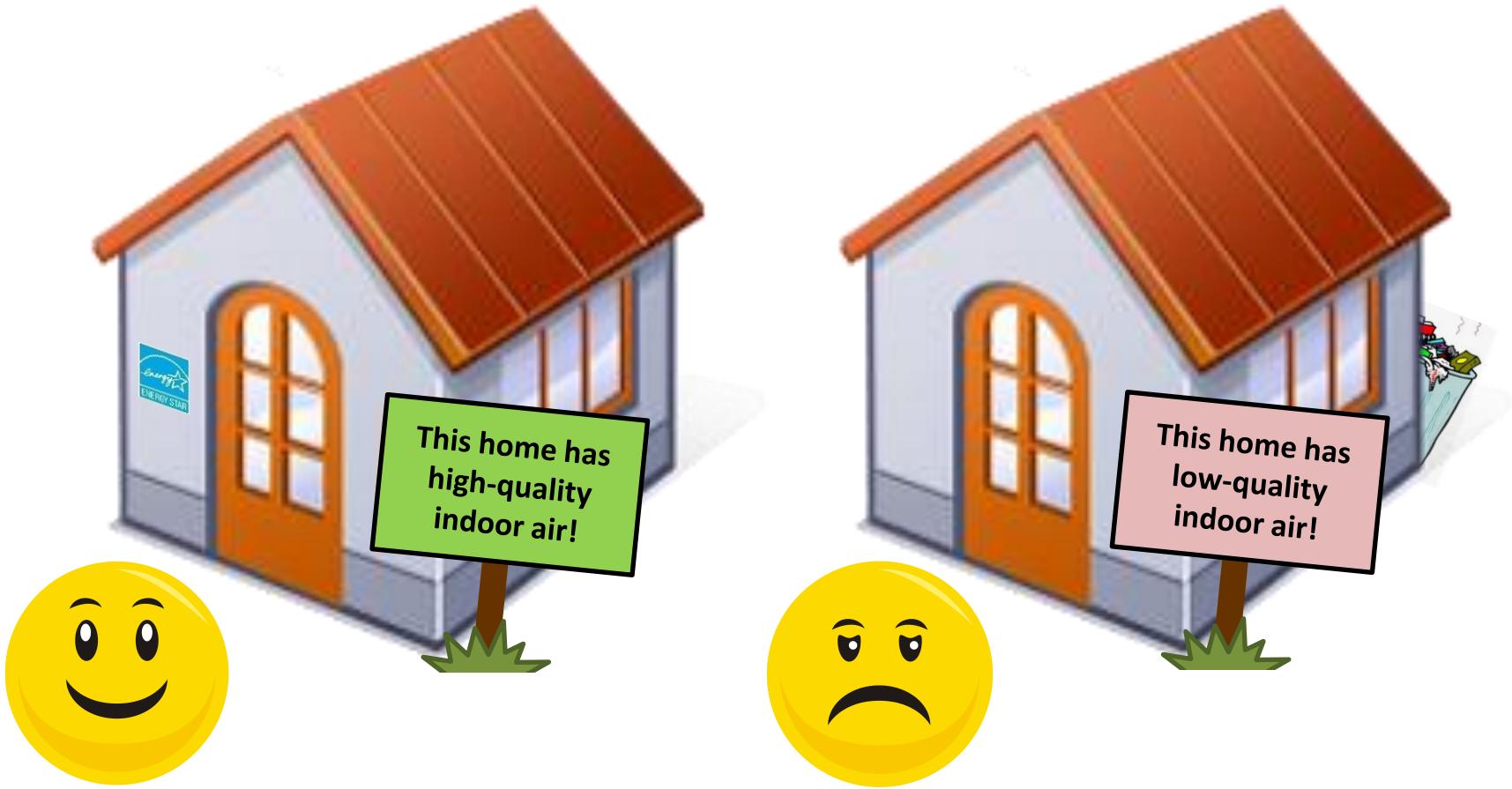
HVAC design step 3: Summary of building science concepts

- A fan uses power to move air.
- This creates two kinds of pressure – static pressure and velocity pressure – and both can be measured in Inches Water Column (IWC).
- Every part of the duct system imposes a static pressure ‘toll’.
- The sum of these ‘tolls’, minus that of the equipment the fan ships in, is the Total External Static Pressure.
- Fan manufacturers publish the Total External Static Pressure a fan can overcome – it’s ‘budget’.

The ‘V’ in HVAC

Ventilation:
Building science concepts

- Consumers place value on indoor air quality.



