# Energy Codes for Architects

2019 BECP
Energy Code
Commentator
Webinar Series

US Department of Energy

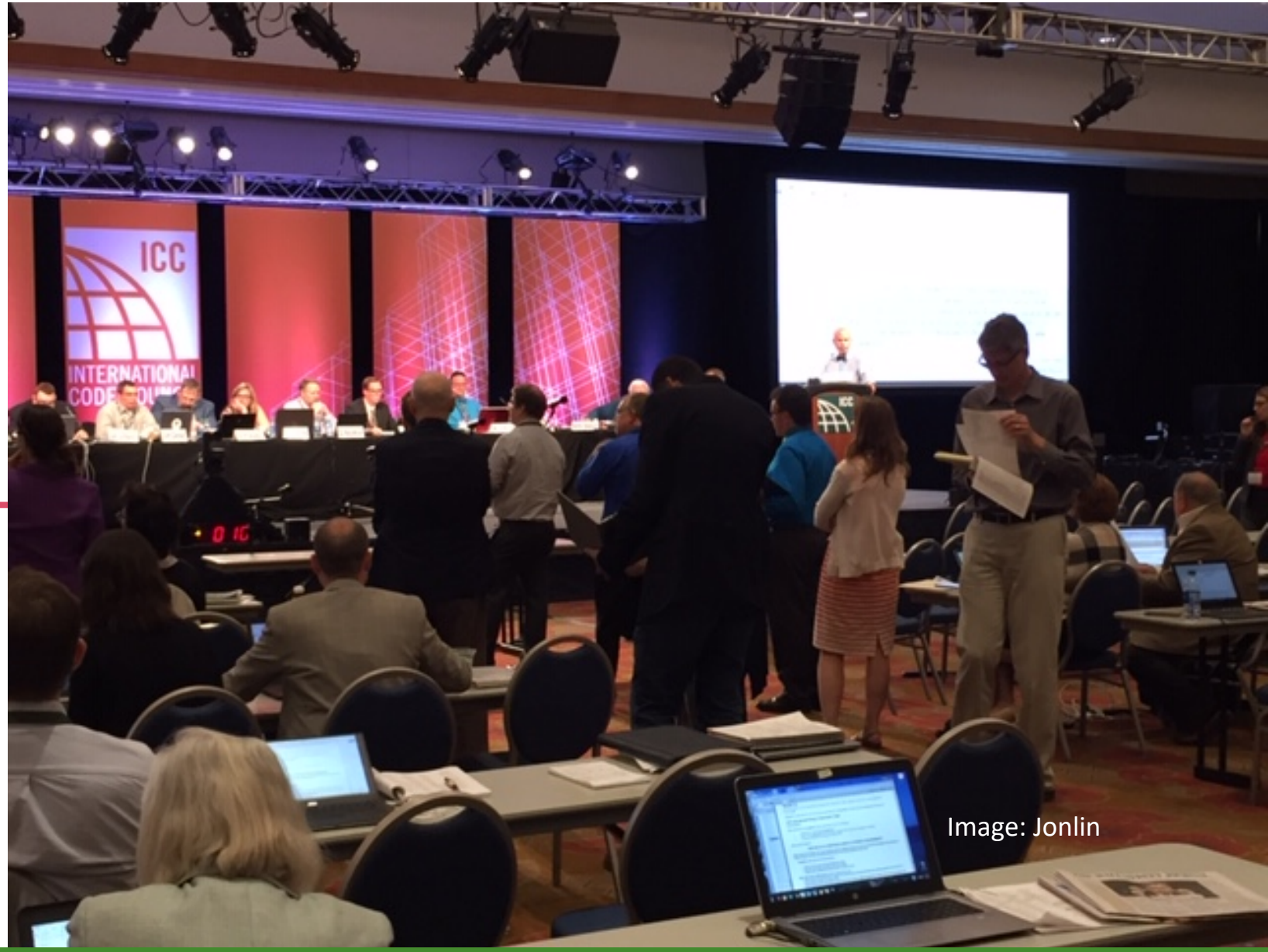



Image: Jonlin

Seattle Department of Construction & Inspections

Duane Jonlin, FAIA

July, 2019

# Course Description and Learning Objectives

Building energy codes can be daunting in their size and complexity, with model codes continually evolving to capture design improvements, greater efficiency, and affordability, while multiple editions can lead to a patchwork of adopted codes across the country. This webinar which is part of DOE's Building Energy Codes Program *Energy Codes Commentator* webinar-based training series, outlines the structure and effective use of these codes for architects, highlighting new and significant provisions that impact architectural design and cost. Specific topics include air tightness, glazing area, alterations, and the use of renewables, as well as possible trends for future codes.

## Learning Objectives

Participants will learn to:

1. Locate critical information in the energy code.
2. Communicate with clients and consultants about energy code impacts.
3. Avoid common pitfalls and misunderstandings in use of the code.
4. Comply with code requirements for existing buildings and other special conditions.

