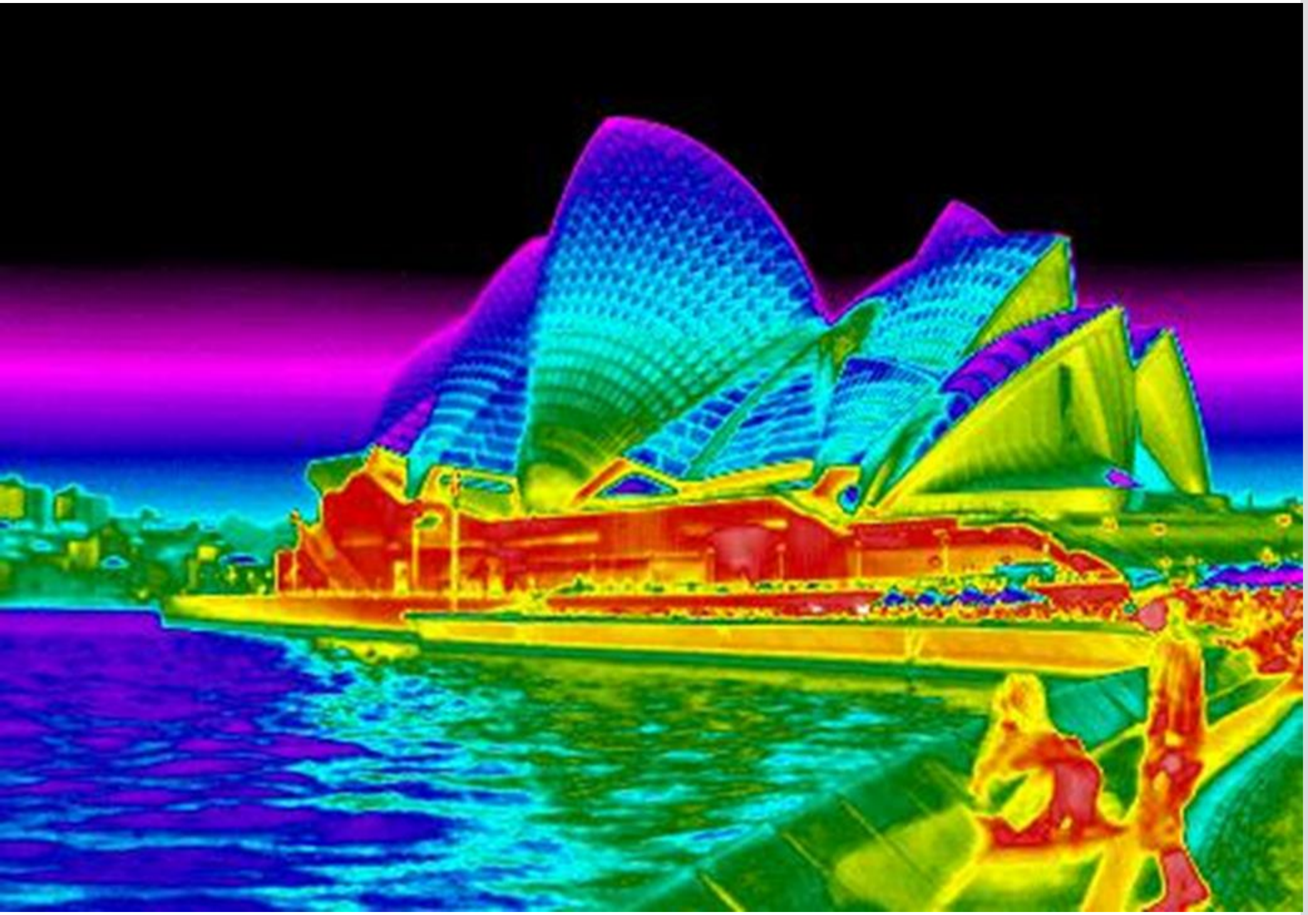


Welcome

Observing Building Enclosures Leaking; Heat, Air and Water Using Infrared Thermography

SWA CONSULTING

Scott Wood Associates, LLC

Your Presenter

Scott D. Wood is the president at SWA Consulting. Since 2003 he created and provides a Level I and II Building Science Thermography course. His training course has provided thousands with knowledge in build applied thermography. In addition to his thermography building envelope and electrical evaluations he provides building consulting and investigations.

Mr. Wood is also the Senior Building Scientist with the VaproShield team, providing lab testing on competitor and VaproShield's products including investigation/testing of properties for new product development.

He provides technical support for the company's representatives, client inquiries, and assists in development--updating product literature and creating VaproShield's AIA presentations.

DISCLAIMER

This Presentation reflects the opinion of the author based on professional experience. The author reserves the right to modify opinions should additional (factual) information be made available that is contrary to the opinions expressed herein.

SWA CONSULTING
Scott Wood Associates, LLC

COURSE DESCRIPTION

- The enclosure envelopes the building separating the conditioned from the exterior environments. Within that enclosure are Heat, Air, Liquid Moisture and Moisture vapor (HAMM) controlling elements.
- Infrared thermography can be utilized to visualize Heat, Air and Moisture (HAM) by the energy emitted from building surfaces affected by HAM.
- We will explore the benefits, limitations and physics behind the use of infrared thermography or thermal science, it's partnering with building science and infrared's use in "seeing" Heat, Air and Moisture at the enclosure.
- By showing and describing thermal imagery, we will demonstrate how thermal patterning shows Heat, Air and Moisture flow. In the end, our audience will better understand how this technology can be applied to the enclosure, minimizing risk, determining retrofit needs, evaluating energy performance and much more.

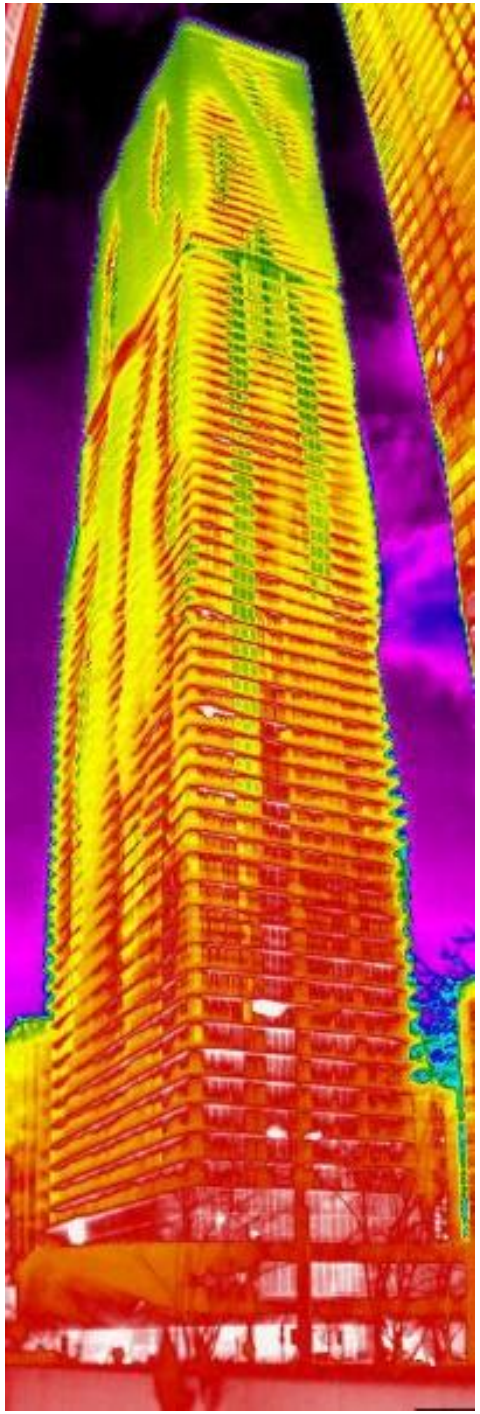
LEARNING OBJECTIVES

At the end of the presentation, participants will be able to:

- Understand the importance of the enclosure, its basic functions and what drives the functional relationships between the occupants and the environment
- Identify reasons for the enclosure and its importance in sustainability
- Recognize the enclosure barriers, their importance and their characteristics
- Identify thermal patterns associated with Heat flow, Air flow, Bulk moisture and Vapor flow

OVERVIEW

- Building Enclosure
  - Reasons for the Enclosure
- Building Science Basics
- Building Barriers
  - Heat or Thermal
  - Air (Heat and Vapor Transport)
  - Moisture (Bulk or Liquid)
  - Moisture (Vapor)



Building Enclosures for net zero

AIA 2030 Commitment provides a set of standards and goals for reaching net zero emissions in the built environment

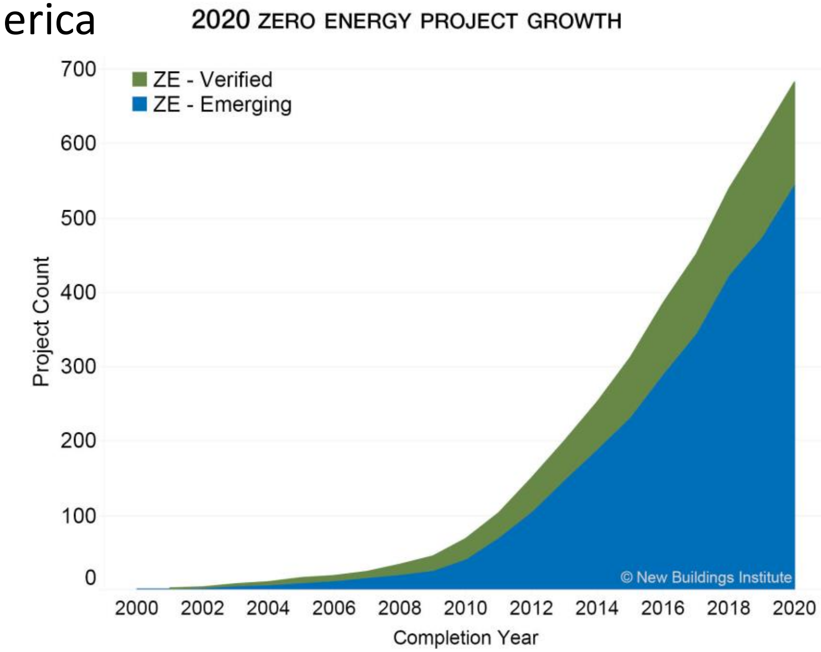
Joyce Centre for Partnership & Innovation Ontario Canada

Bullitt Center Seattle Washington, USA

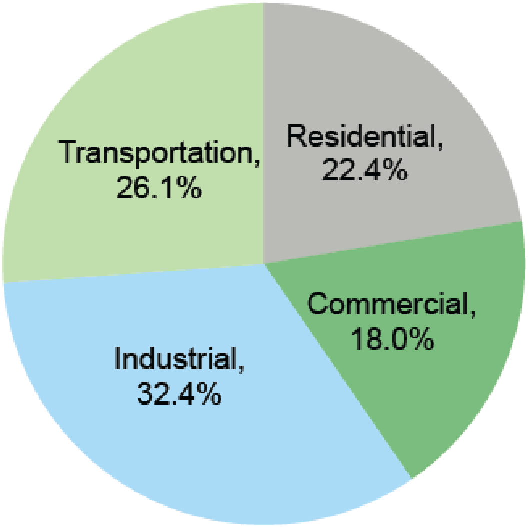
When Net Zero?

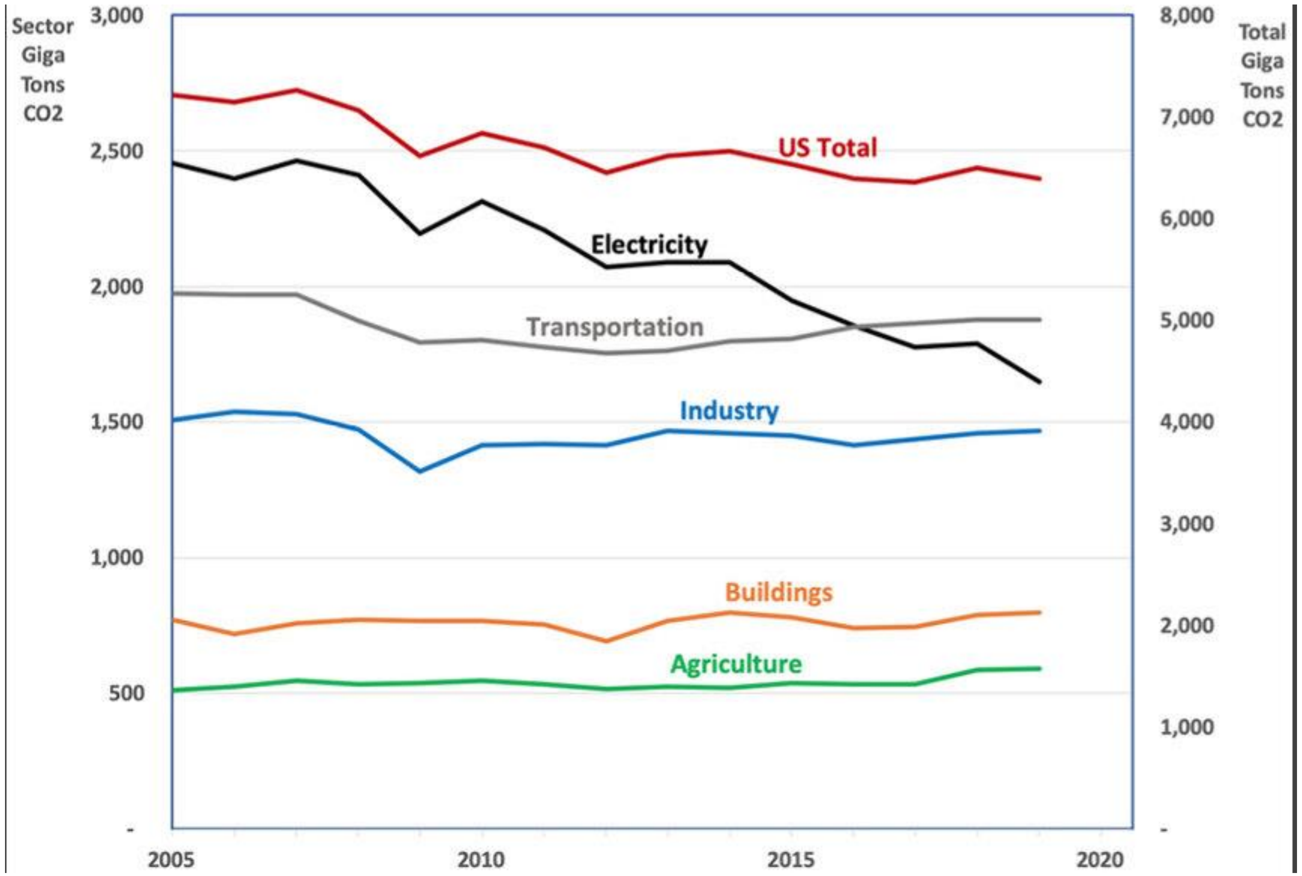
- By 2030… now a 50-52% reduction from 2005 levels
- Currently by 2050 *United Nations Framework Convention on Climate Change*