Ventilation:
Building science concepts

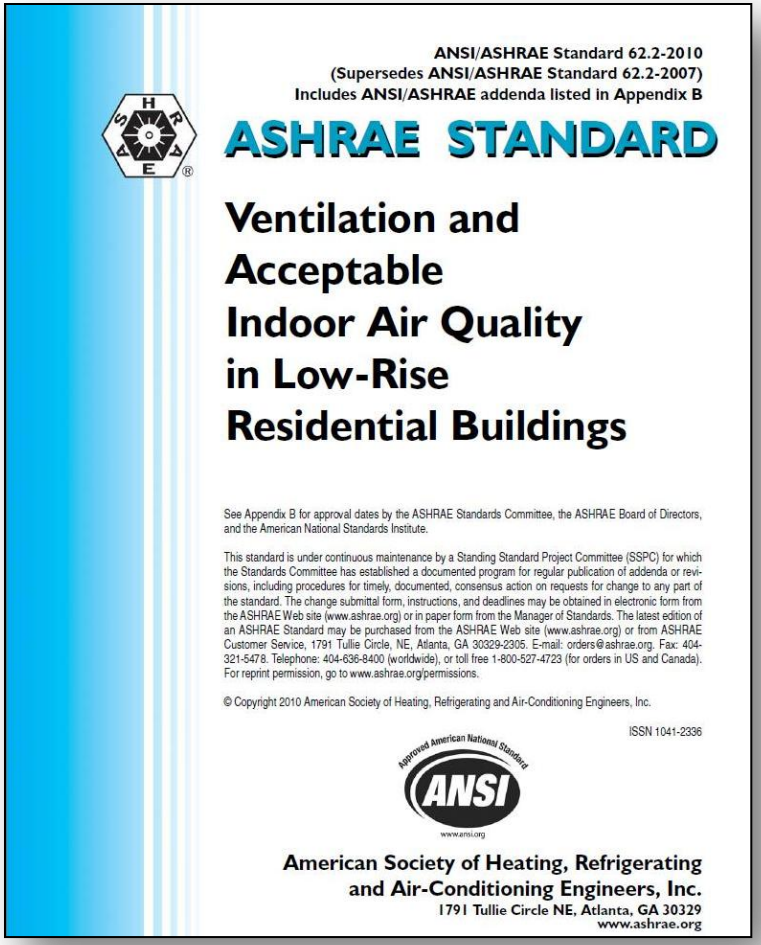
1. Homeowner is satisfied (e.g., no odors or irritants).

2. Low levels of contaminants known to pose health risks.

Ventilation:
Building science concepts

- This is the basic definition of indoor air quality in the industry standard, ASHRAE 62.2-2010.

- Don’t sacrifice indoor air quality in exchange for efficiency.



Ventilation:
Building science concepts

- Give them the option to exhaust smells and cooking moisture out of the kitchen

Ventilation:
Building science concepts

- Give them the option to exhaust moisture from the bathroom.

Ventilation:
Building science concepts

- Homeowners benefit from an automated system for bringing outdoor air into the house.

How are the ENERGY STAR & Indoor airPLUS programs related?

- Both are voluntary labeling programs run by EPA.
- ENERGY STAR is better than standard practice, while Indoor airPLUS offers a complete indoor air quality package.
- For more information, visit www.epa.gov/indoorairplus/