# Roadmap

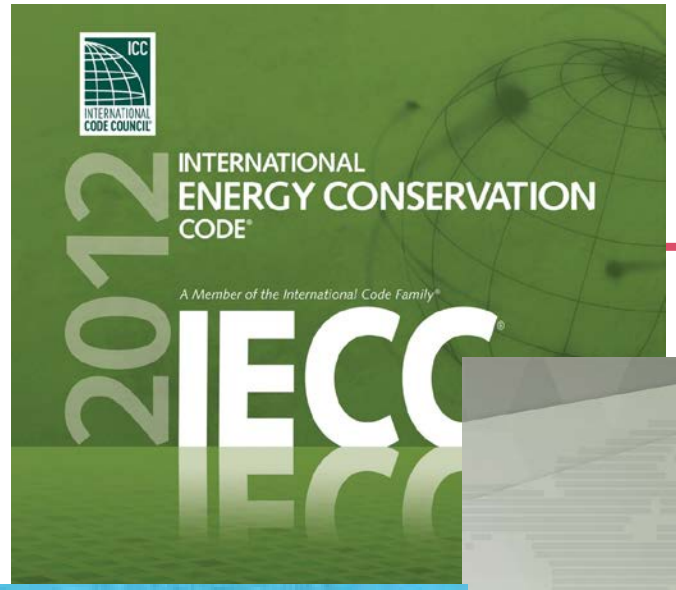
Image: Adventurecycling.org

1. Code Overview
2. Residential
3. Envelope
4. HVAC
5. Lighting
6. Energy Modeling
7. Existing Buildings
8. The Future

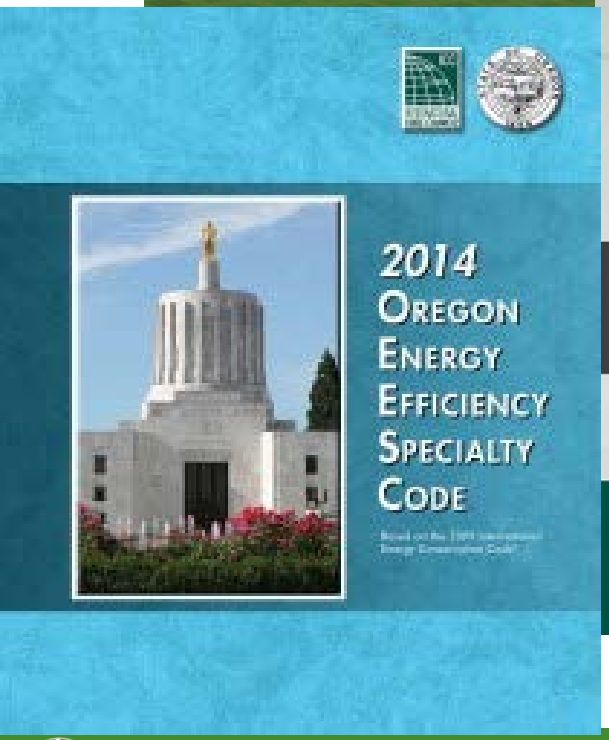
CA
AZ
NM
TX
OK
MO
IL

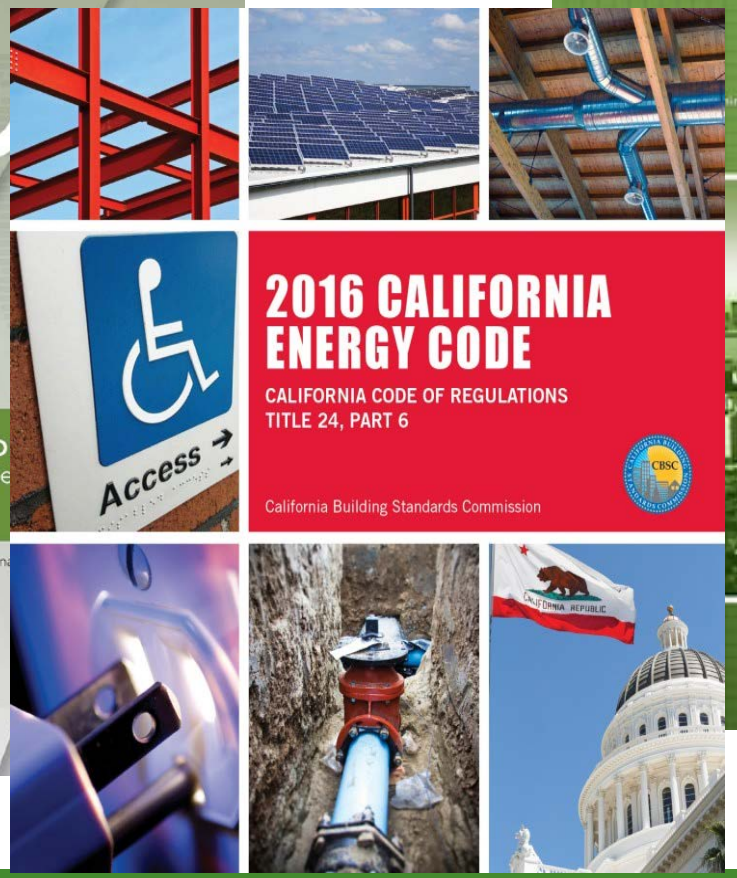
Santa Monica
Los Angeles
Pasadena
Ontario
San Bernardino
Barstow
Victorville
Laughlin
Needles
Oatman
Kingman
Seligman
Flagstaff
Sedona
Petrified Forest Nat'l Park
Winslow
Gallup
Acoma Pueblo
Albuquerque
Tucumcari
Amarillo
Clinton
Oklahoma City
Catoosa
Miami
Riverton
Galena
Joplin
Carthage
Springfield
Sullivan
Meramec Caverns
St. Louis
Springfield
Pontiac
Chicago

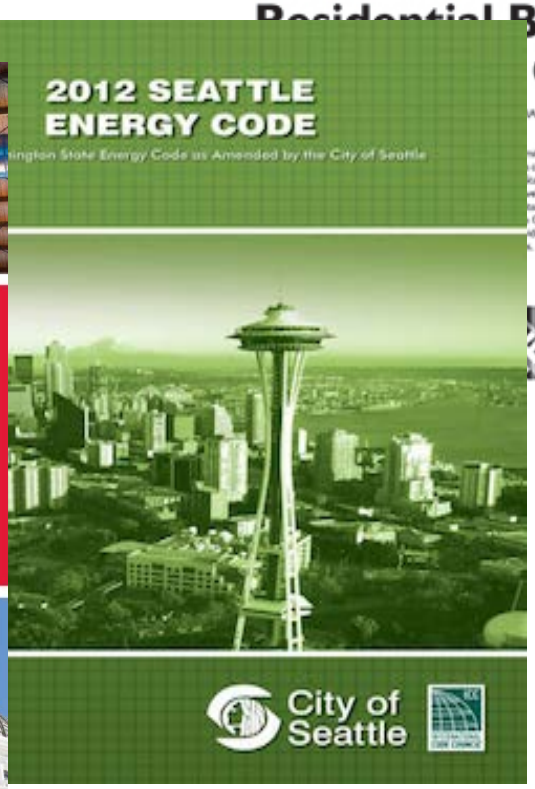
# They're all Different
## (are you using the right one?)