Net zero buildings in North America



Net Zero building: American Geophysical Union (AGU)
Washington DC





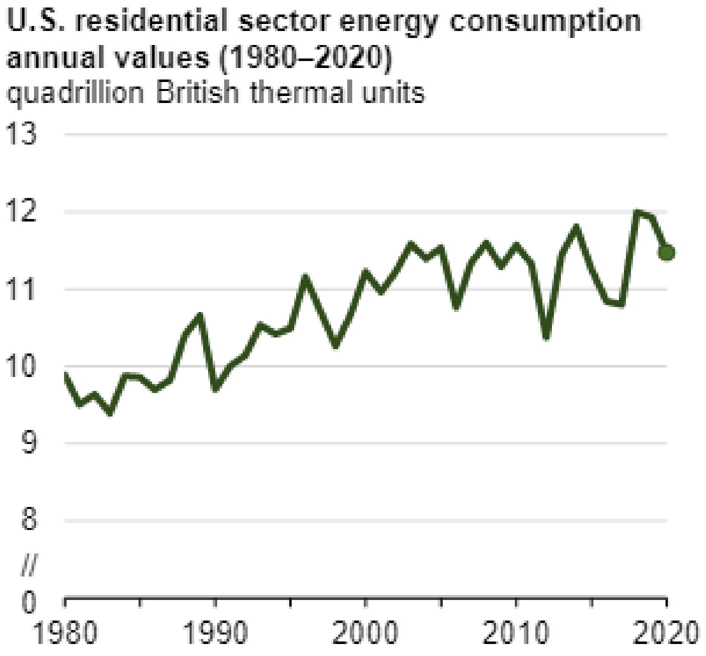
US Energy Information Administration

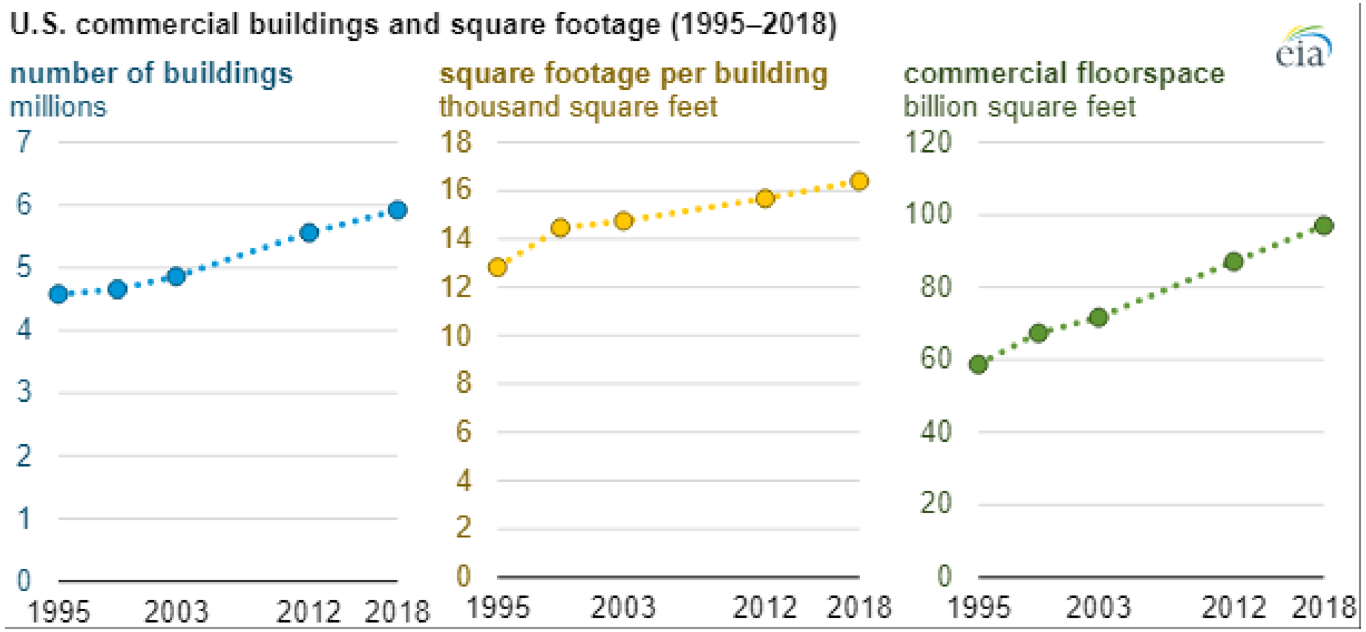
2020 US Energy Consumption

Greenhouse-Gas Emissions

Residential and Commercial Energy Consumption

- 40% 2020
- Buildings produce nearly half of all greenhouse gas emissions





Independent Statistics & Analysis
U.S. Energy Information Administration

Building America
U.S. Department of Energy

2021 Solar house by students from the Southern California Institute of Architecture (SCI-Arc) and Caltech Institute of Technology (Caltech)

The Enclosure Envelopes the Building

It Is an Environmental Separator

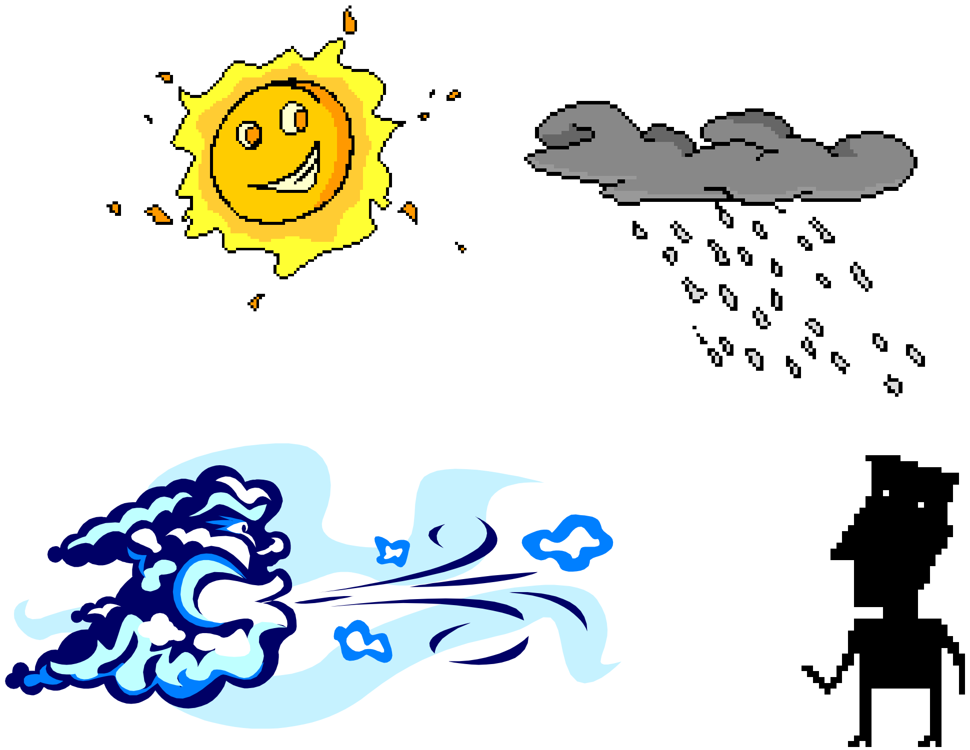
Basic Requirement

Separator between conditioned space and the exterior environment

Dr. Neil Hutcheon 1963
They need to:

- Control Heat, Air, Moisture flow
- Control rain
- Control vapor
- Control rain penetration
- Control light, solar & other radiation
- Control noise & vibration
- Control fire
- Provide strength and rigidity
- Be durable
- Be of economic value
- Be of aesthetic value

Building Interacts With:



The occupants and the environment.

The functional relationships are driven by physical, chemical and biological reactions.

Controlled by:

- Heat flow
- Air flow
- Moisture flow

The Enclosure Envelopes the Building

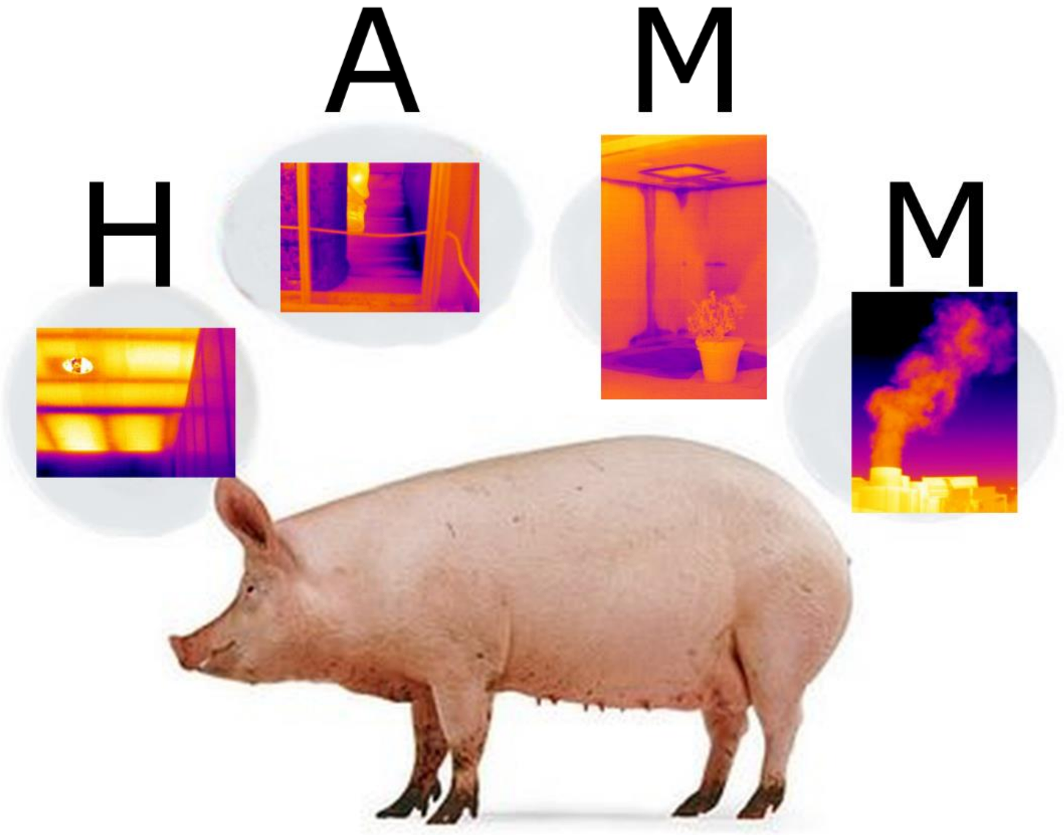
Including the shell, the building enclosure has four major functions.

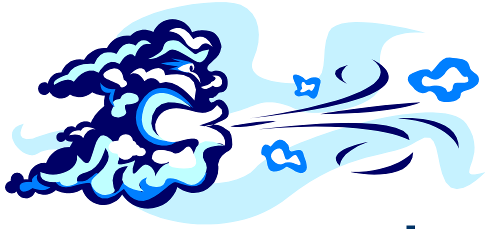
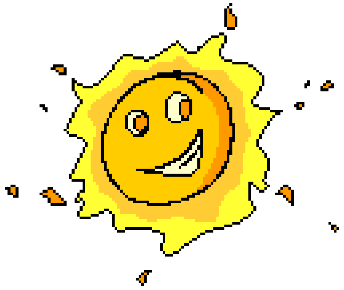
H: Thermal control

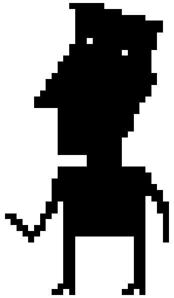
A: Air control

M_{liquid}: Rain control

M_{vapor}: Vapor control





The Wall Assembly's Four Controlling Elements HAMM

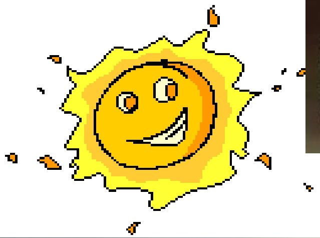
What is The Order of Importance of HAMM?

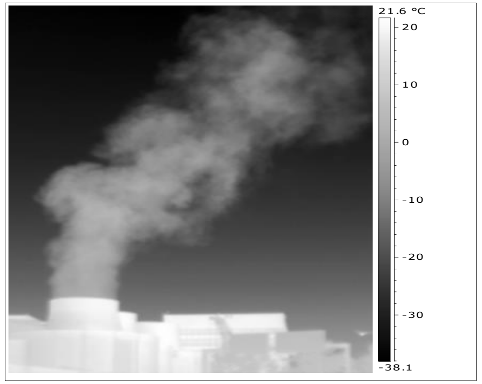
Polling

The Enclosure Envelopes the Building

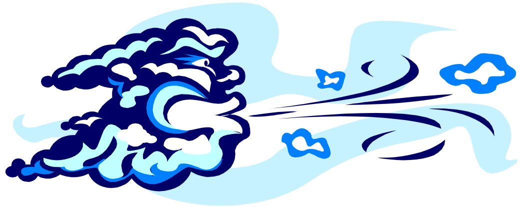
The controlling elements order of importance include:

1. M_{liquid}: Rain control
2. A: Air control
3. M_{vapor}: Vapor control
4. H: Thermal control










How do we control these elements?

Do we Hermetically Seal?

1. Rain control
2. Air control
3. Vapor control
4. Thermal control

The Cladding Provides

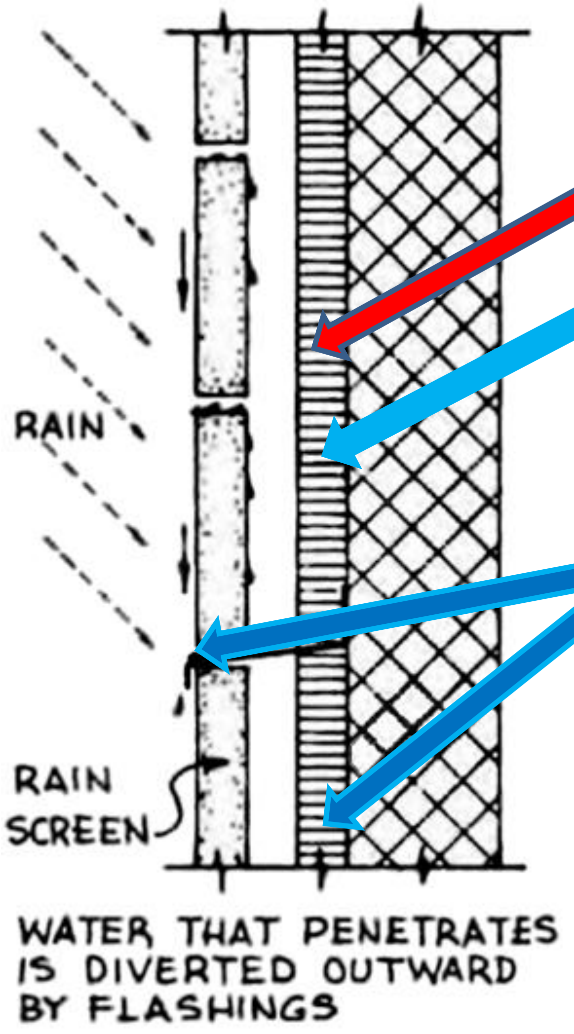
1. Aesthetics (Ugly buildings don’t seem to last)
2. Protection from UV
3. Protection from Water and Heat

Unless maybe a museum

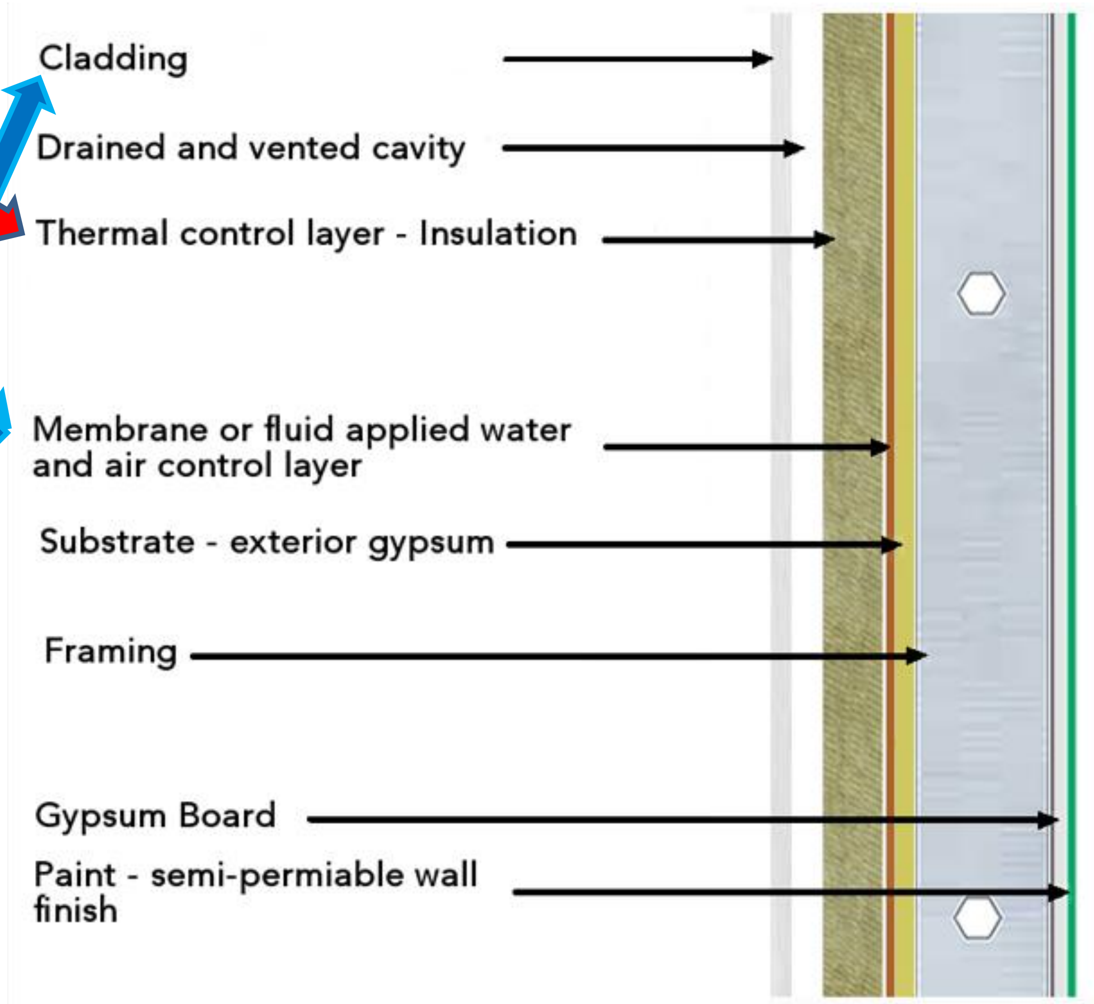
The Wall, Old? To New

Must Block:

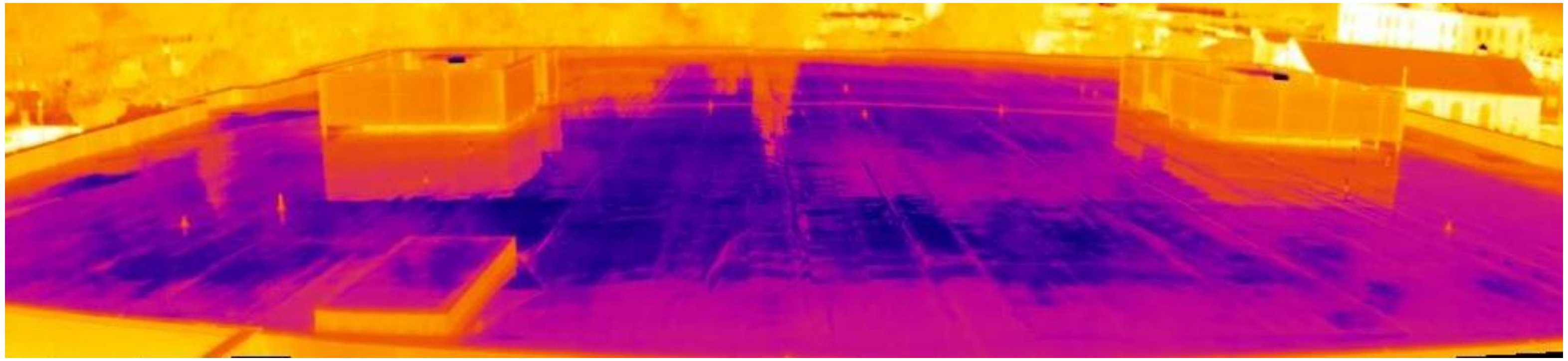
- Heat
- Air
- Moisture



1964 Hutcheons'



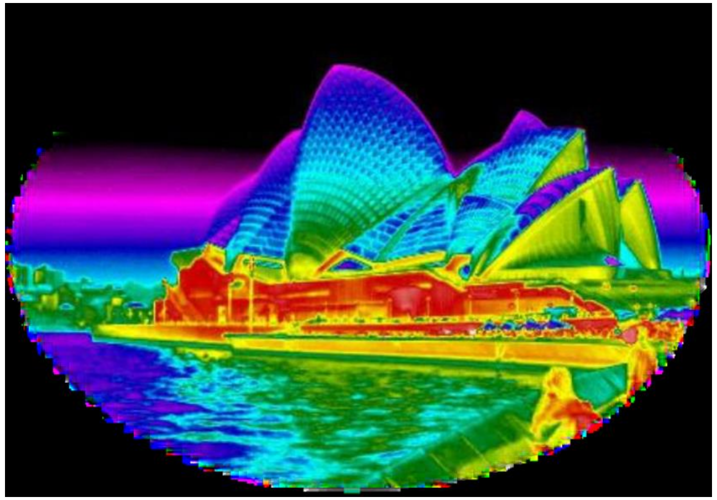
Building Science and Thermography



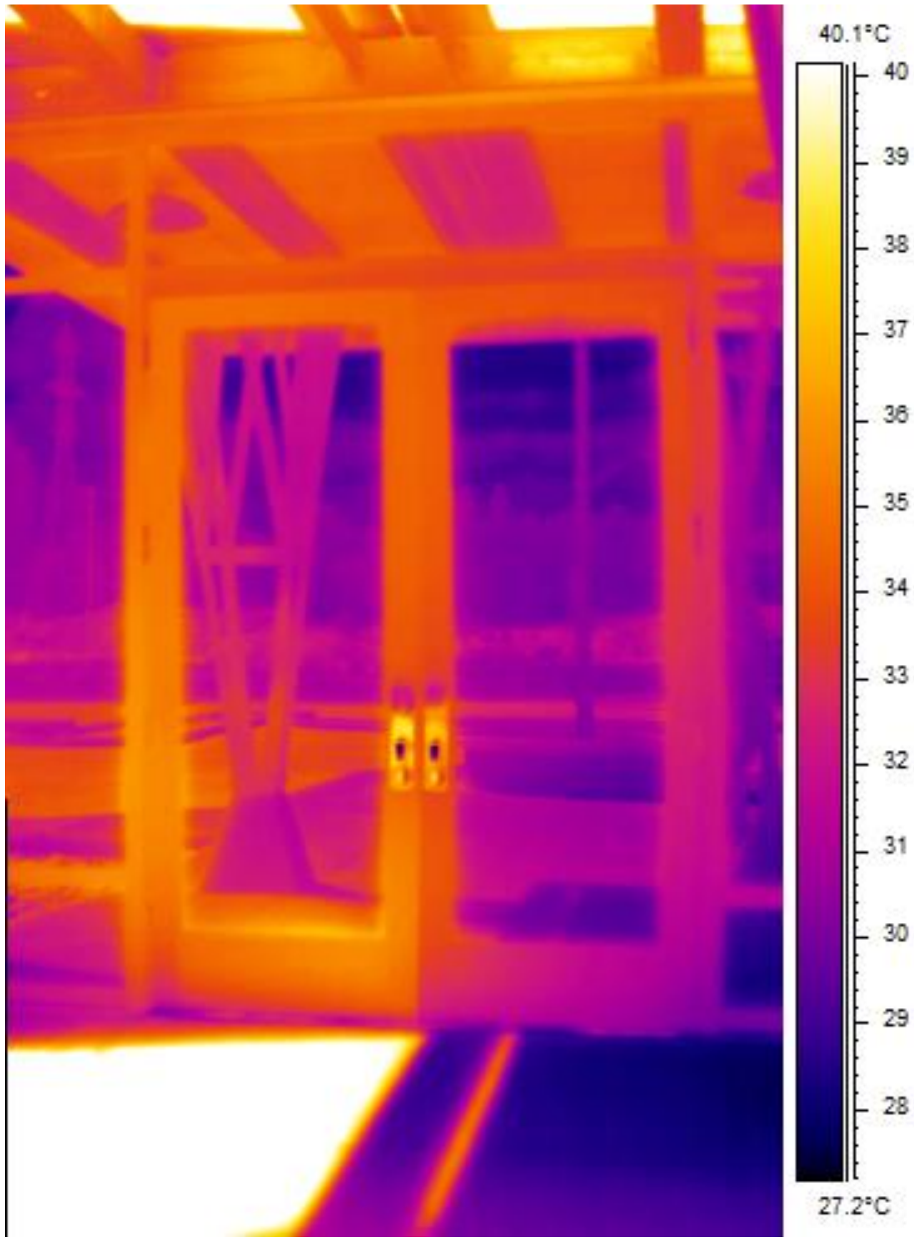
Thermography "sees" radiation

We "see" reflections

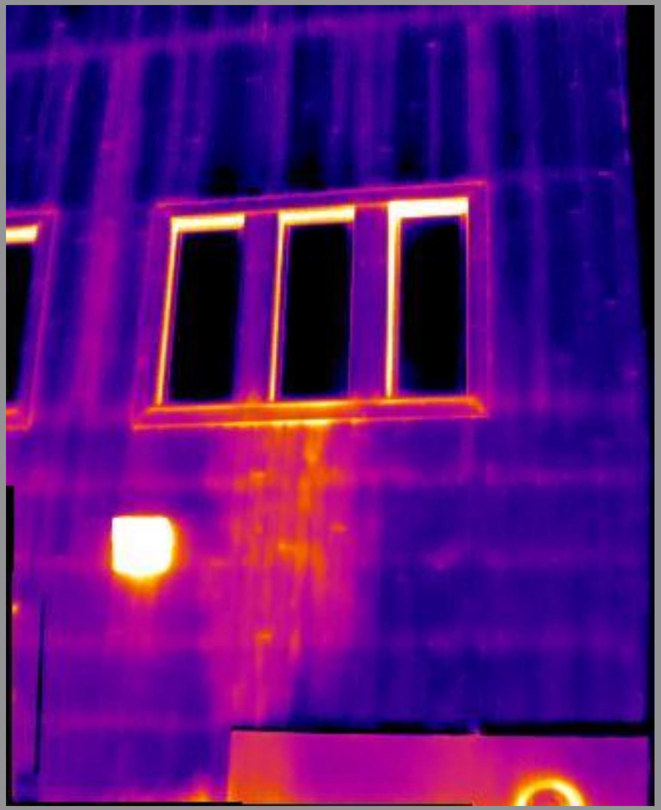
Thermal Imager



Converts invisible infrared radiation into a visible image.

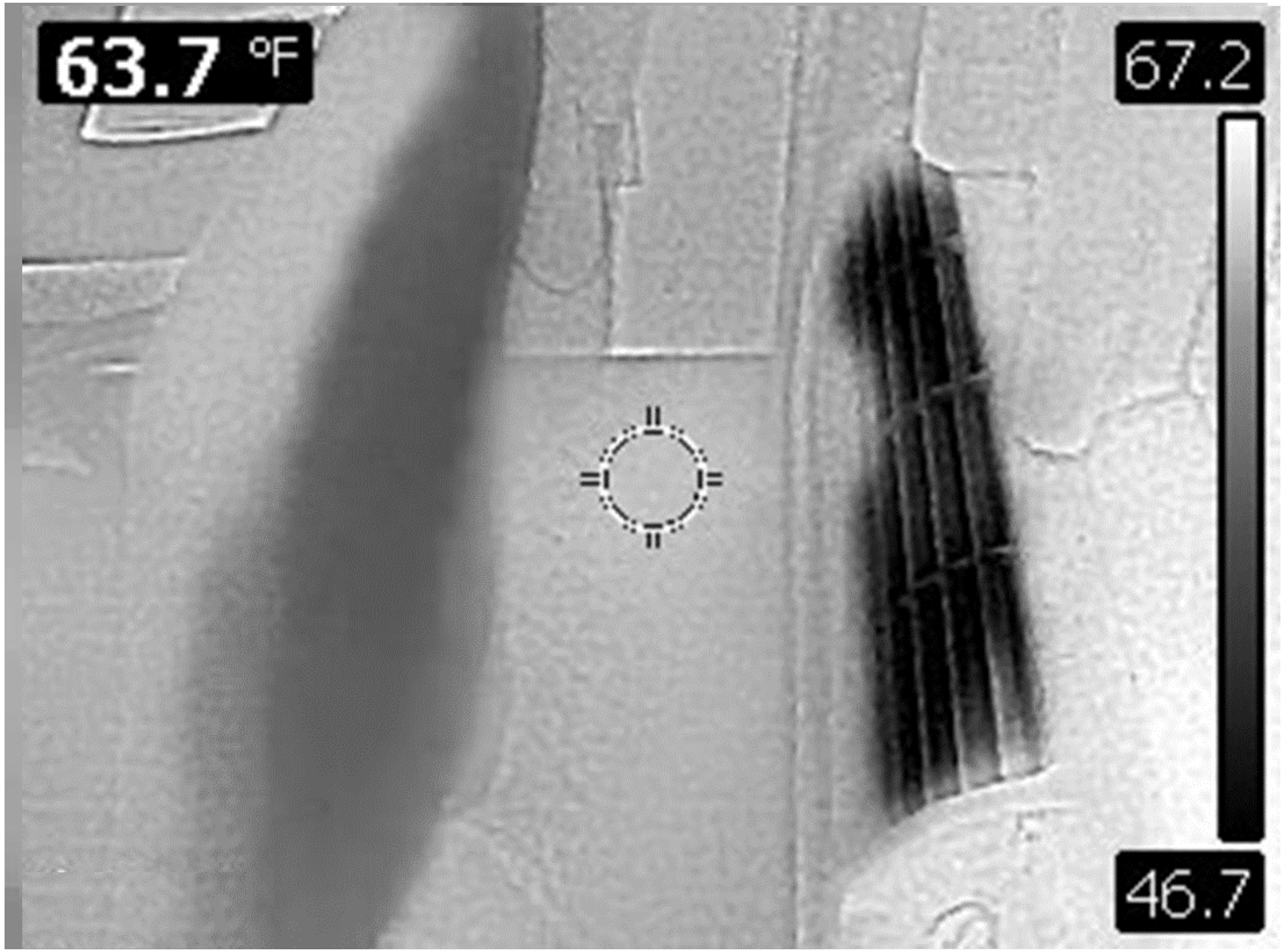


Interpreting the Thermal Image is KEY



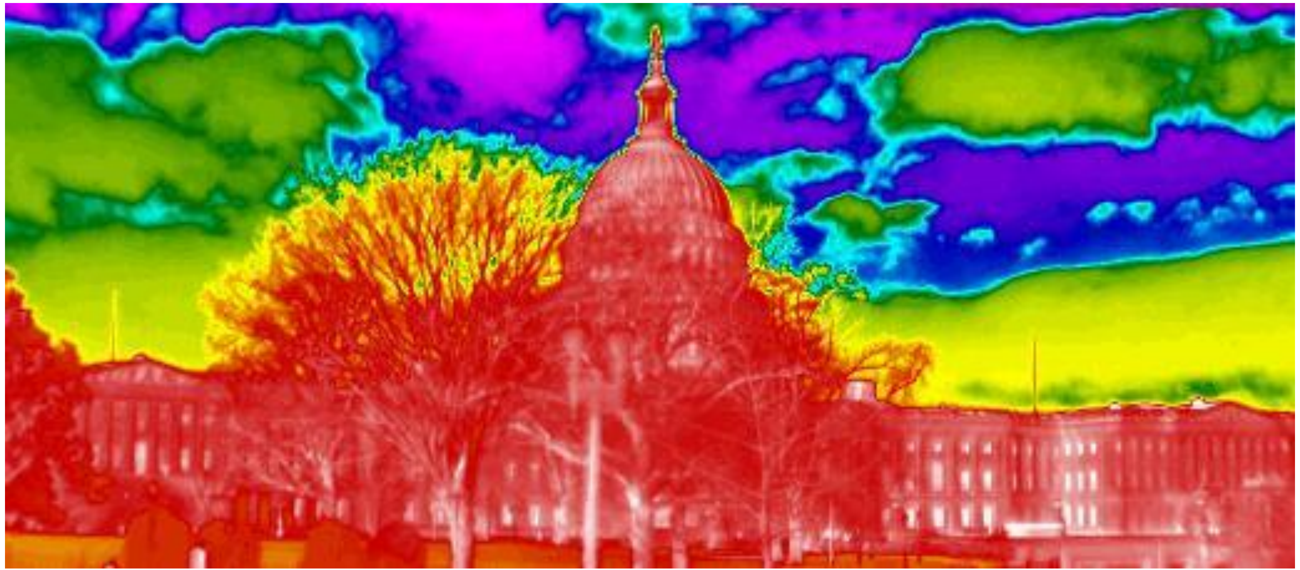
“Enhancements”

- Visual “Overlay”
- “Smoothed” IR
- Raw IR Image



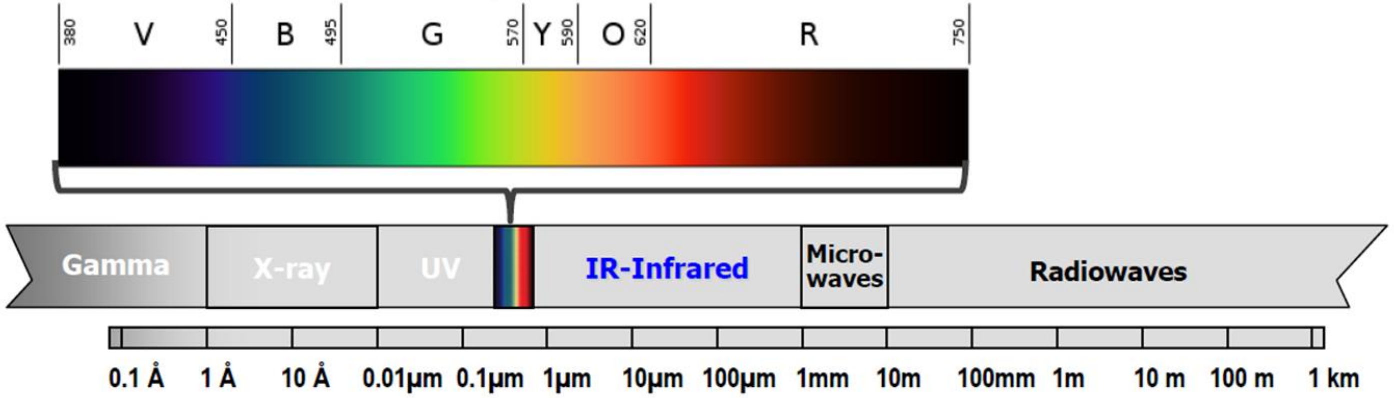
"Enhancements"

- Color?