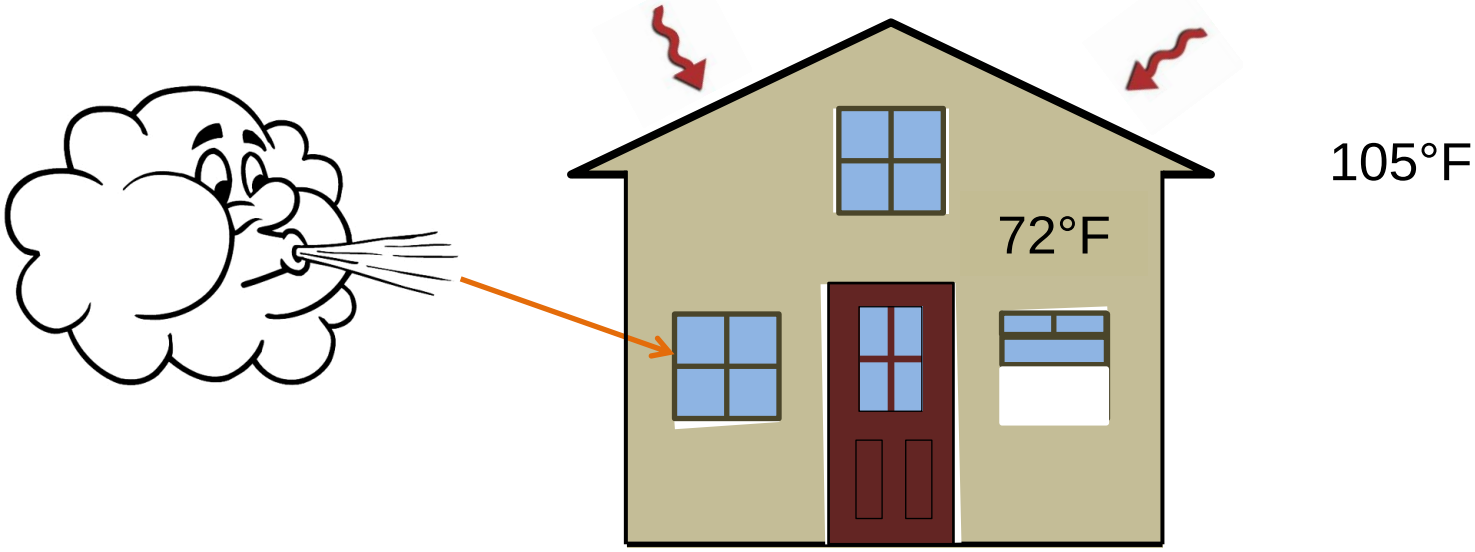
Complete IAQ Protection

Ventilation:
Building science concepts

- Some advantages, but mostly disadvantages.
- Advantages of leaky homes:
  - Dilution of contaminants in home.
  - Drying of building components that become wet.

Ventilation:
Building science concepts

- Disadvantages of leaky homes:
  - Rate of outdoor air is not controlled.
  - Source and path of outdoor air is unknown.
  - Outdoor air may cause discomfort if not first conditioned.
  - Excess outdoor air increases energy use.



Ventilation:
ENERGY STAR approach

1. Build the home tight to improve efficiency & comfort.
2. Remove contaminants using occupant-controlled exhaust fan in kitchens & bathrooms and a filter in HVAC system.
3. Bring in outdoor air in a controlled way to dilute contaminants.
4. Include key durability details relating to water management.

Ventilation:
Summary of building science concepts

- Indoor air quality is valued by consumers.
- ENERGY STAR addresses efficiency without sacrificing indoor air quality or durability through:
  - Tight homes.
  - Removal of contaminants.
  - Dilution of contaminants with outdoor air.
  - Durability details related to moisture.

Poll question #3

- What whole-house mechanical ventilation system do you most often see in certified homes?
  A. Exhaust fan
  B. Ventilation inlet on the return side of the HVAC system
  C. ERV/HRV
  D. Other

System 3:
Water management system

3

Water Management System

- A water management system that directs water off the roof, down the walls, and away from the foundation and site, as well as keeping building materials from getting wet, improves durability and indoor air quality.

Water management system: Building science concept

- Many materials used in building homes are not durable when wet.
- Especially important in high performance homes, regardless of whether the home is ENERGY STAR certified.

Water management system: Building science concept

Water management system: Summary of building science concept

- Helps prevent durability problems from moisture.
- Based on code requirements, plus best practices.
- Especially important in high performance homes, regardless of whether the home is ENERGY STAR certified.

But who cares about Building science anyway?

For builders:

- Greater quality and process control.
- Reduced costs from warranty issues & customer complaints.
- Maximum value for money invested.

For HVAC contractors:

- Reduced callbacks for comfort issues.
- Justification to invest in higher-value products and services.

For homeowners:

- Lower utility bills.
- Better comfort, durability, and quality.
- A more livable home.

Upcoming webinars

Webinar	Date
HVAC Design Webinar Series Part 2: The Basics of Manual S	Thurs., March 27th
HVAC Design Webinar Series Part 3: The Basics of Manual D	Thurs., April 3rd
Working with ENERGY STAR as a Habitat Affiliate	Tues., April 15th
Cost-effective Strategies for Building ENERGY STAR Certified Homes	Thurs., April 24th
Air Sealing Done Right	Wed., April 30th

- Also see www.energystar.gov/newhomeswebinars for both ENERGY STAR and Challenge Home sessions.

ENERGY STAR Certified Homes

Web:

Main: www.energystar.gov/newhomespartners
Technical: www.energystar.gov/newhomesguidelines
Training: www.energystar.gov/newhomestraining
HVAC: www.energystar.gov/newhomesHVAC

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