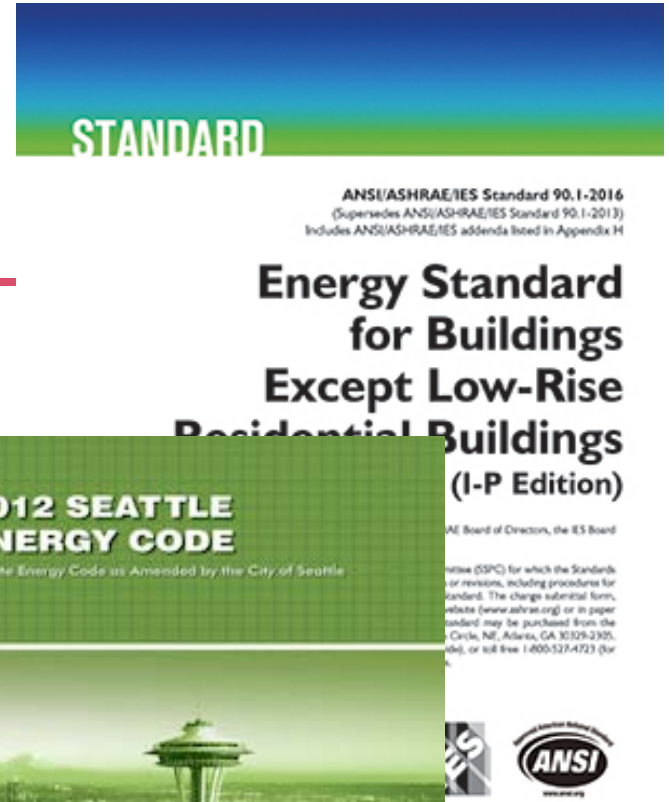






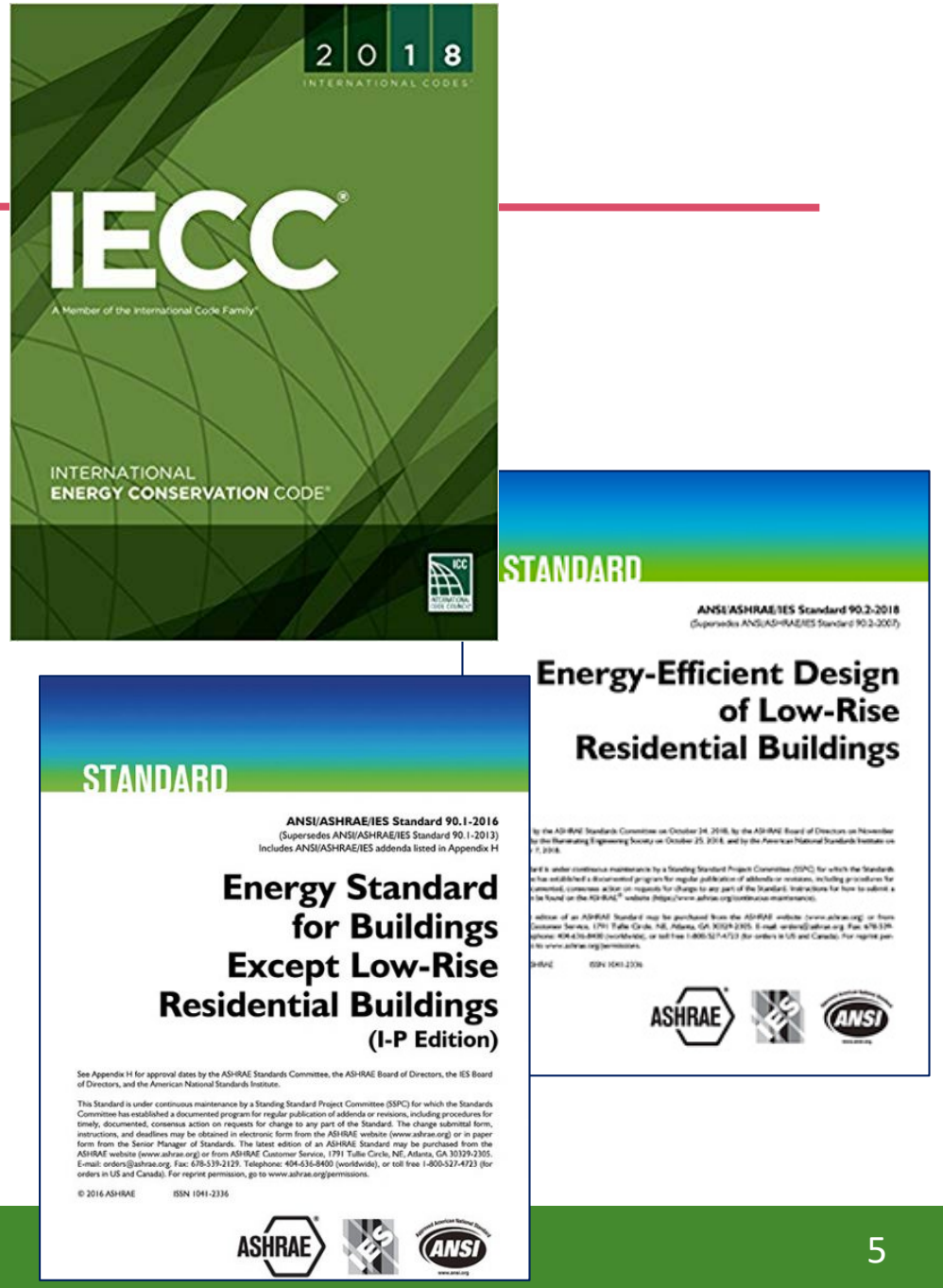



# Residential vs. Commercial

- IECC: Two codes in one
  - Residential: (includes low-rise M-F)
    - National standard
  - Commercial: everything besides residential
    - Allows ASHRAE 90.1 as substitute
- ASHRAE: Two separate standards:
  - 90.1 commercial
    - National standard for stringency
    - But only a few states adopt it directly
  - 90.2 residential
    - …but nobody uses it



# IECC Commercial:

- 1 Scope & Admin
- 2 Definitions
- 3 General
- 4 Energy Efficiency
- 5 Existing Buildings
- 6 Referenced Standards
- Appendix

## Most Everything's in Chapter 4

402 Envelope
403 Mechanical
404 Water Heating
405 Lighting & Elec
406 Additional Options
407 Total Building Perf
408 Commissioning
409 Metering

...or Chapter 5

502 Additions
503 Alterations
504 Repairs
505 Change of Use

# IECC Residential:

- 1 Scope & Admin
- 2 Definitions
- 3 General
- 4 Energy Efficiency
- 5 Existing Buildings
- 6 Referenced Standards
- Appendix

# It's all about the envelope

402 Envelope
403 "Systems"
404 Lighting
405 Simulated Perf
406 Energy Rating Index

three pages

one sentence!

## …or Chapter 5

502 Additions
503 Alterations
504 Repairs
505 Change of Use

## Appendix RA

Solar-ready

# Commonly Used for Modeling

## ASHRAE 90.1:

- 1-4 Admin & Defs
- 5 Envelope
- 6 HVAC
- 7 Water heating
- 9 Lighting
- 11 ECB (modeling)
- 12 References
- Appendix
- (esp. Appendix G)

An optional IECC compliance path. Often source of new IECC requirements

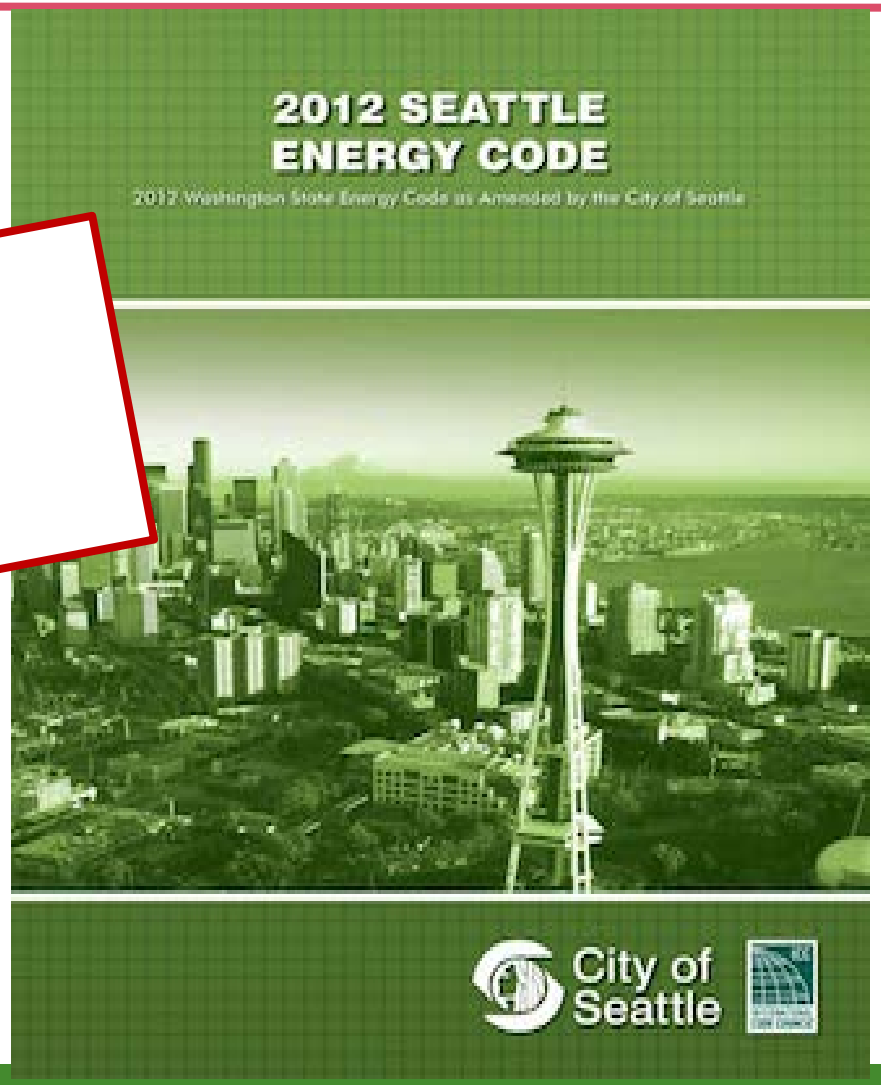
Additions and Alterations are handled within each chapter