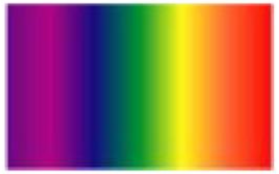


“Enhancements”

- Color?
- Is a specific wavelength of visible electromagnetic energy

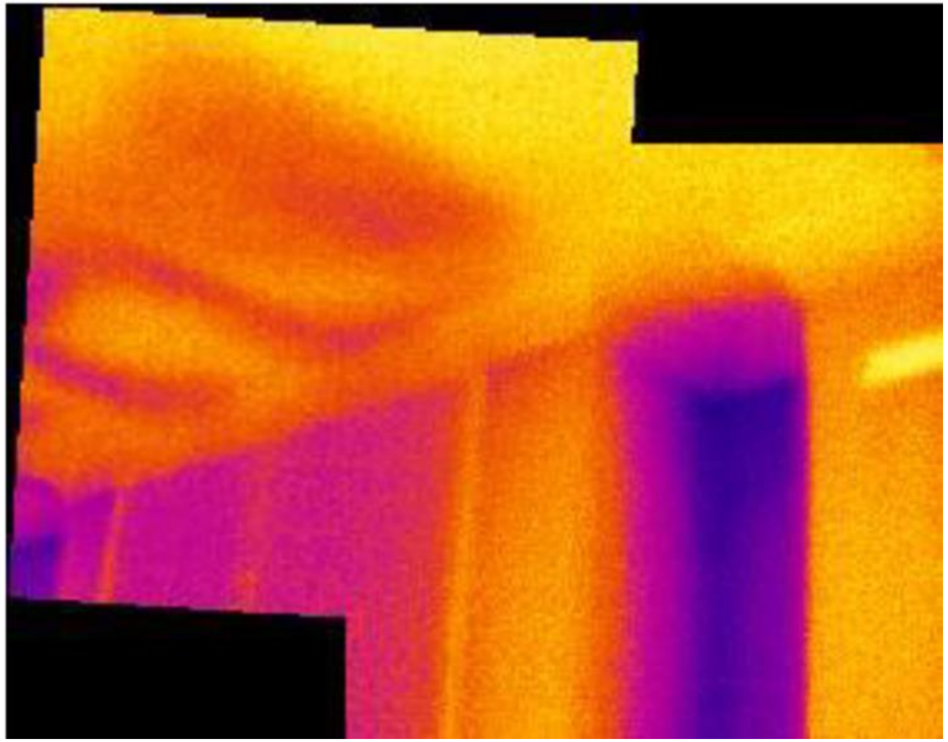


Sight 0.490 - 0.750µm



Visible Spectrum 0.400 - 0.790µm

Typical Thermal image (240x240)

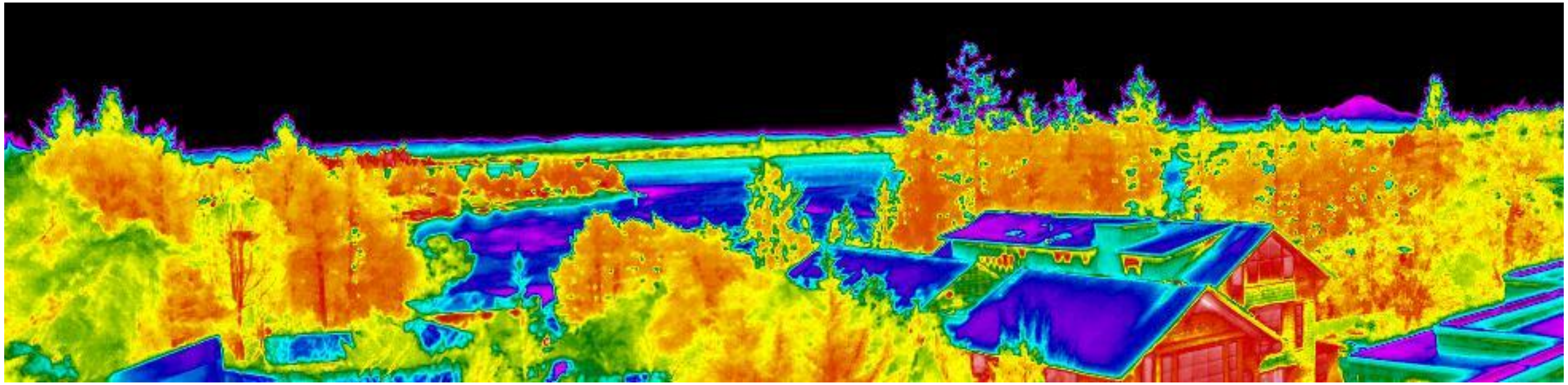


Images from Blair Freeman, Energy Leaks,
Melbourne Australia

High Resolution Thermal image?

- Smart Phone 7-16 megapixels

High Resolution Thermal image?

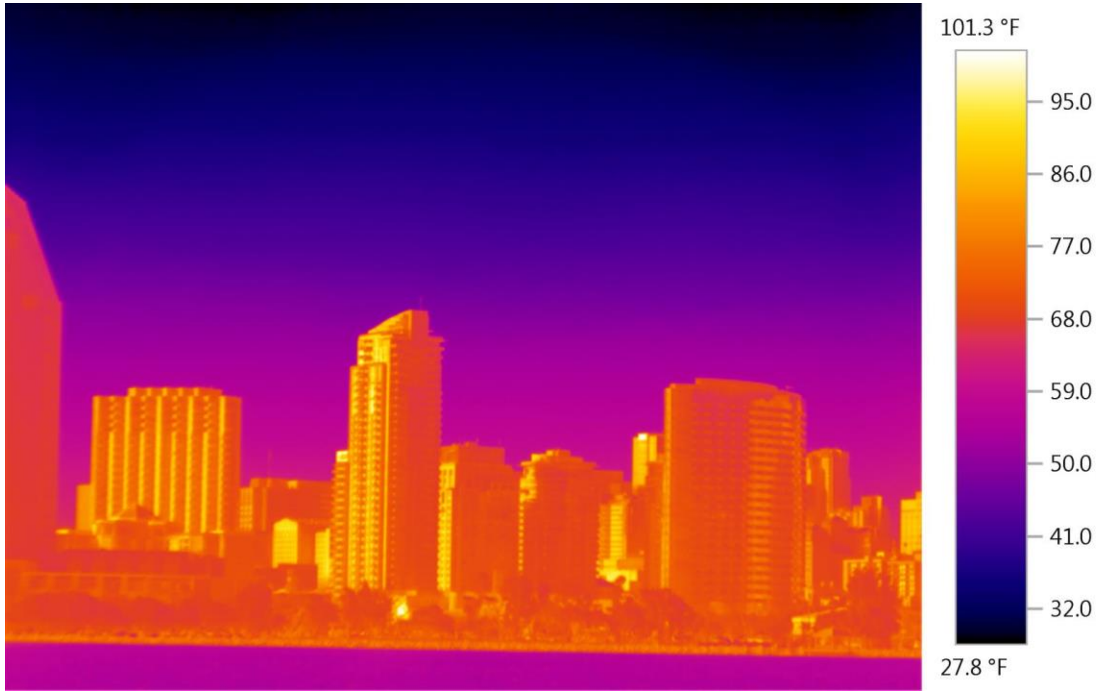


320x240 Composite

984x248 0.24 MP

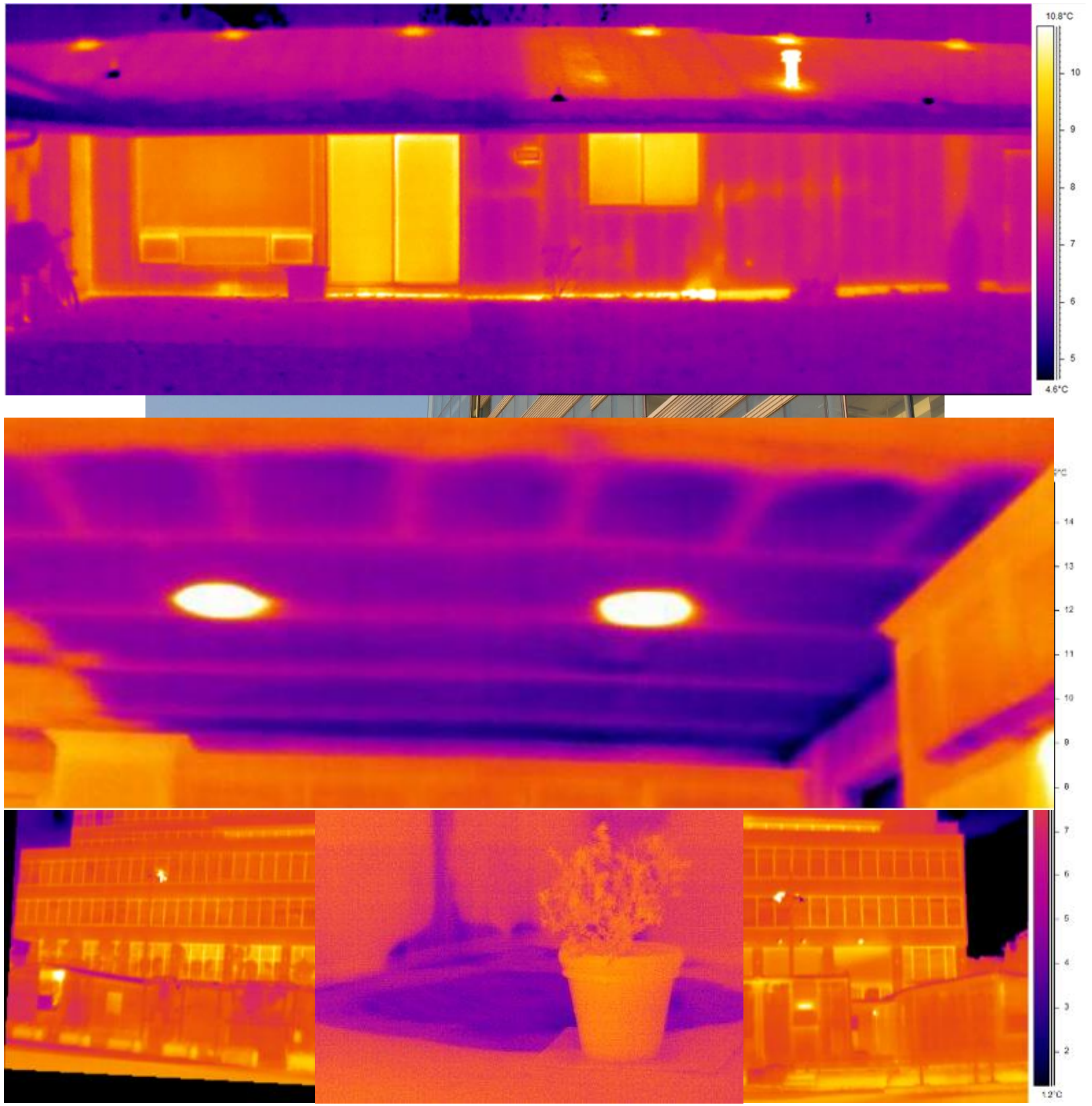
640x480

0.3 MP



Buildings Leak:

- Heat
- Air
- Moisture



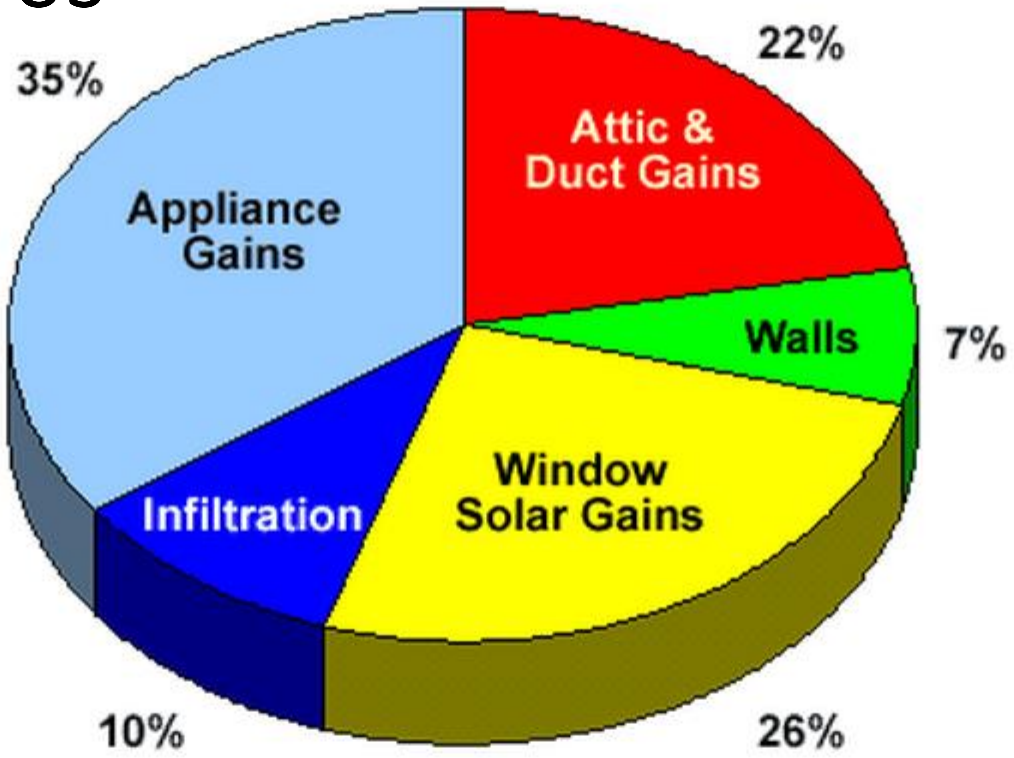
Radiant Heat Barriers

U.S. DEPARTMENT OF ENERGY | Office of Science

Radiant Barrier – Foil Low emissive surfaces

Radiant Barriers – Cooling Climates

- Provides 8-12% savings for cooling costs in the South East US (cooling climates)
- 6-7 year payback

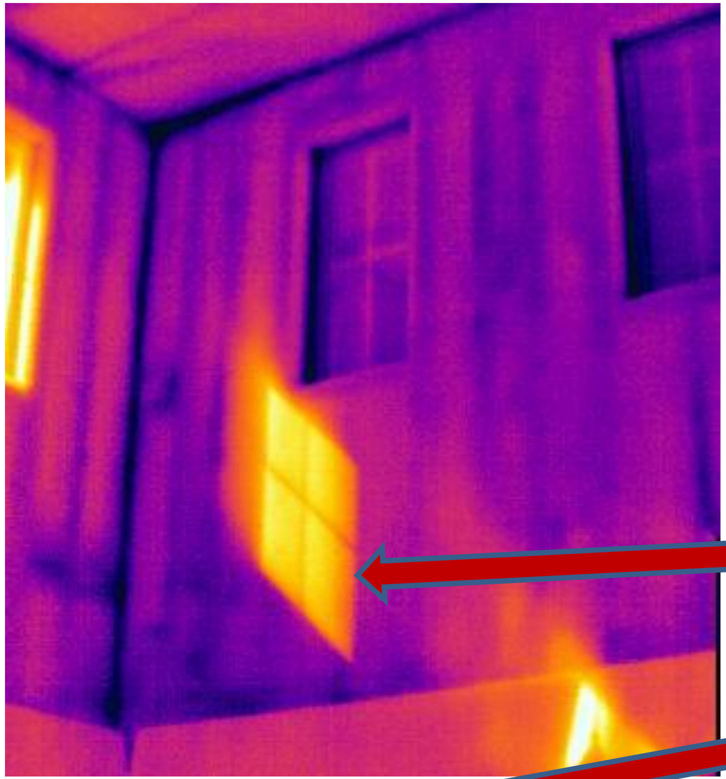


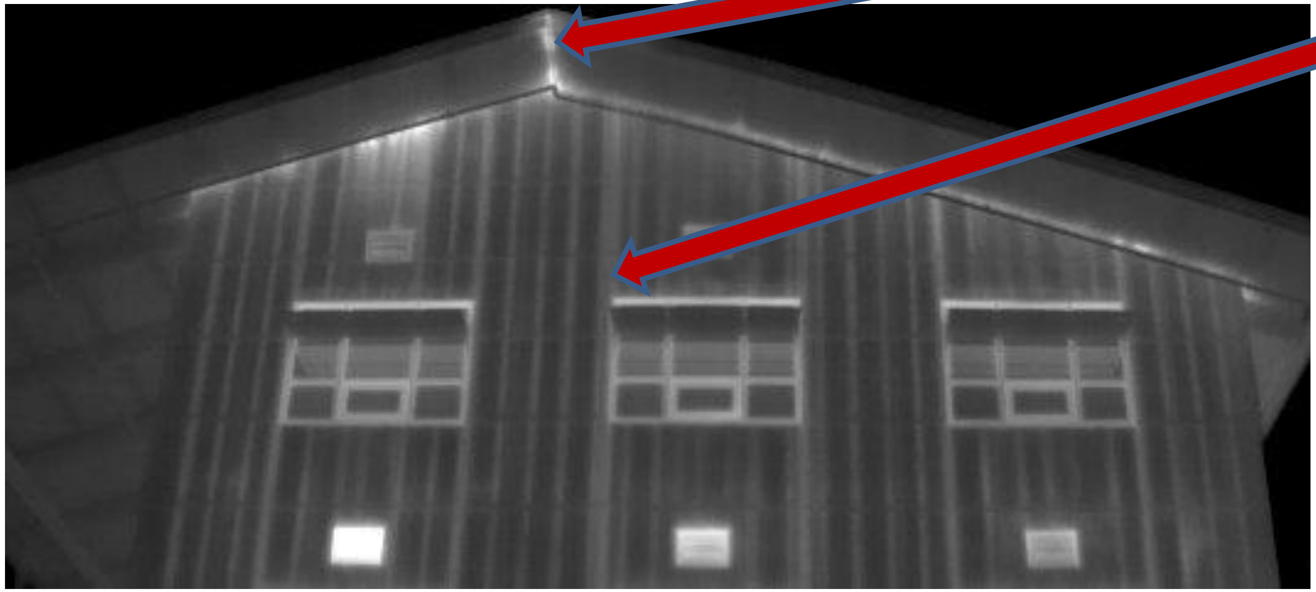
FSEC-EN-15 2005 Radiant Barriers: A Question and Answer Primer

Radiant Barriers – Heating Climates

- 1" air gap and 1"foil faced EPS
- Foil increased the R-value only 1.4%
- And is a vapor barrier

2011.04.12 Cold Climate Housing Research Center, Reflective Insulation in Cold Climates



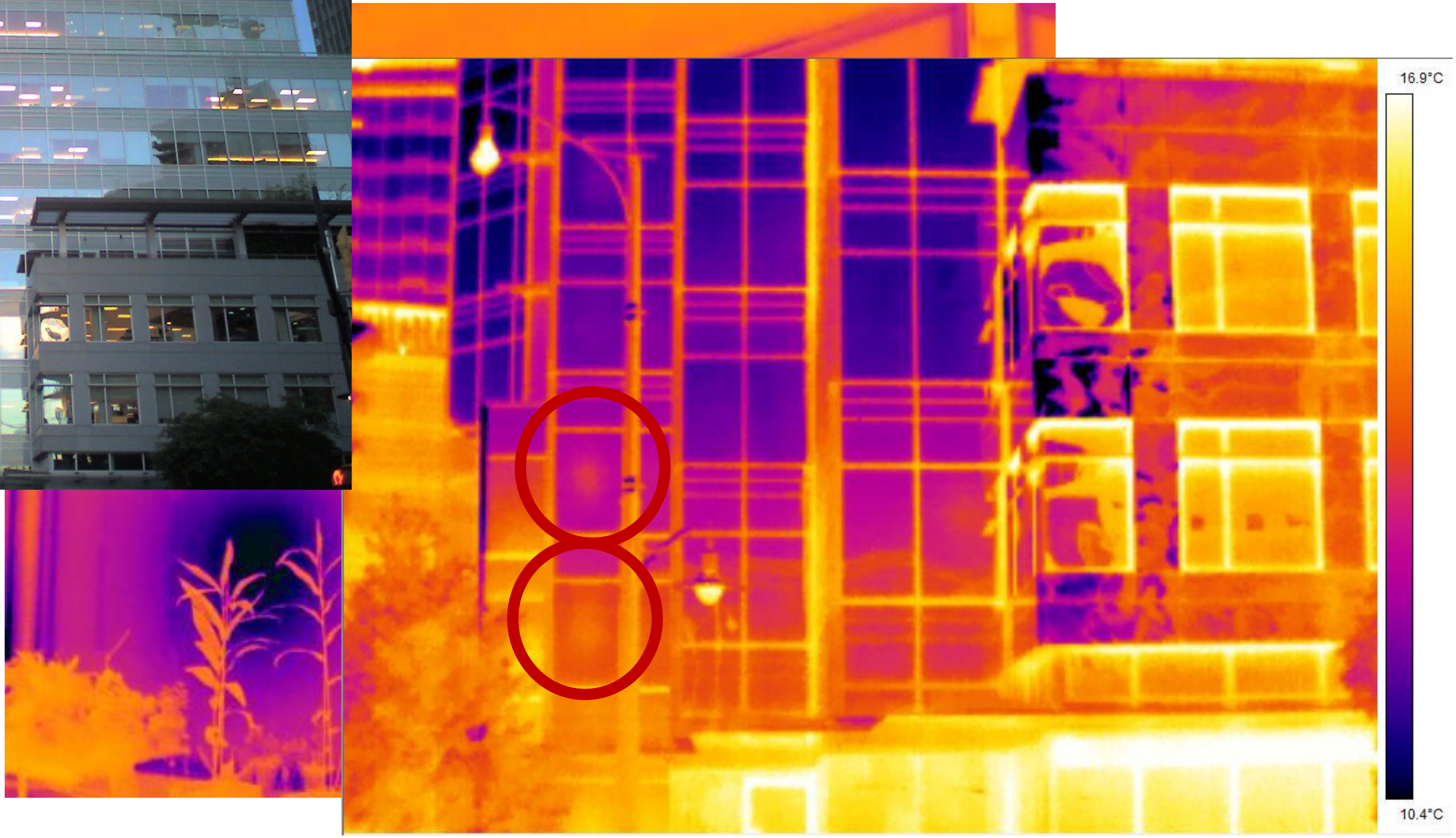


➢Heat

Modes of Heat transfer:

- Radiation
- Convection
- Conduction

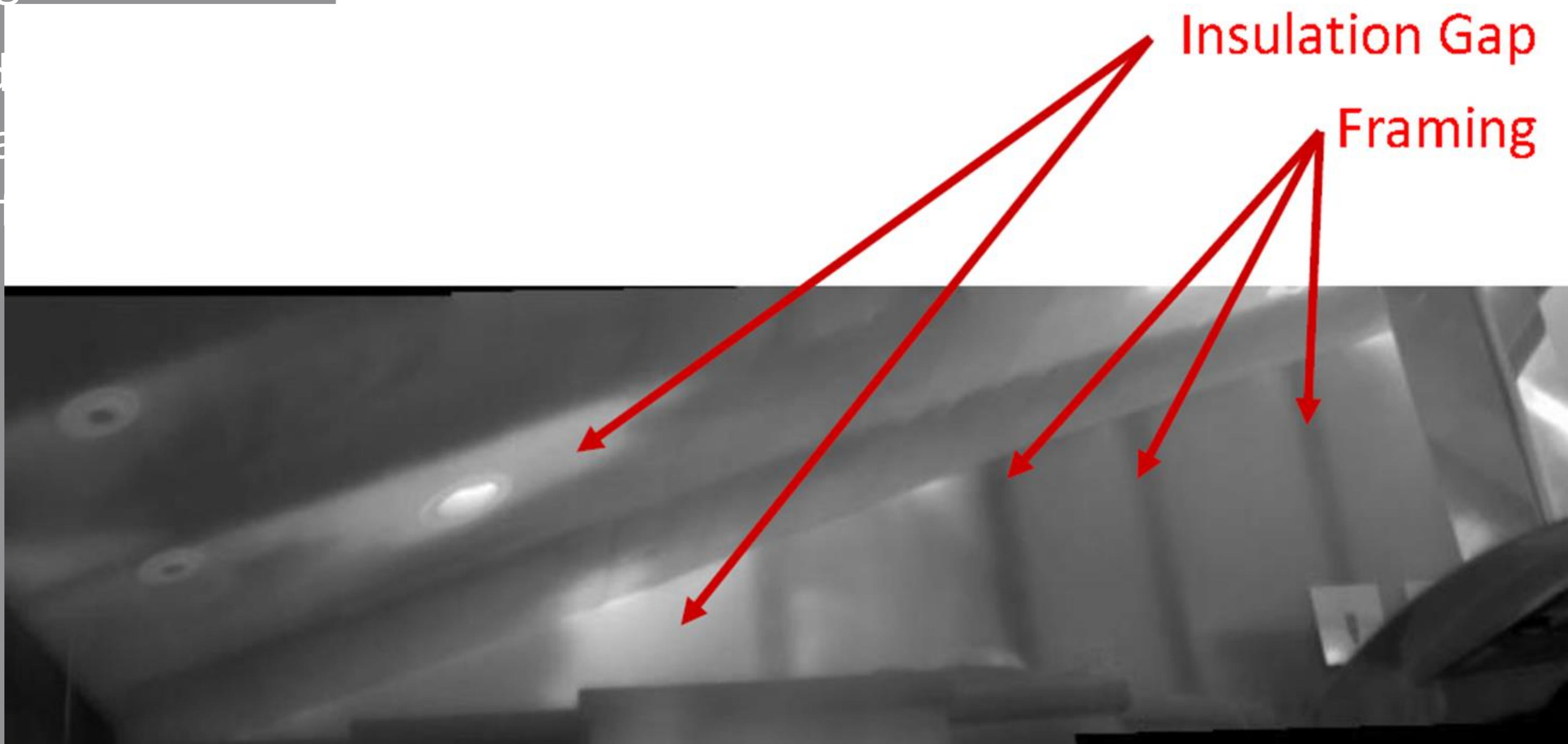
Conductive Heat Transfer



Standards

- Walls: ASTM C1060 Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings
- Roof: ASTM C 1153 Stand
for Location of Wet Insula
Roofing Systems Using Inf
Imaging

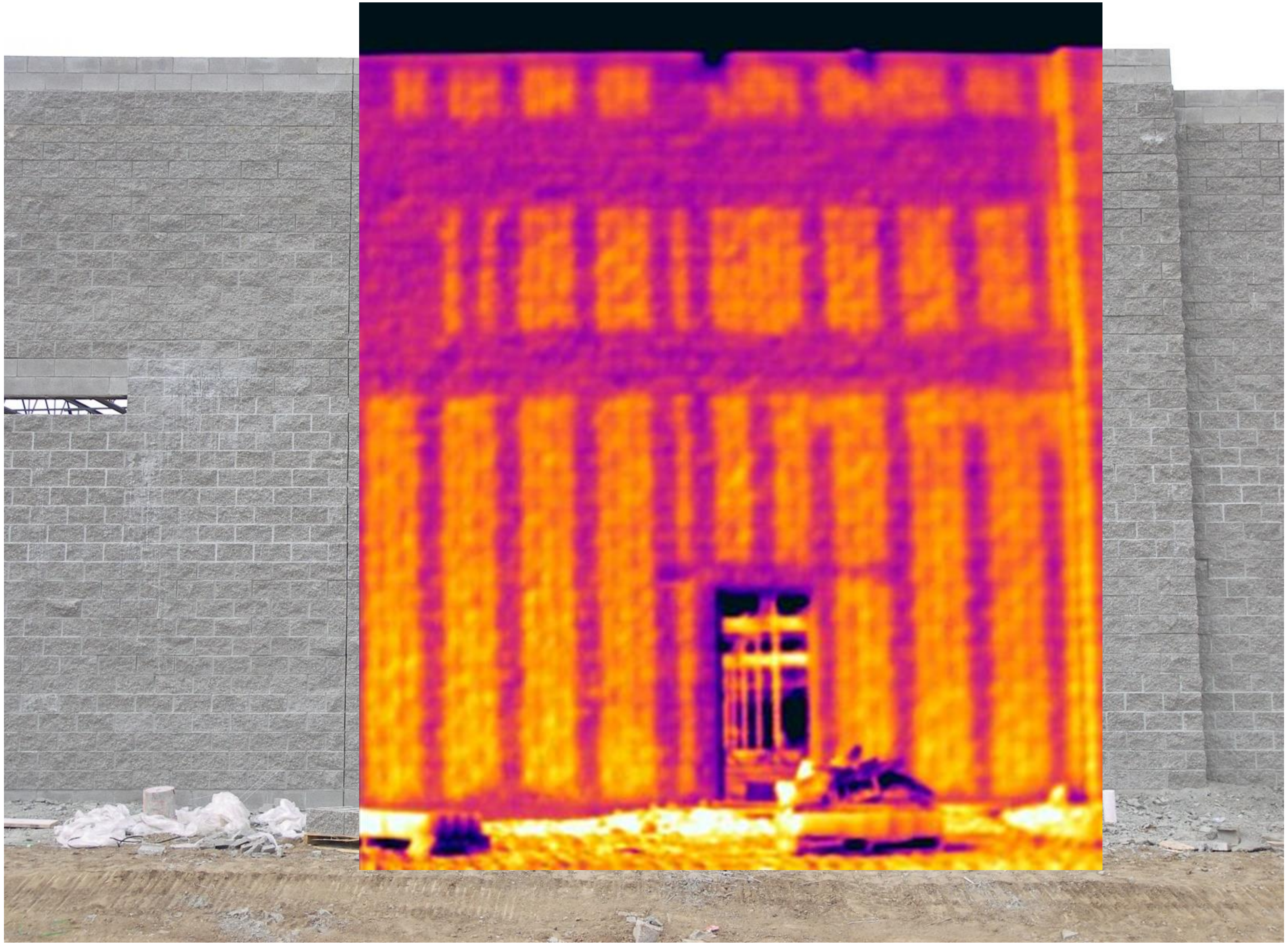
- Mottled looking variation in the thermal patterns
- Framing should be visible



Thermal Bridging

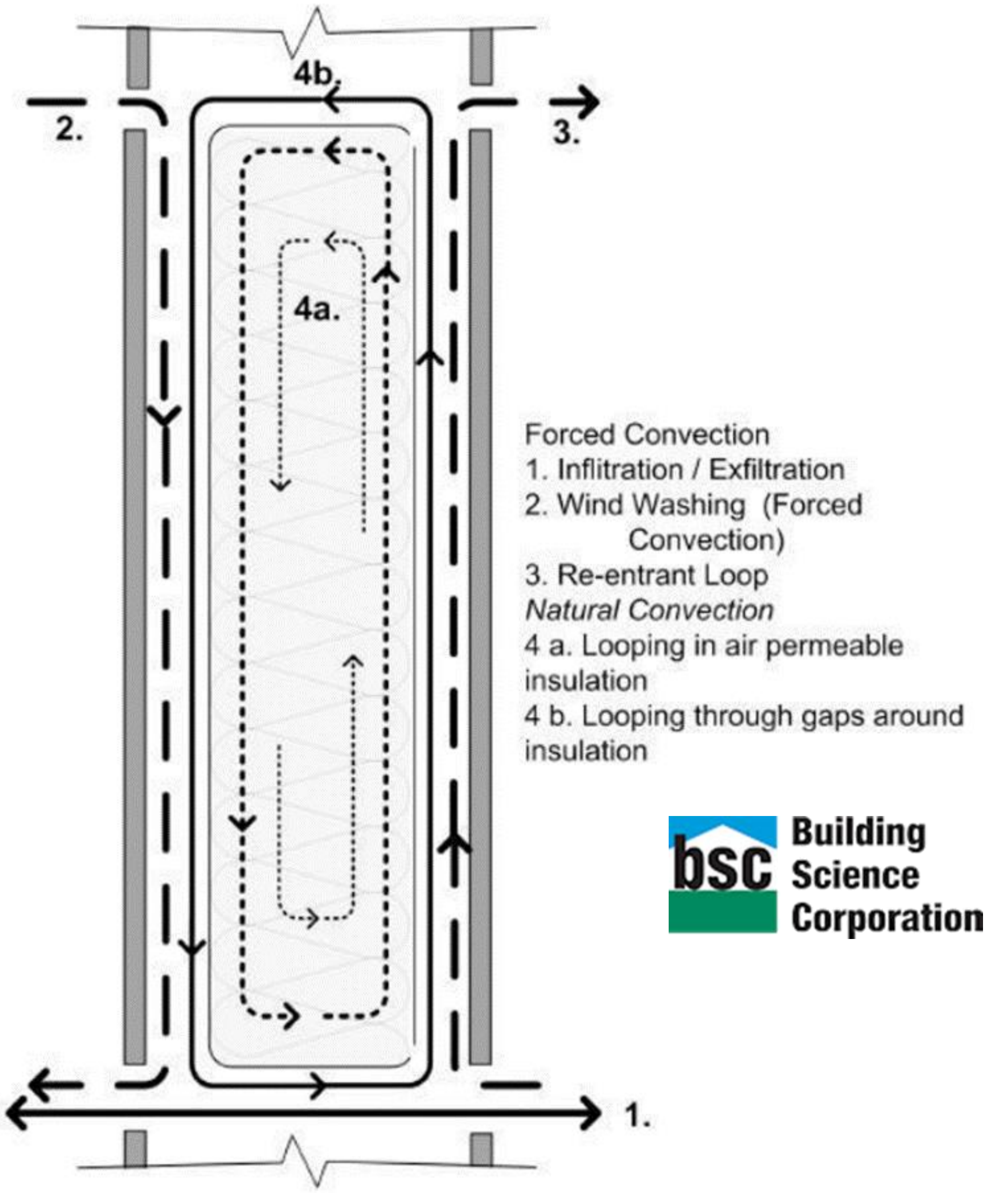
Continuous Insulation

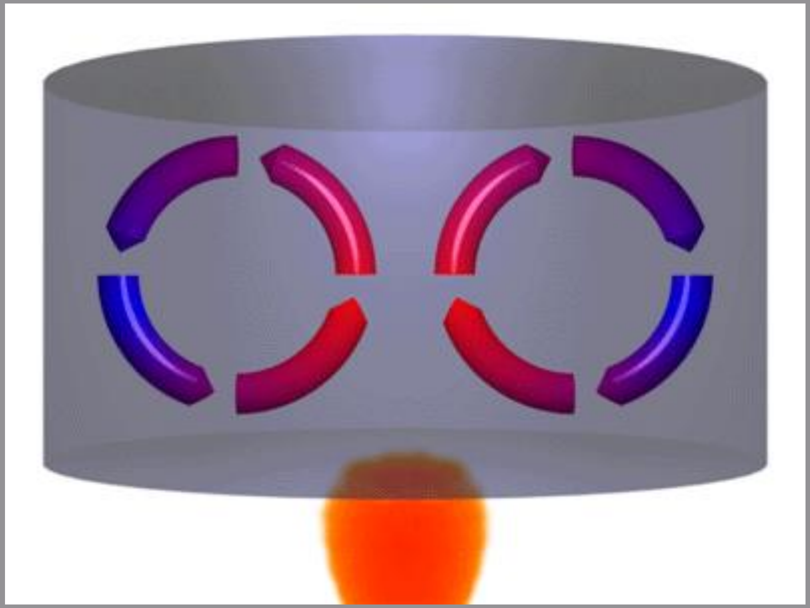
Concrete Masonry Unit (CMU)