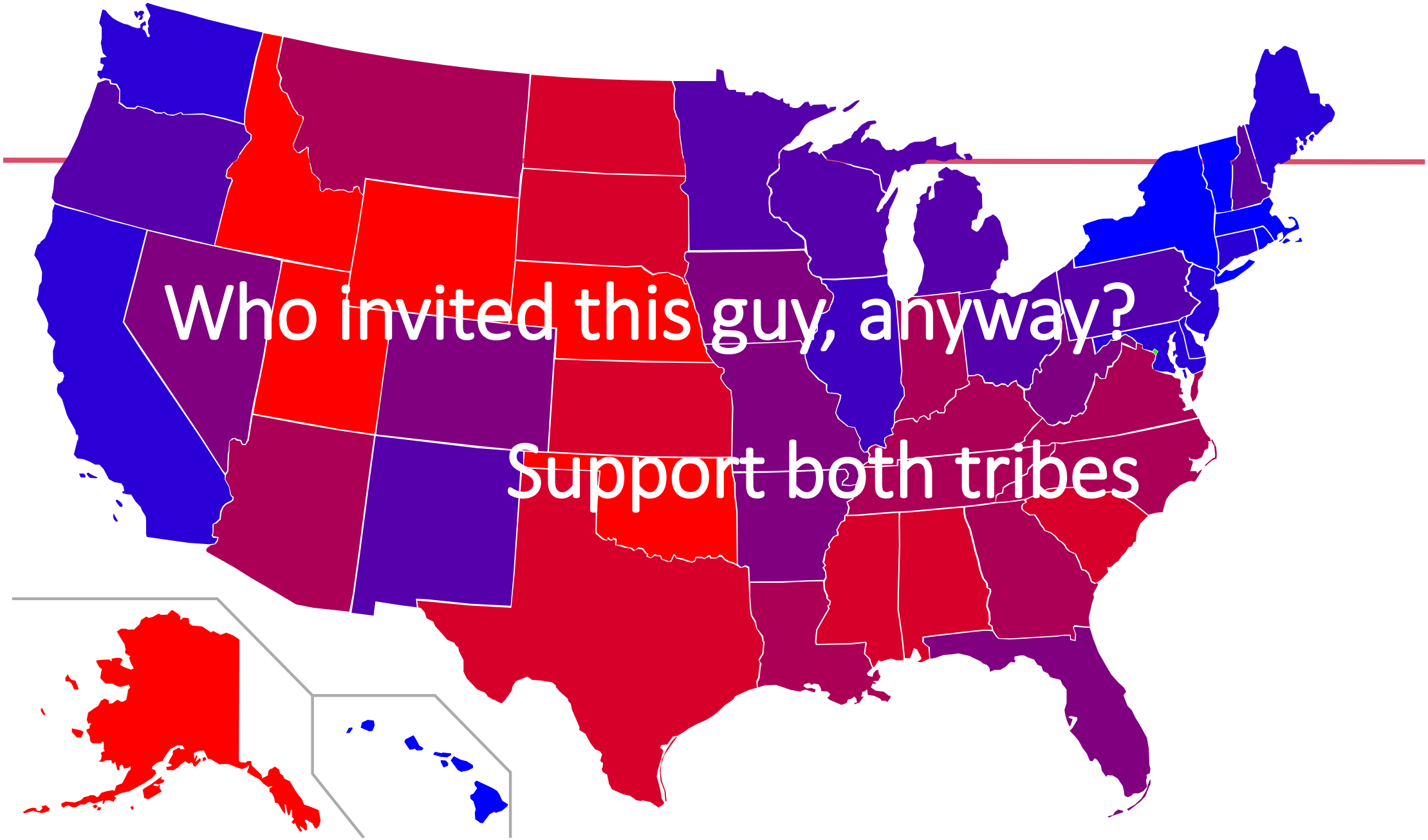
# An advanced energy code is your friend
## (If you're trying to do high-performance buildings)

**Laws & codes are what drives change…**

**Did your firm sign the 2030 challenge?**
**So, are all your projects 70% better than 2005?**
**No?**
**Maybe your clients just don't see the benefit.**

**…and it really is that fast.**




Who invited this guy, anyway?
Support both tribes

# Rural vs. Urban


Image: Wikimedia Commons Henry Han

Cautious vs. progressive
Slow vs. Nimble

Cities are where change originates.

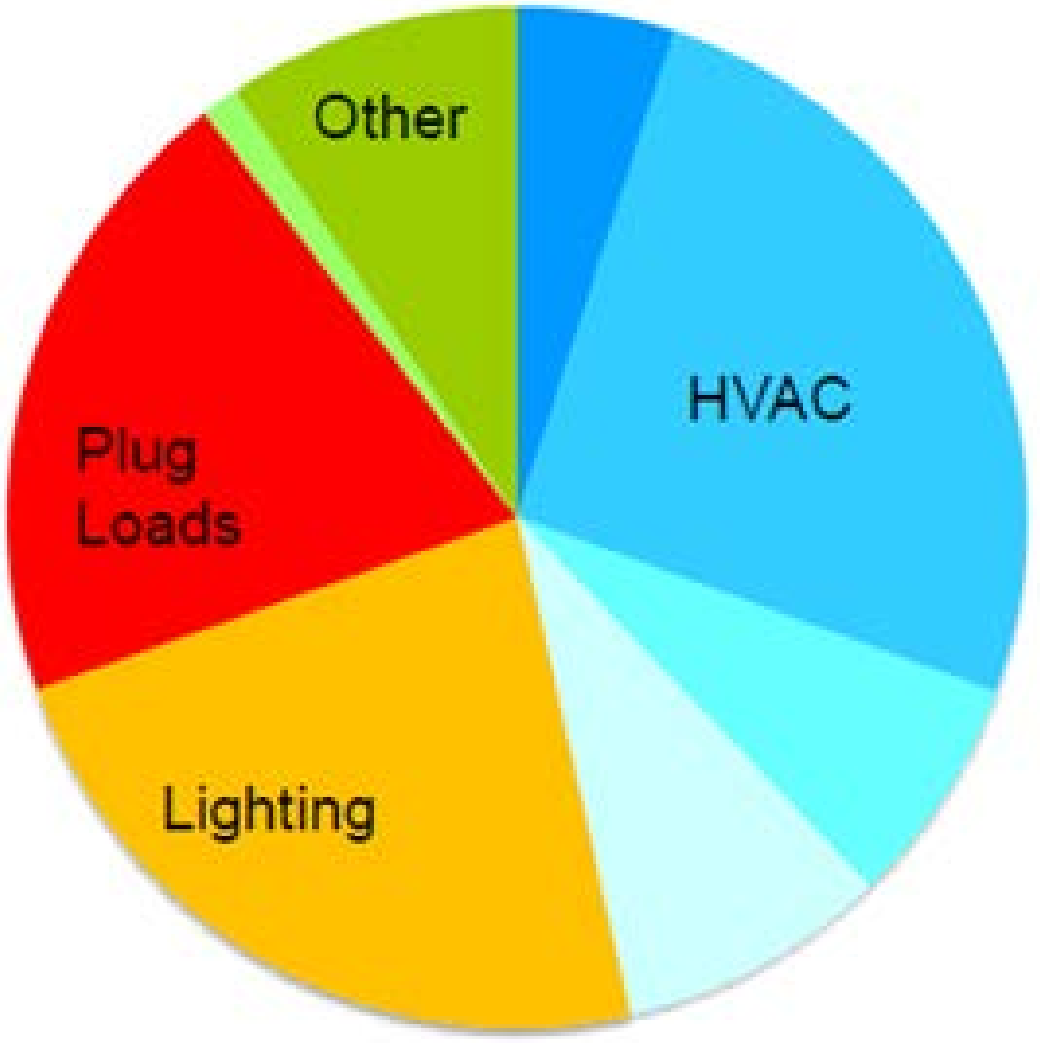
# Where do little code provisions come from?