➢Heat

- Convection (Air Movement)

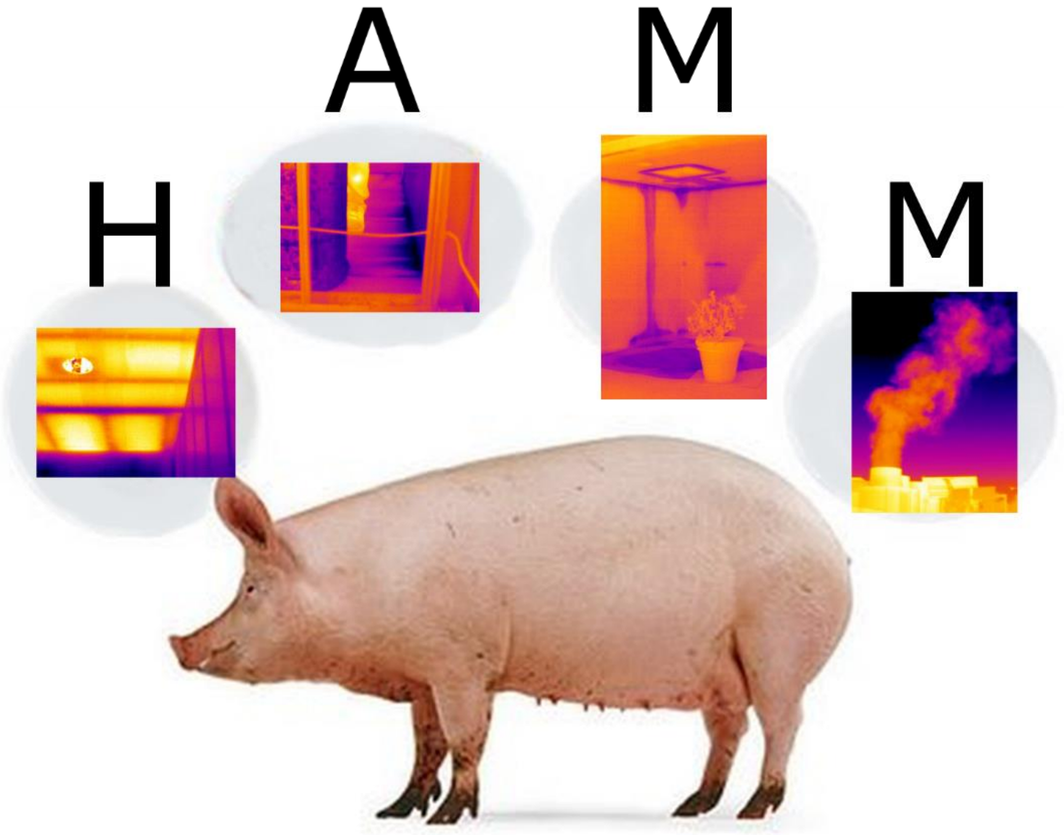




The Enclosure Envelopes the Building

H: Thermal control

A: Air control



Air Barrier

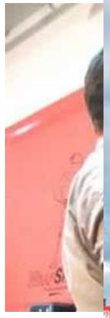
- Material prevents air movement as tested by **ASTM E2178-13**, Standard Test Method for Air Permeance of Building Materials

- Assemblies: **ASTM E2357-11**, Standard Test Method for Determining Air Leakage of Air Barrier Assemblies

- Buildings: **ASTM E779** Standard Test Method for Determining Air Leakage Rate by Fan Pressurization

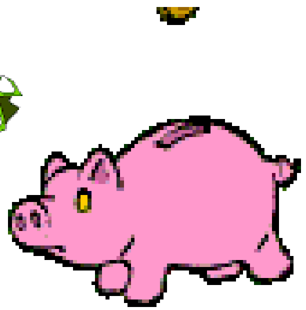
< 0.004 cfm/ft^2 @ 1.57 lb/ft^2
(0.02 L/s•m^2 @75 Pa)

< 0.04 cfm/ft^2 @ 1.57 lb/ft^2
(0.02 L/s•m^2 @75 Pa)



< 0.4 cfm/ft^2 @ 1.57 lb/ft^2
(0.25 L/s•m^2 @75 Pa)

Must be a Continuous System
six sides to a building



Air Leakage Reduction

- Studies have shown that air barriers can reduce air leakage by up to 83%
- Energy consumption for heating & cooling savings up to 40%

Air Transported Moisture

- 1961, A. G. Wilson at the NRC
- 1965, Kirby Garden at the NRC
- 1977, G. Handegord at the IRC-NRC concluded in a paper entitled, “The need for Improved Airtightness in Buildings”, that air leakage through construction is “the principle means by which water vapor moves to cold surfaces and is the major cause of condensation in buildings.

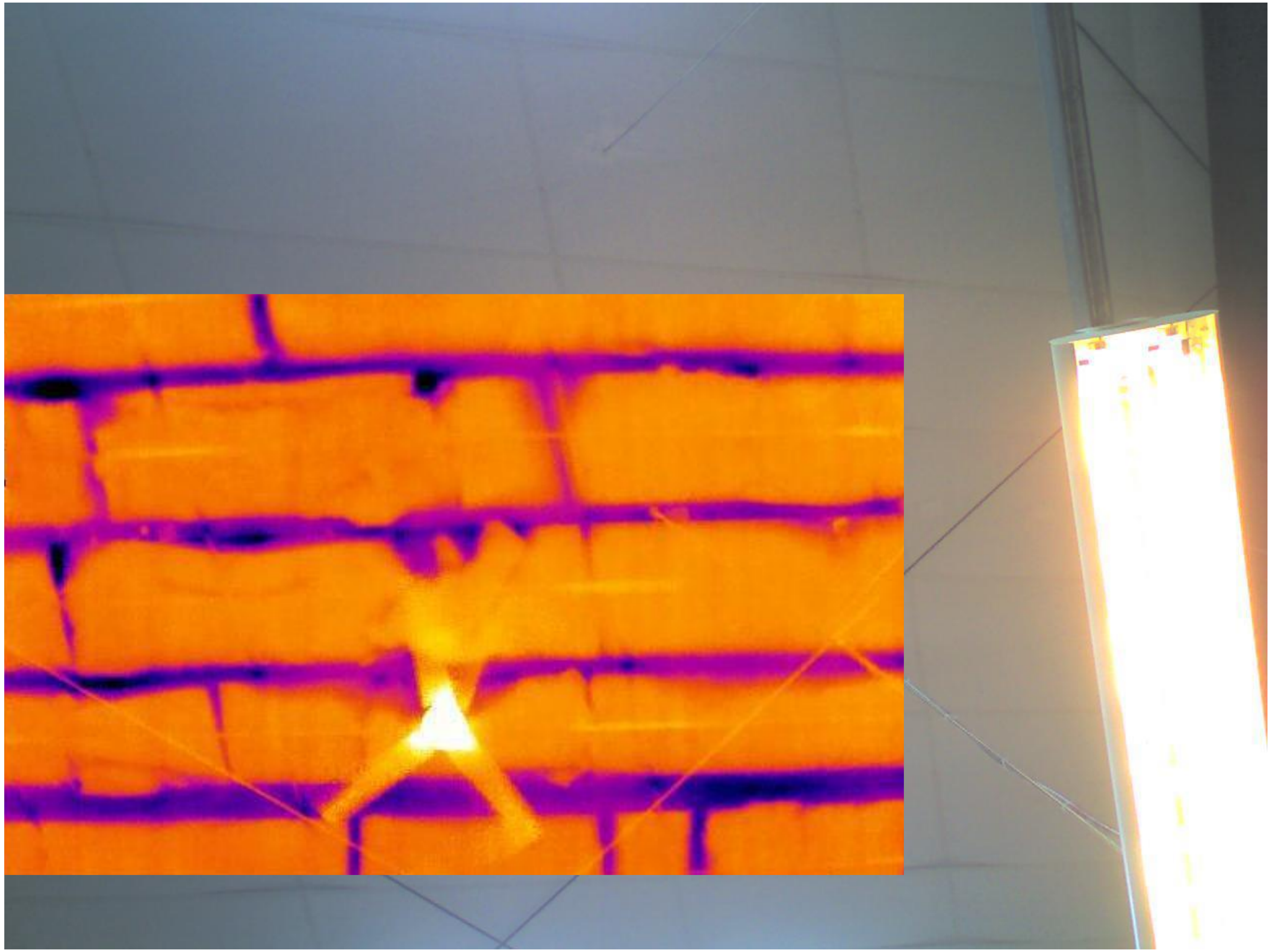
“Seal tight, Ventilate right”

Viewing Air Leaks

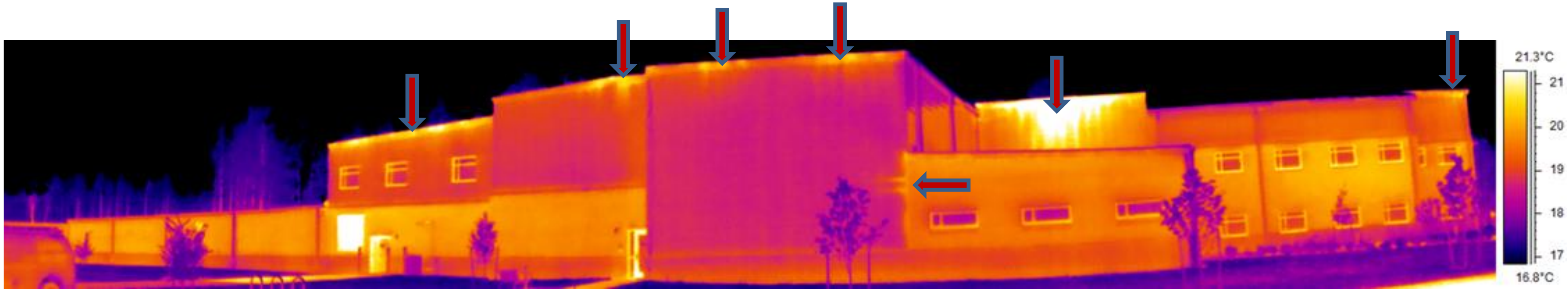
- Infrared Thermography

- Traditional smoke generator

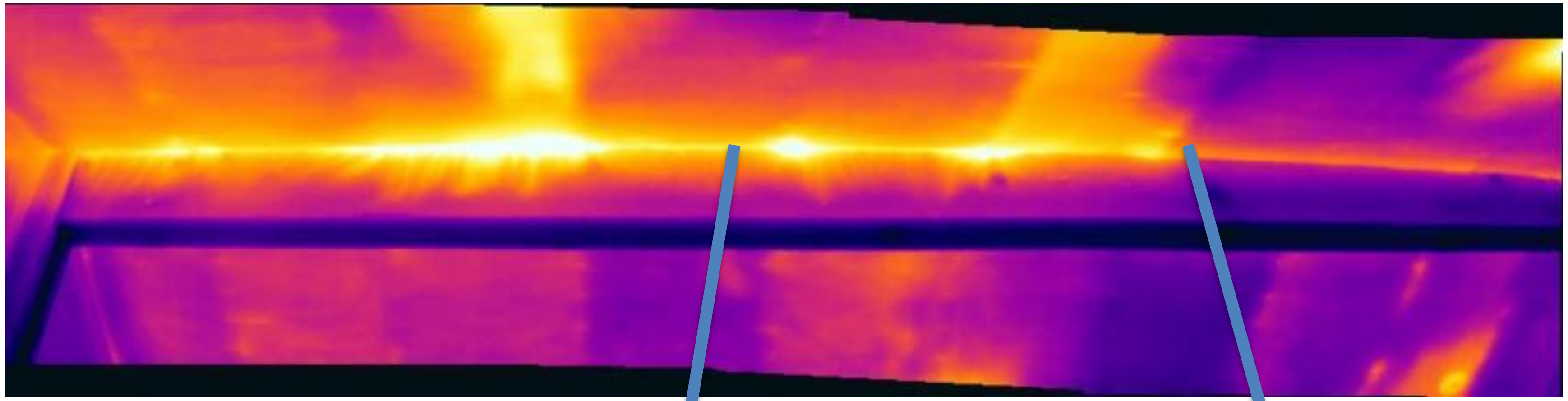
Is it continuous?

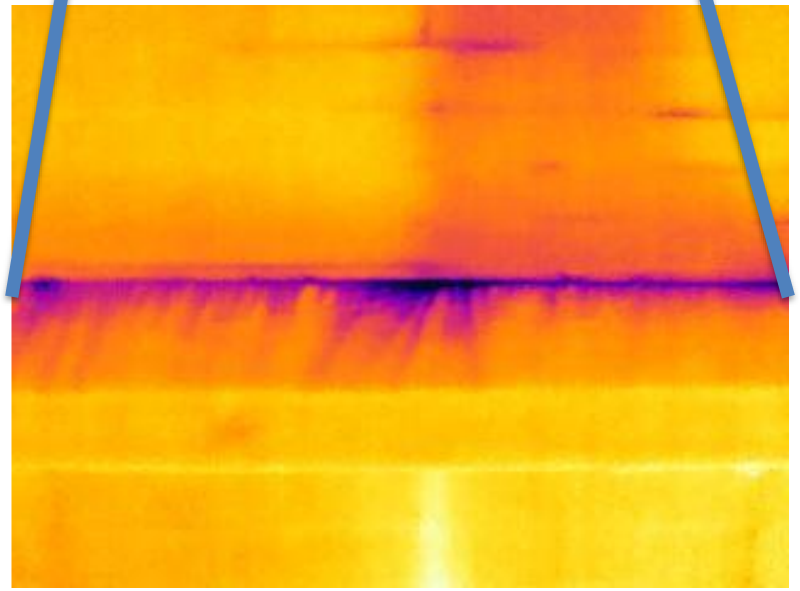


It Passed Air Barrier Tightness but…

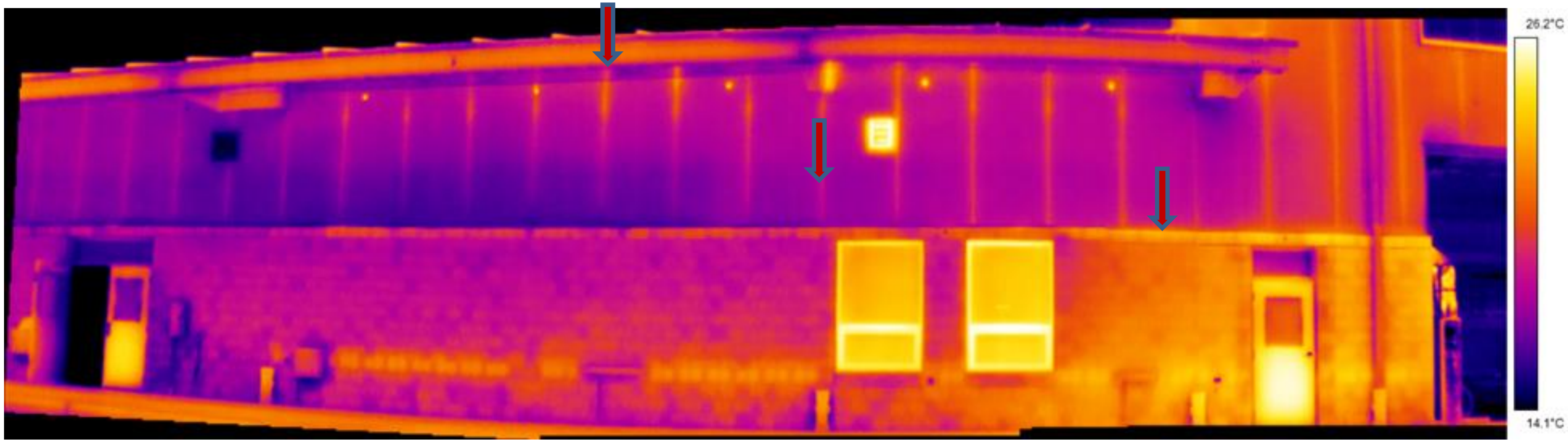


Warm or Cold

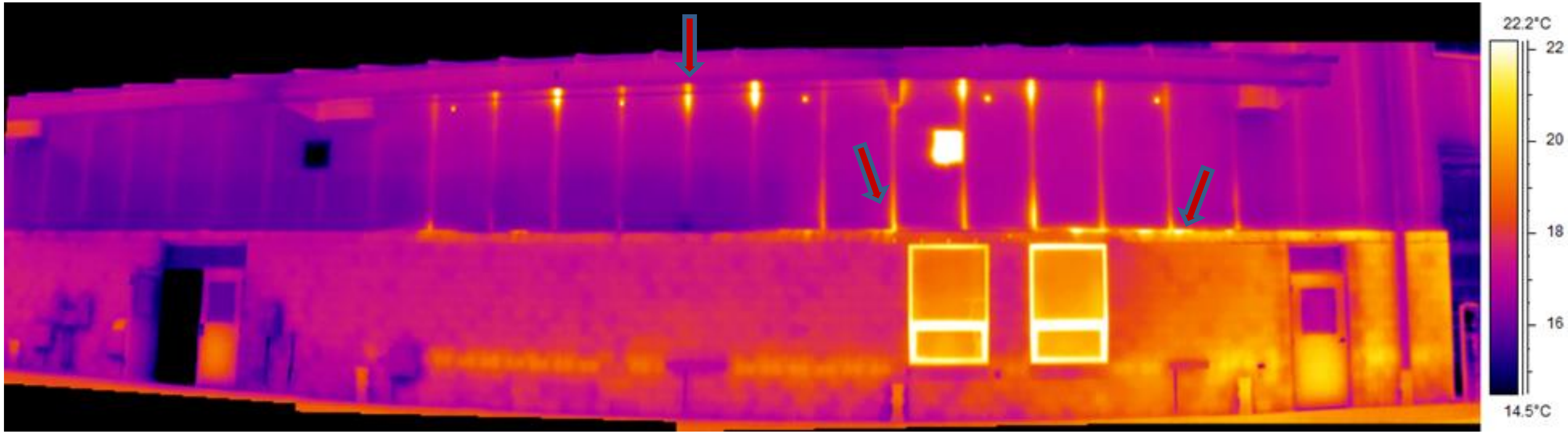




It’s just conduction?