- Technology
- Other codes
- New ideas
- Old ideas


"Don't do stupid things." J. Lstiburek

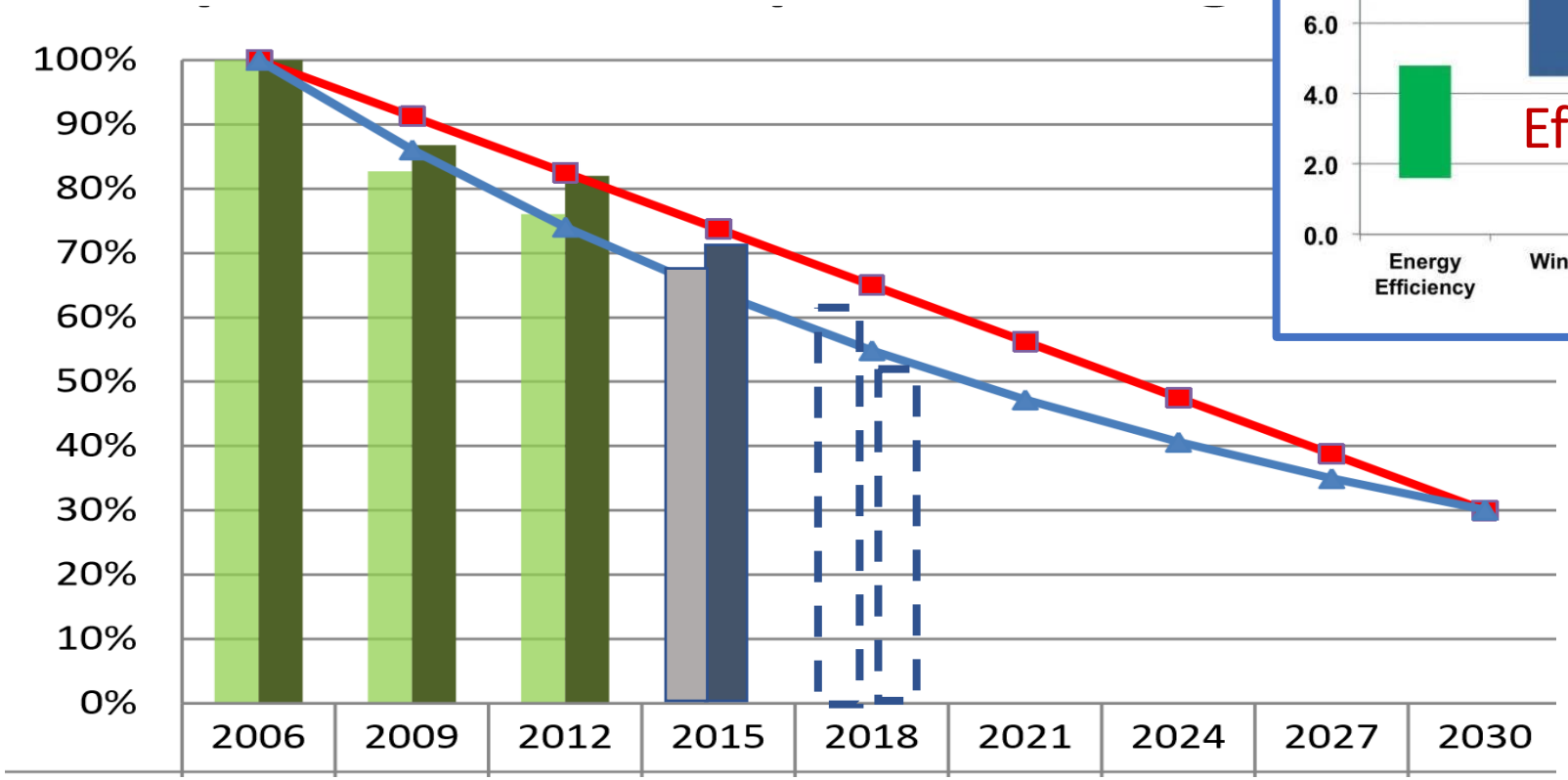
# Go for the big slices

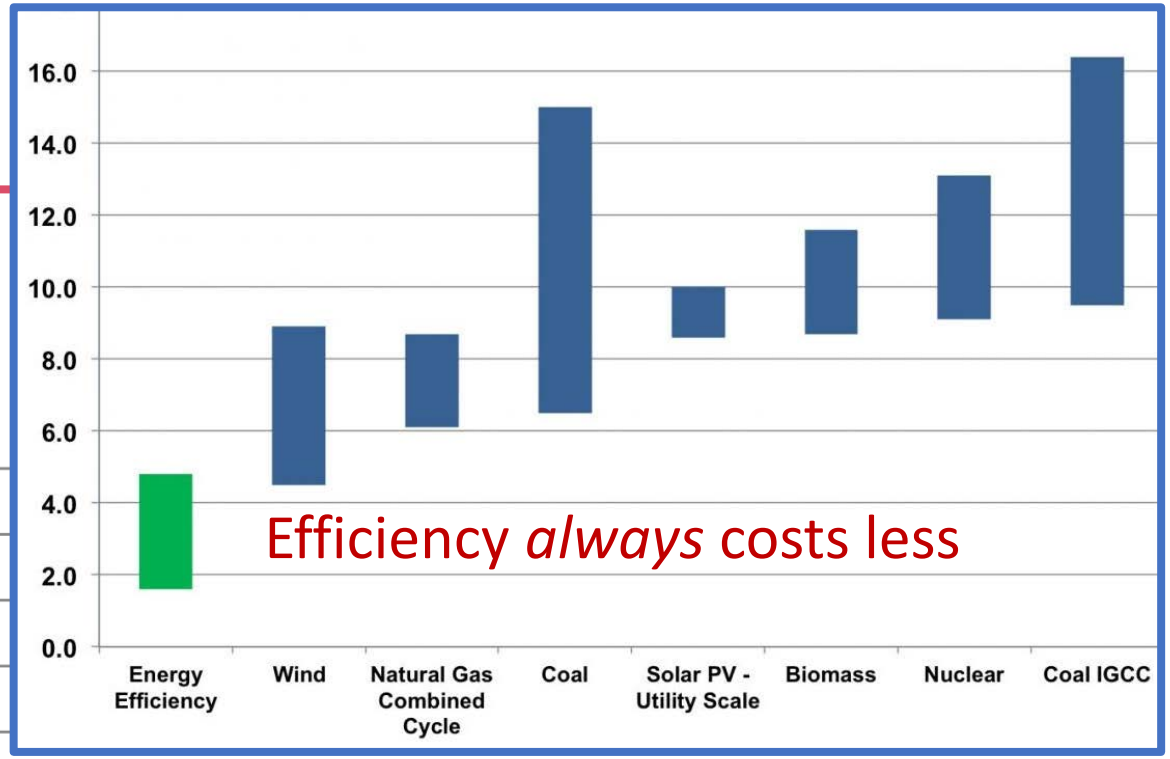
- Regulated loads:
  - Lighting
  - HVAC
  - Water heating
- Where possible:
  - Plug loads
  - Process loads



# Cost-effectiveness

## Why only the energy code?




- Good discipline
- Respects stakeholders
- Works even with low-cost electricity

# Two Compliance Paths (or is it three?)

- Prescriptive  Comply w/ whole code
  - Envelope UxA tradeoff (or Comcheck)
- Total Building Performance Modeling
  - & meet all “mandatory” requirements
- Or use ASHRAE – Energy Cost Budget
- Or new ASHRAE Appendix G Method

Image: Pinterest Jo White

# Chapter 2 - Definitions

- Mostly only lawyers read Chapter 2
  - That's why *you* should read it!
- Look for *italicized* words
- (What's a "below-grade wall"?)
- (What's "fenestration"?)