Negative Pressure



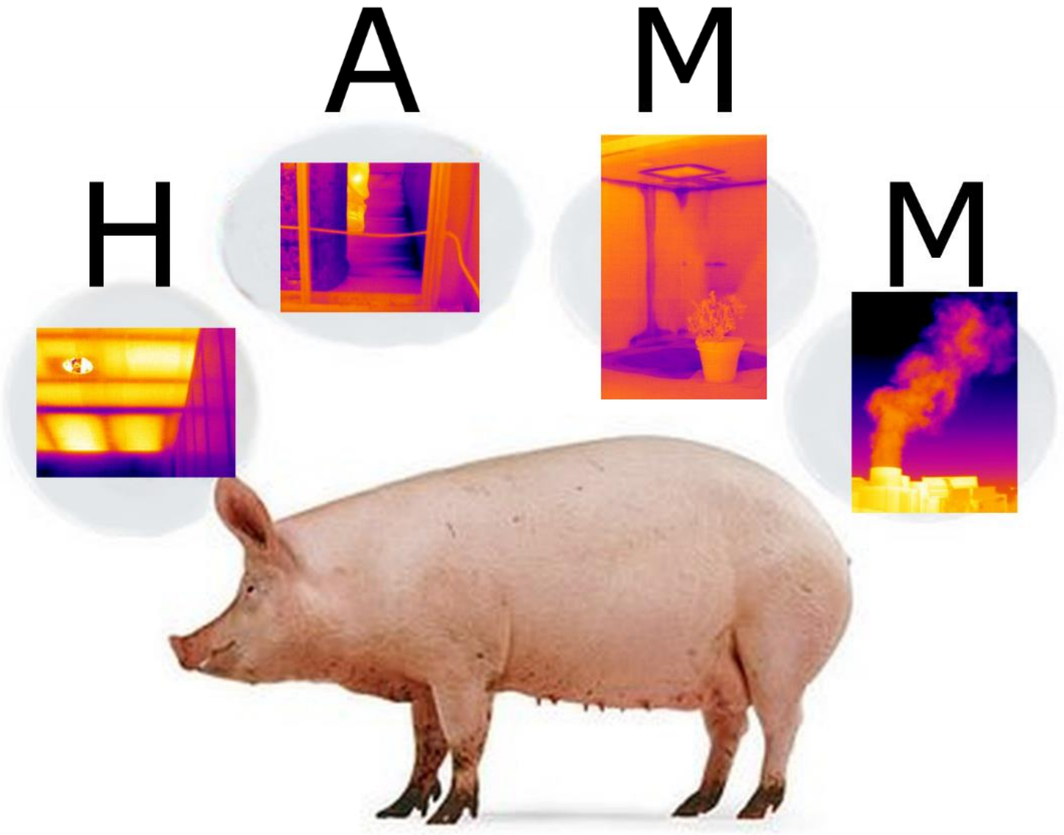
Positive Pressure

The Enclosure Envelopes the Building

H: Thermal control

A: Air control

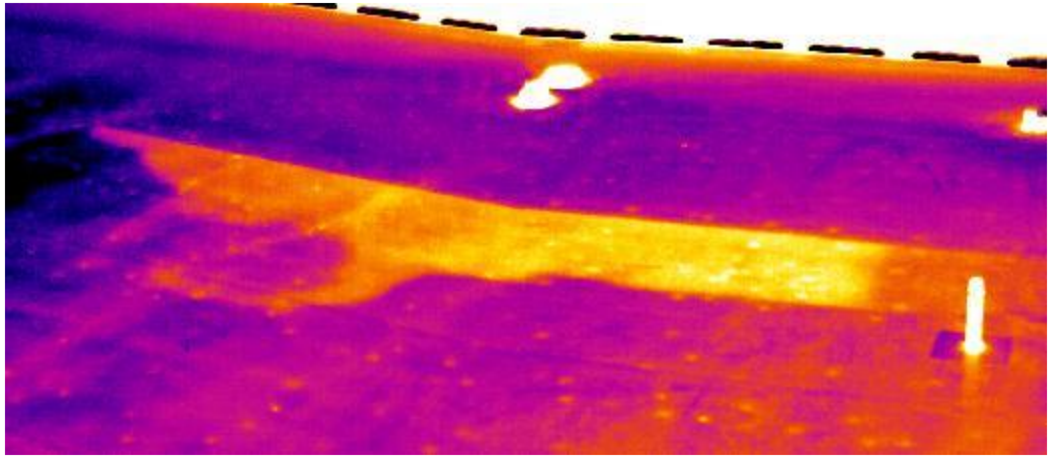
M_{liquid}: Rain control

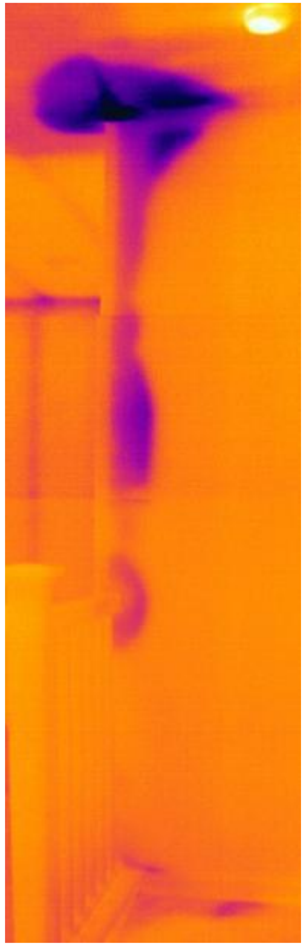


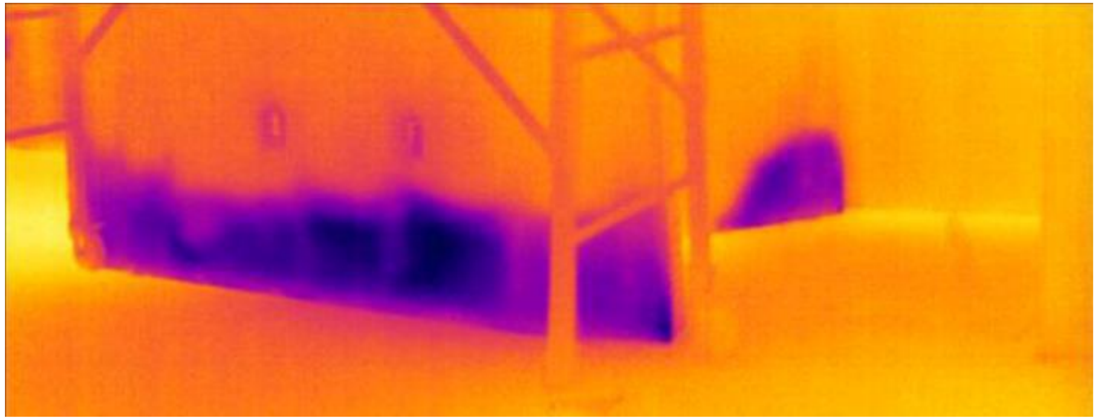
Moisture Meters or Thermography

Thermography's Moisture Detection

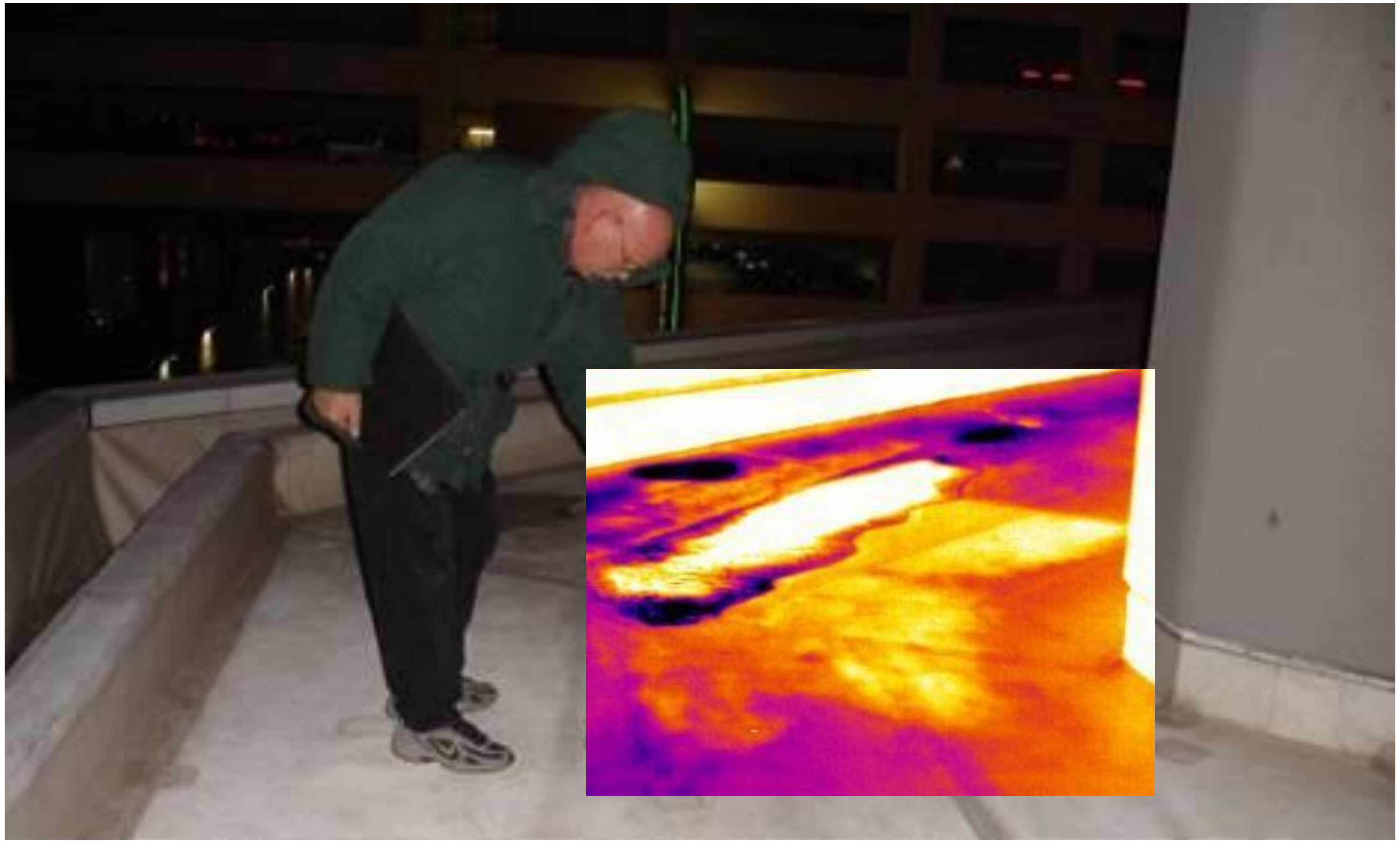
- Evaporative Cooling
- Thermal Capacitance