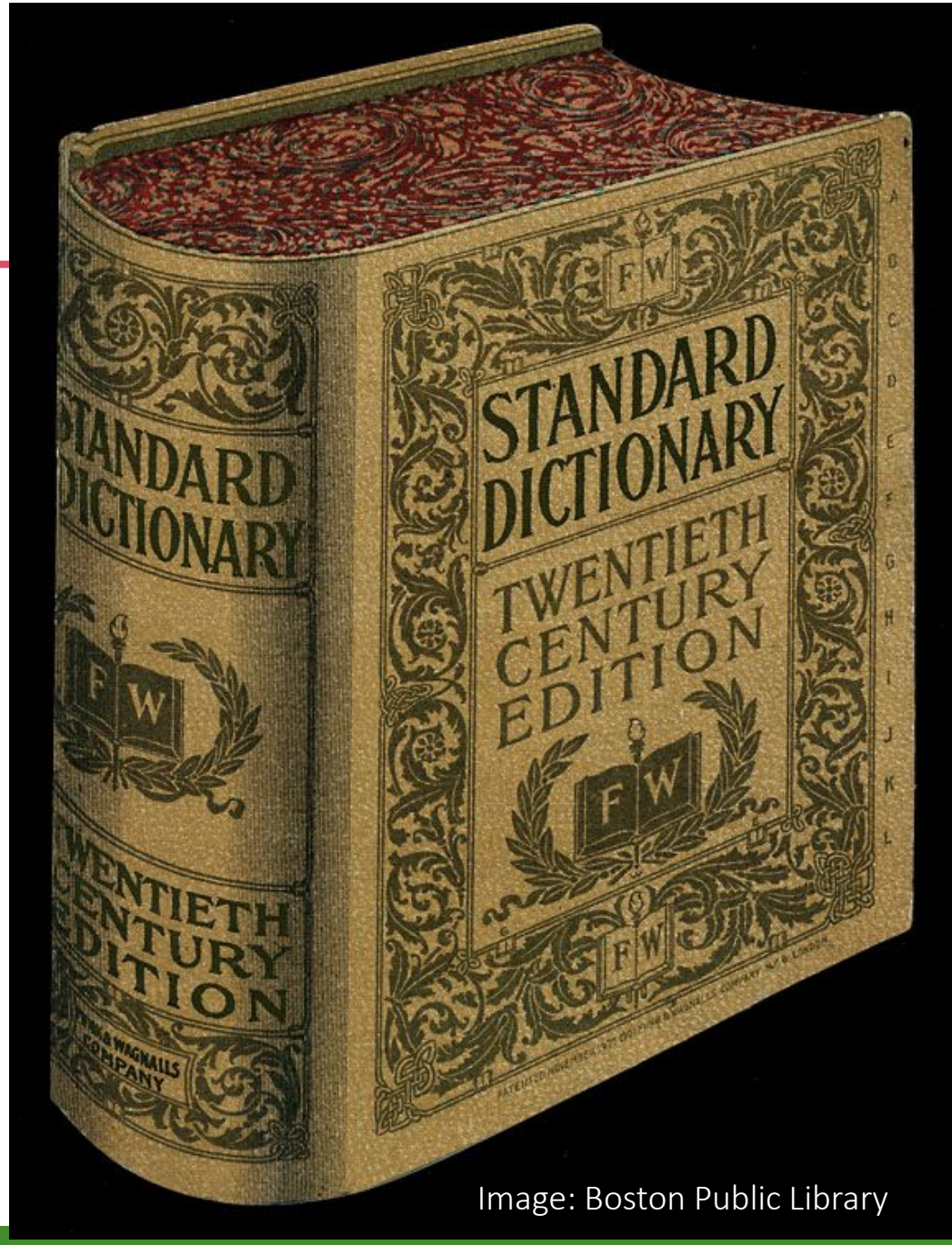



Image: Boston Public Library

# What's in Chapter 3, anyway? (not much)

- Climate Zone
  - (Example: Seattle's in 4C)
- Design temperatures
- Insulation installation rules
- Default fenestration values
  - Never use window/skylight values
  - Always use opaque door values