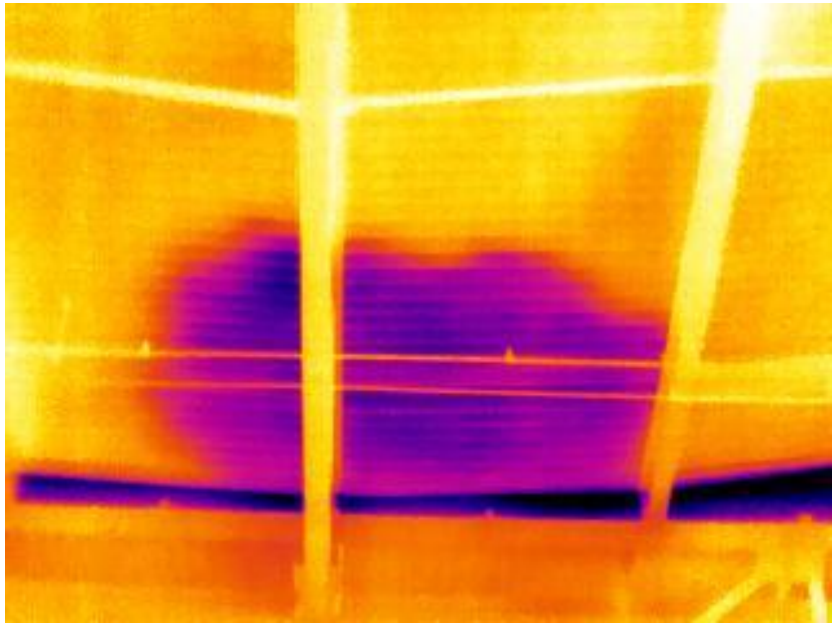


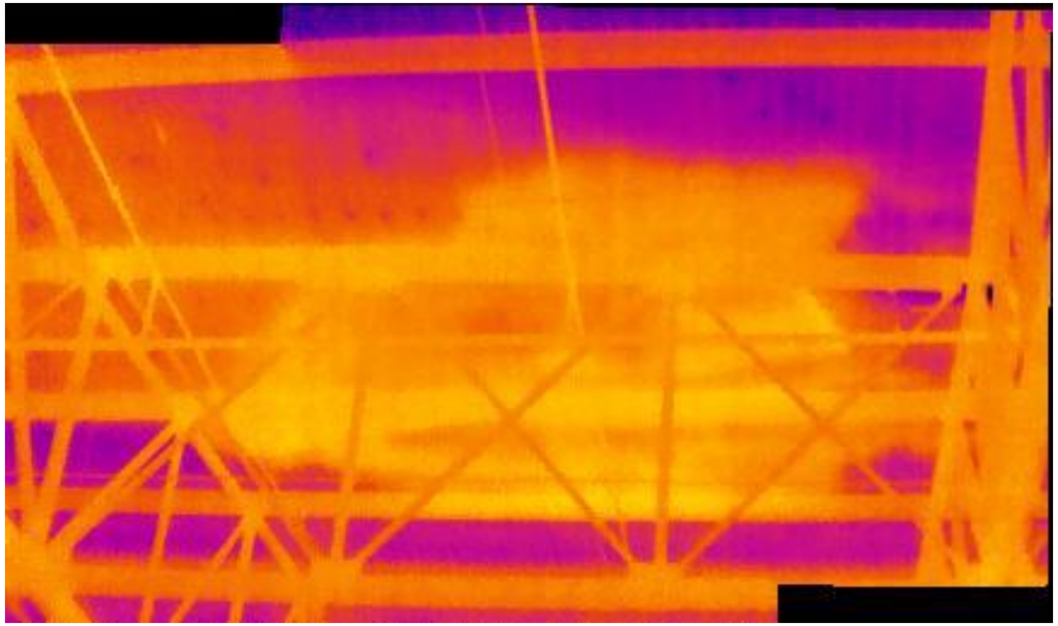


Capacitance Moisture Meter and Thermography

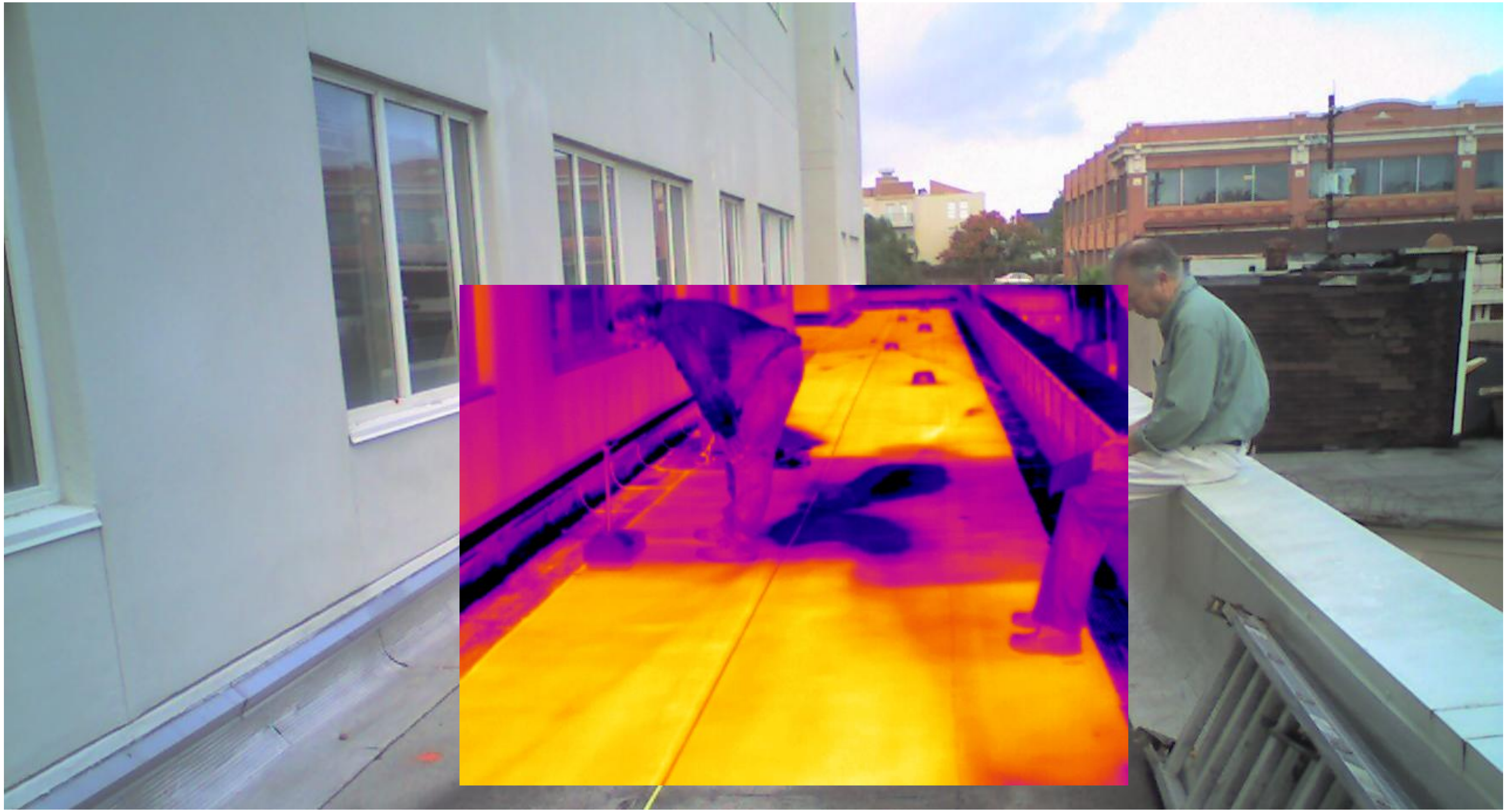


Thermal Capacitance Slows Cooling and Heating



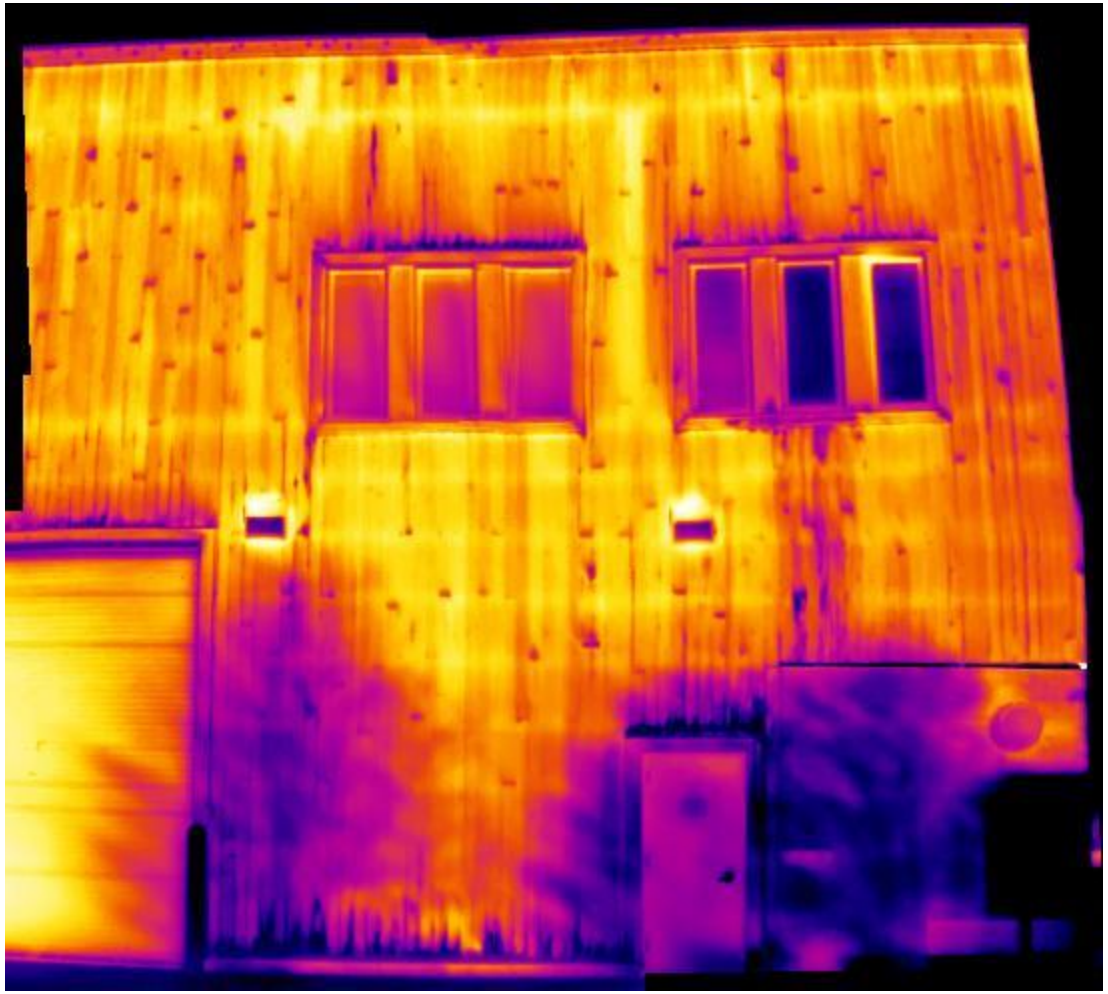


Nuclear Moisture Survey and Thermography

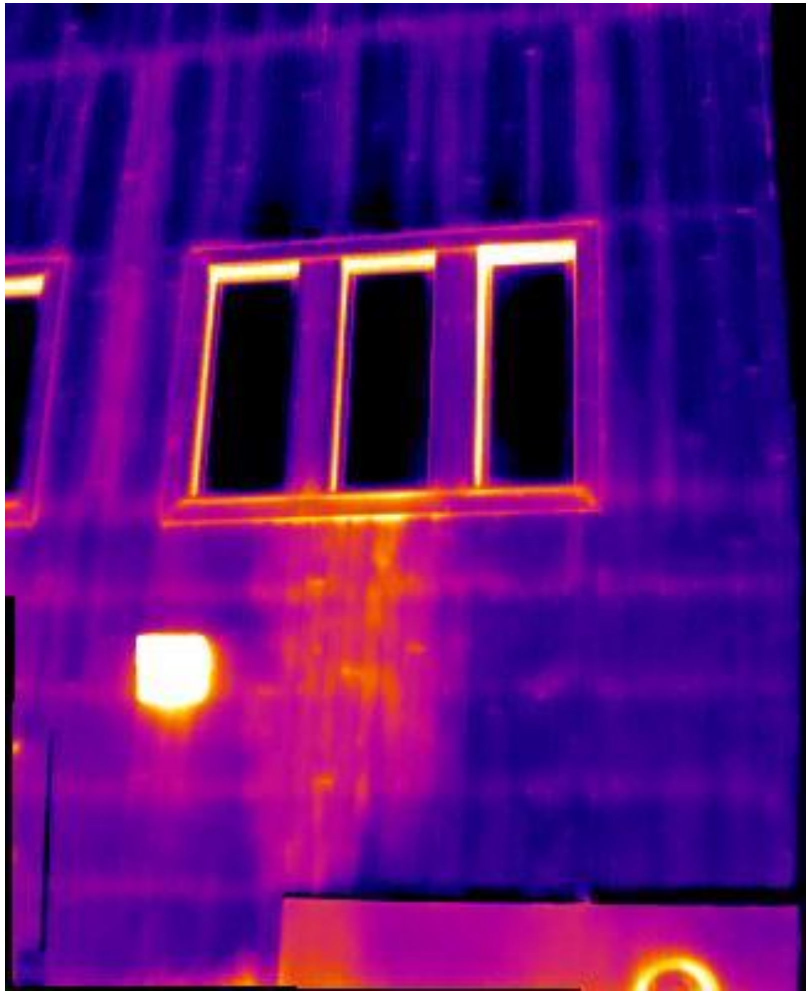


Trapped Moisture Within Walls

Morning



Evening



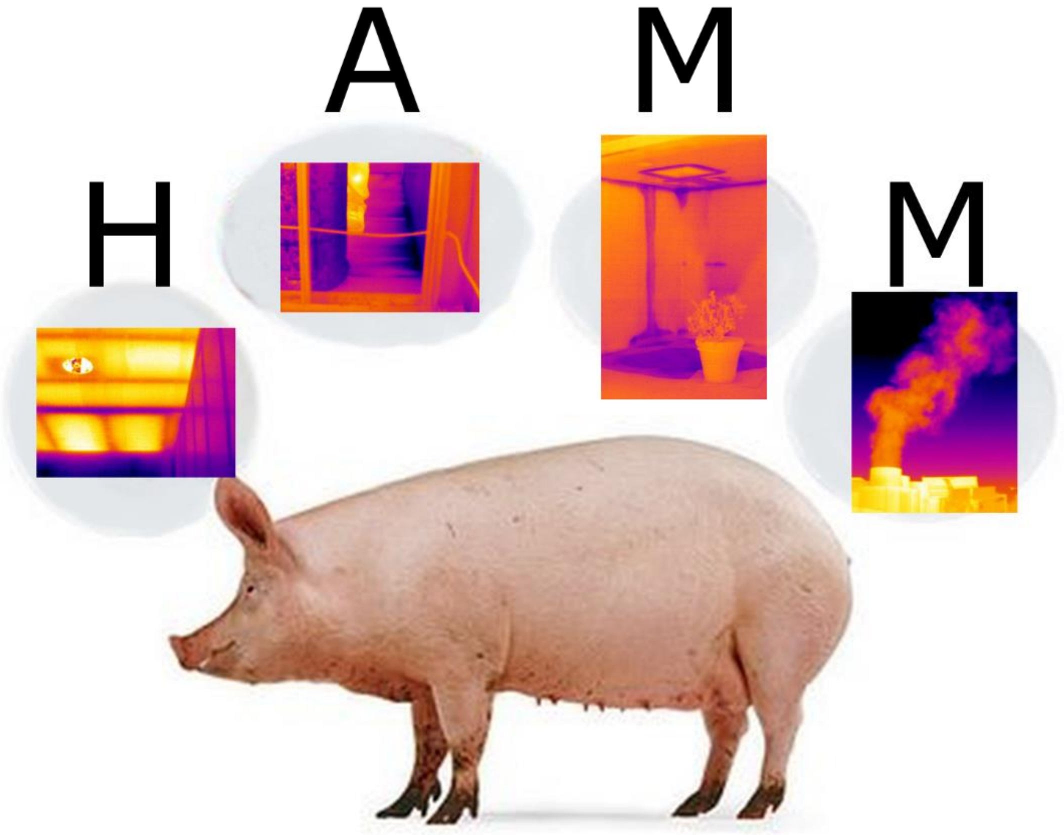
The Enclosure Envelopes the Building

H: Thermal control

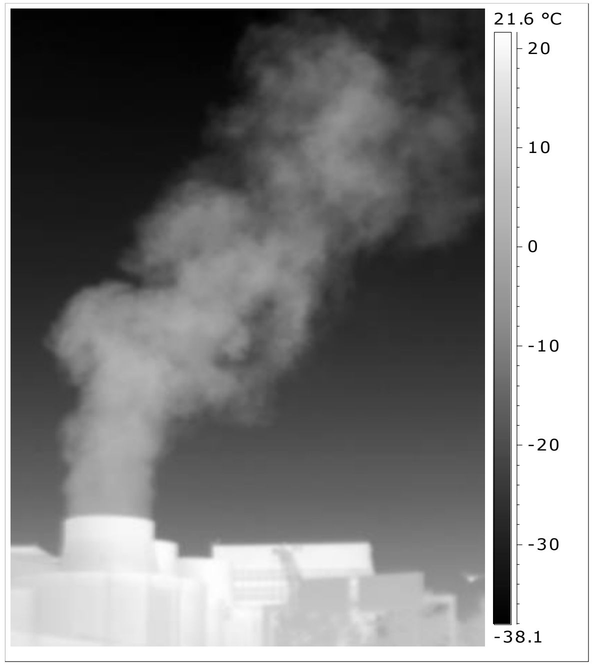
A: Air control

M_{liquid}: Rain control

M_{vapor}: Vapor control

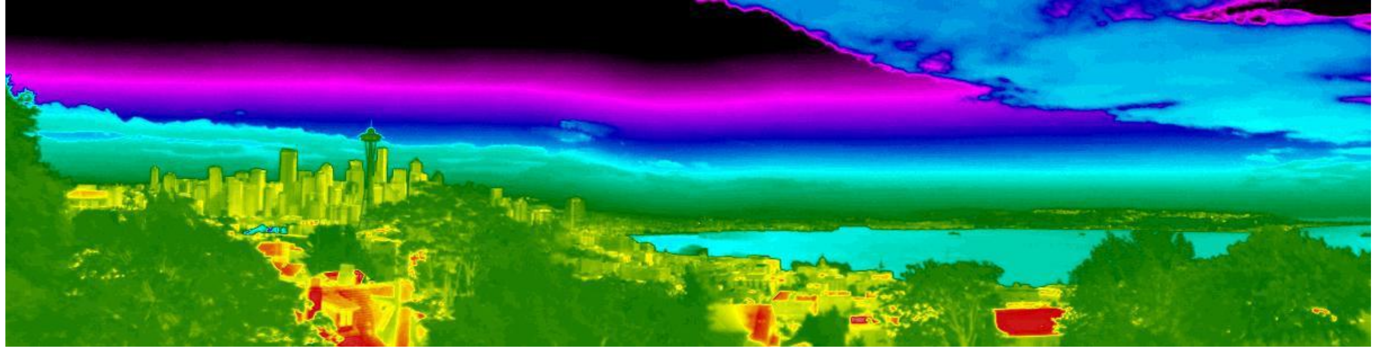


Vapor?

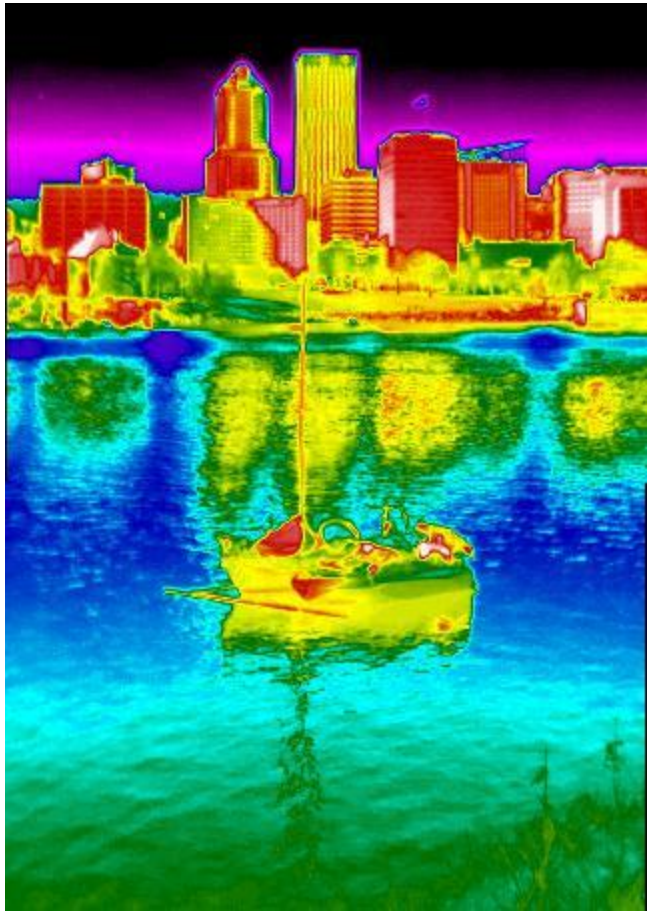


Summary

- Building Enclosure
  - Environmental Separator
  - Energy Use Net Zero
- Building Science Basics
- Building Barriers
  - Heat or Thermal
  - Air (Heat and Vapor Transport)
  - Moisture (Bulk or Liquid)
  - Moisture (Vapor)



Observing Building Enclosures Leaking: Heat, Air and Water Using Infrared Thermography



Thankyou for Your Time

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