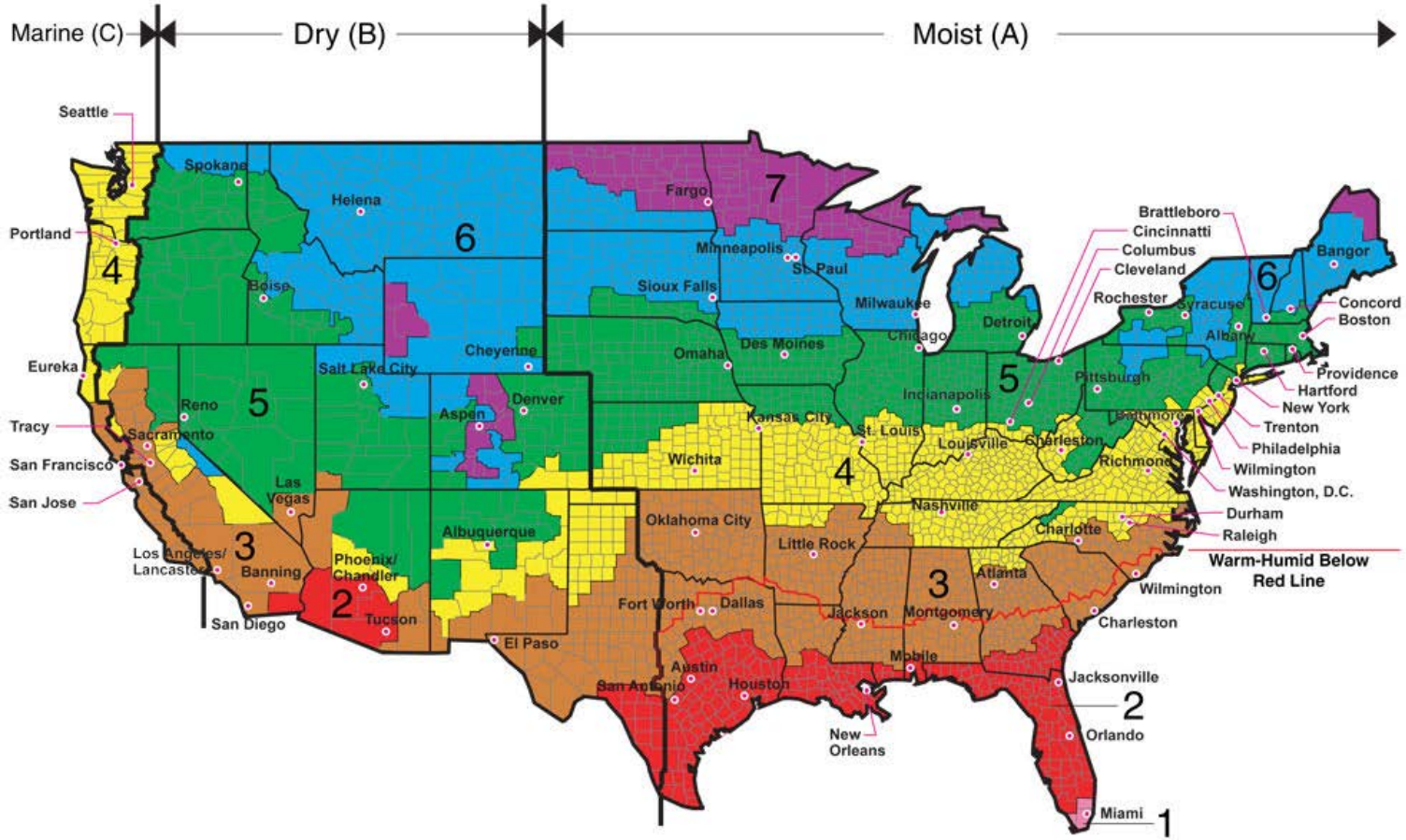



Image: ASHRAE

Image: City of Seattle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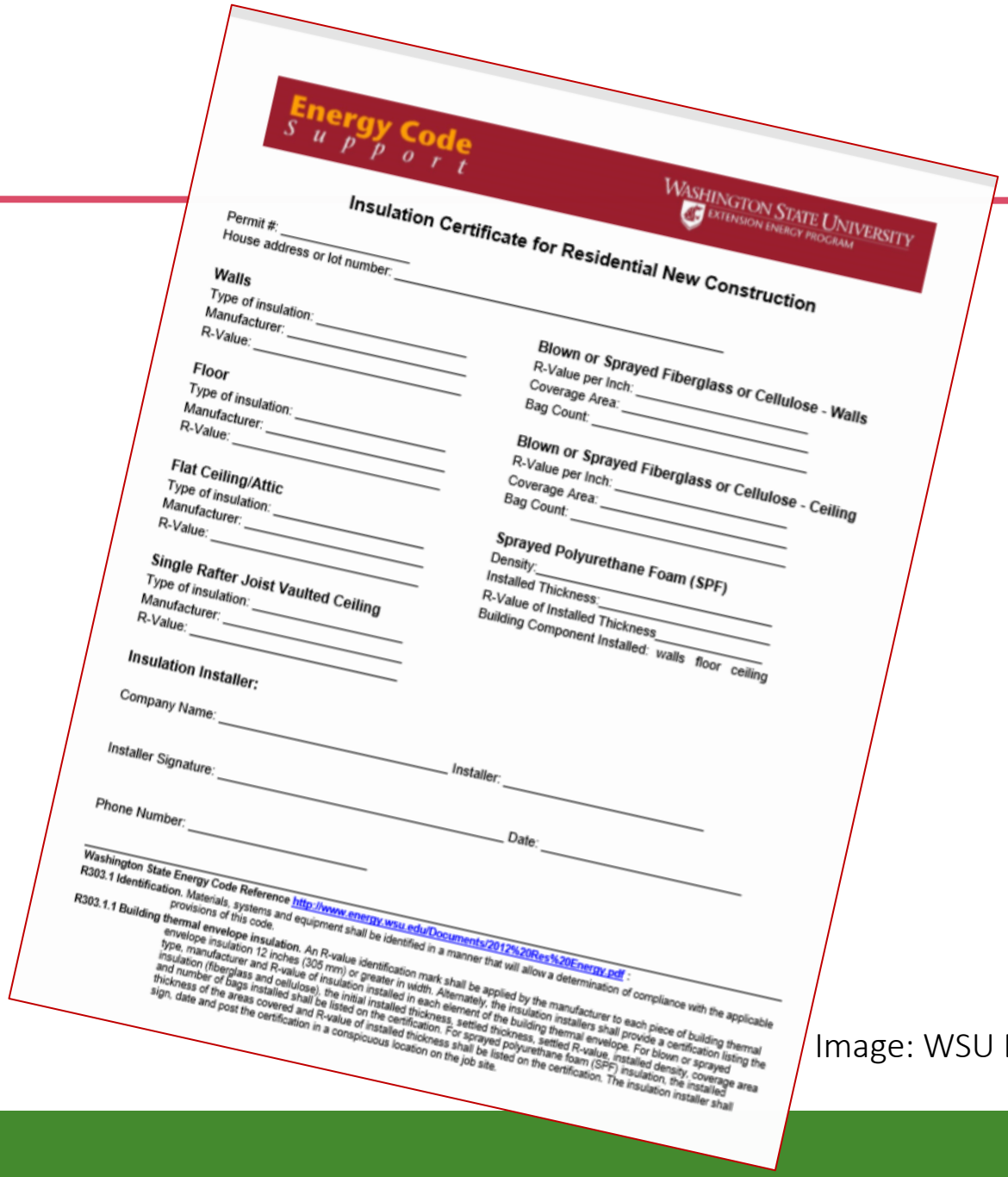
# Certificate

- On wall near furnace or in utility room
  - Insulation R-values
  - Window U-values
  - Equipment efficiencies
  - Air barrier & duct test results
- Hey architects, why not brand the certificate for <u>your</u> firm? Maybe something more exciting than this one?



Energy Code Support

Washington State University Extension Energy Program

**Insulation Certificate for Residential New Construction**

Permit #:

House address or lot number:

**Walls**
Type of insulation:
Manufacturer:
R-Value:

**Floor**
Type of insulation:
Manufacturer:
R-Value:

**Flat Ceiling/Attic**
Type of insulation:
Manufacturer:
R-Value:

**Single Rafter Joist Vaulted Ceiling**
Type of insulation:
Manufacturer:
R-Value:

**Blown or Sprayed Fiberglass or Cellulose - Walls**
R-Value per Inch:
Coverage Area:
Bag Count:

**Blown or Sprayed Fiberglass or Cellulose - Ceiling**
R-Value per Inch:
Coverage Area:
Bag Count:

**Sprayed Polyurethane Foam (SPF)**
Density:
Installed Thickness:
R-Value of Installed Thickness
Building Component Installed: walls floor ceiling

**Insulation Installer:**

Company Name: Installer:

Installer Signature: Date:

Phone Number:

**Washington State Energy Code Reference** http://www.energy.wsu.edu/Documents/2012%20Res%20Energy.pdf :

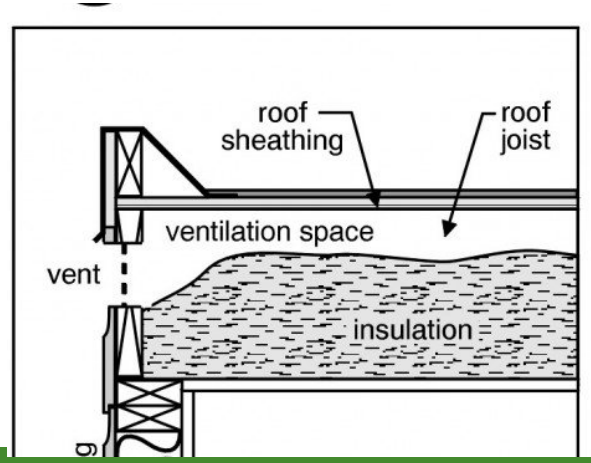
**R303.1 Identification.** Materials, systems and equipment shall be identified in a manner that will allow a determination of compliance with the applicable provisions of this code.

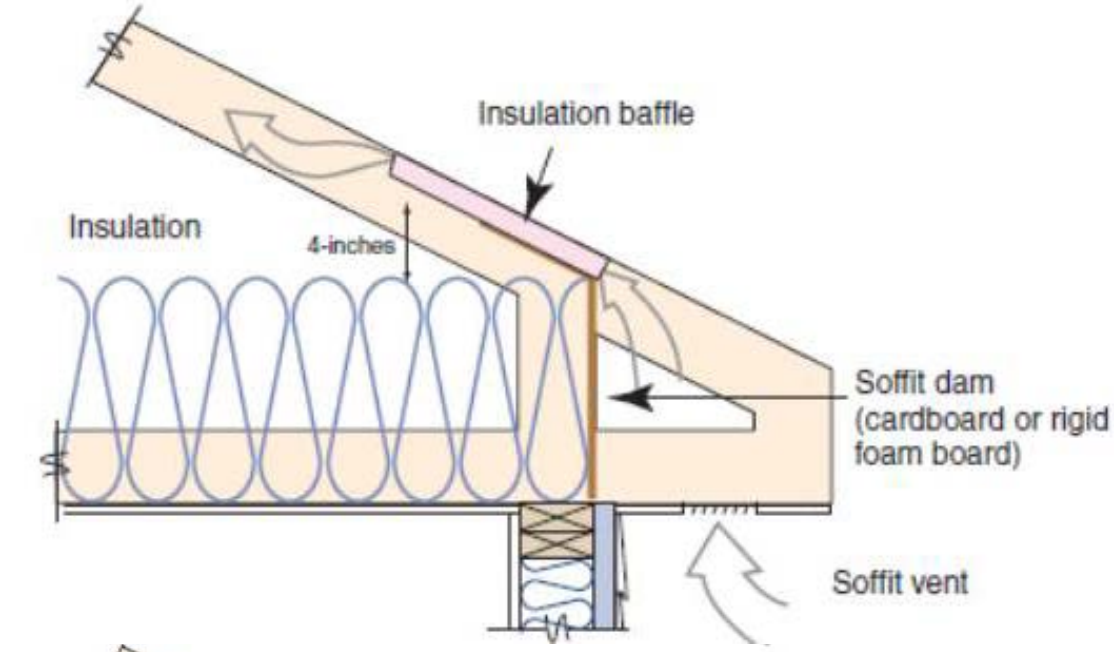
**R303.1.1 Building thermal envelope insulation.** An R-value identification mark shall be applied by the manufacturer to each piece of building thermal envelope insulation 12 inches (305 mm) or greater in width. Alternately, the insulation installers shall provide a certification listing the type, manufacturer and R-value of insulation installed in each element of the building thermal envelope. For blown or sprayed insulation (fiberglass and cellulose), the initial installed thickness, settled thickness, settled R-value, installed density, coverage area and number of bags installed shall be listed on the certification. For sprayed polyurethane foam (SPF) insulation, the installed thickness of the areas covered and R-value of installed thickness shall be listed on the certification. The insulation installer shall sign, date and post the certification in a conspicuous location on the job site.

Image: WSU Energy

# Envelope values

- R-value is insulation value only
- (U-value is for entire assembly)
- Roof R-38 or R-49, *except*
  - R-30 or R-38 with raised-heel truss
  - R-30 single rafter (20% of roof area only)
  - These 2 exceptions for residential only!
- Wall: cavity insulation only (or cavity + c.i.)



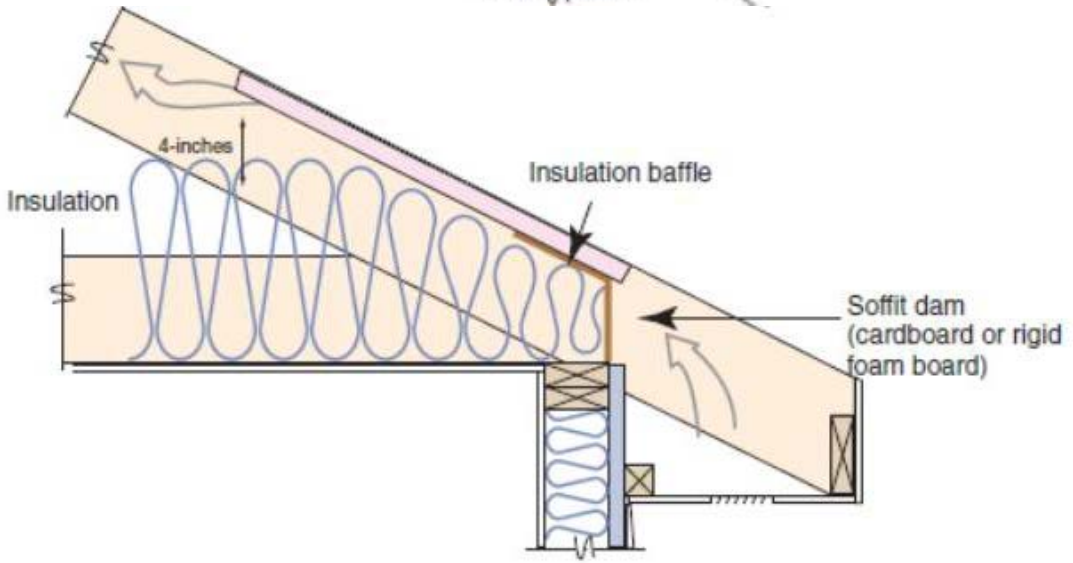




Image: PNNL

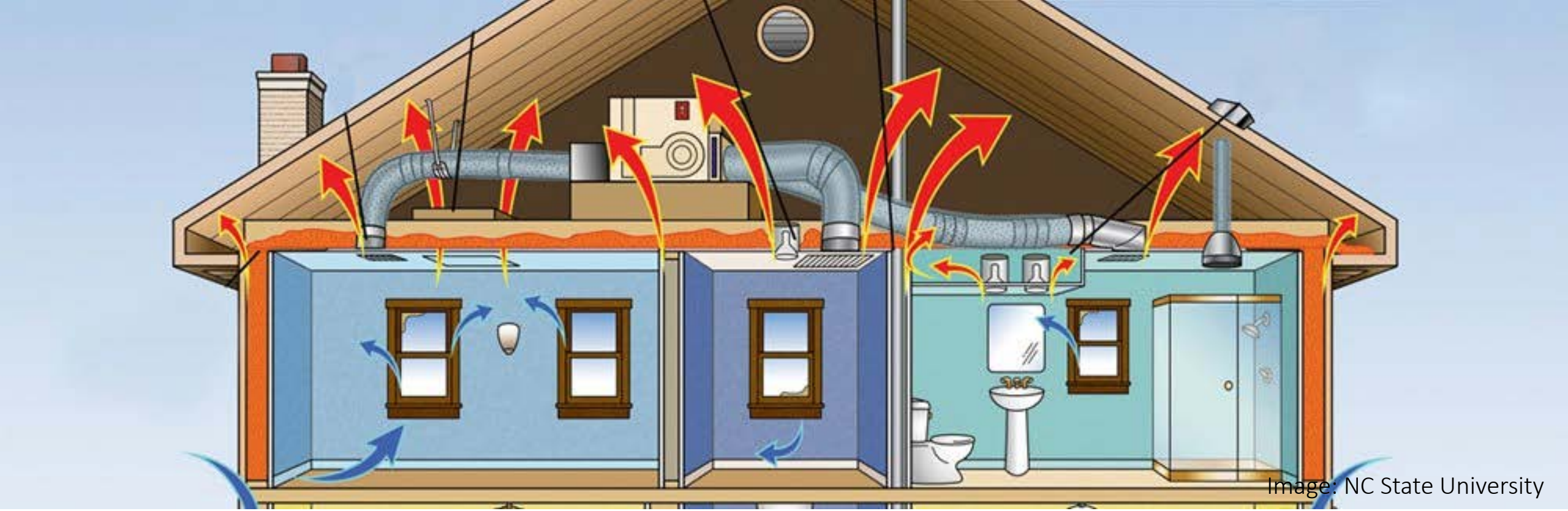


Image: NC State University

# Air barrier

## Continuous & sealed around entire envelope

- Blower door test required
- Max leakage rate:
- 5.0 ACH50 in CZ 1 – 3
- 3.0 ACH50 in CZ 4 – 8

# Ducts & Pipes

## Be aware of cavity space impacts

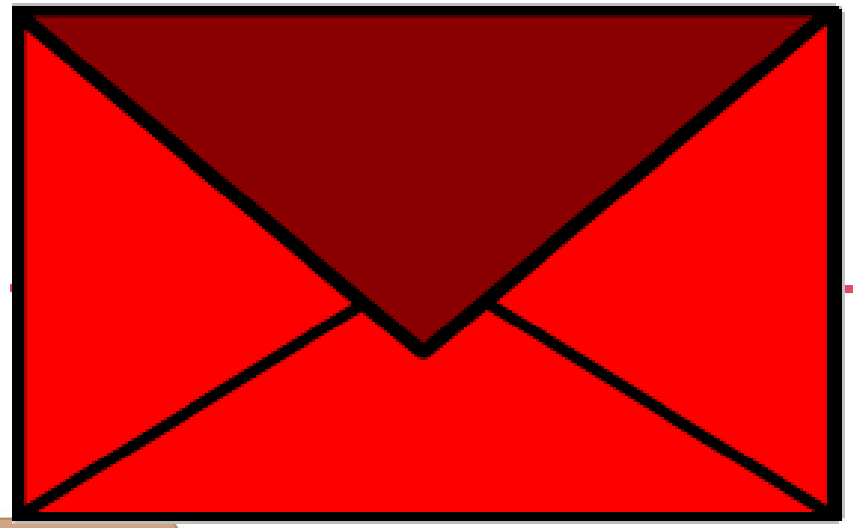
Ducts

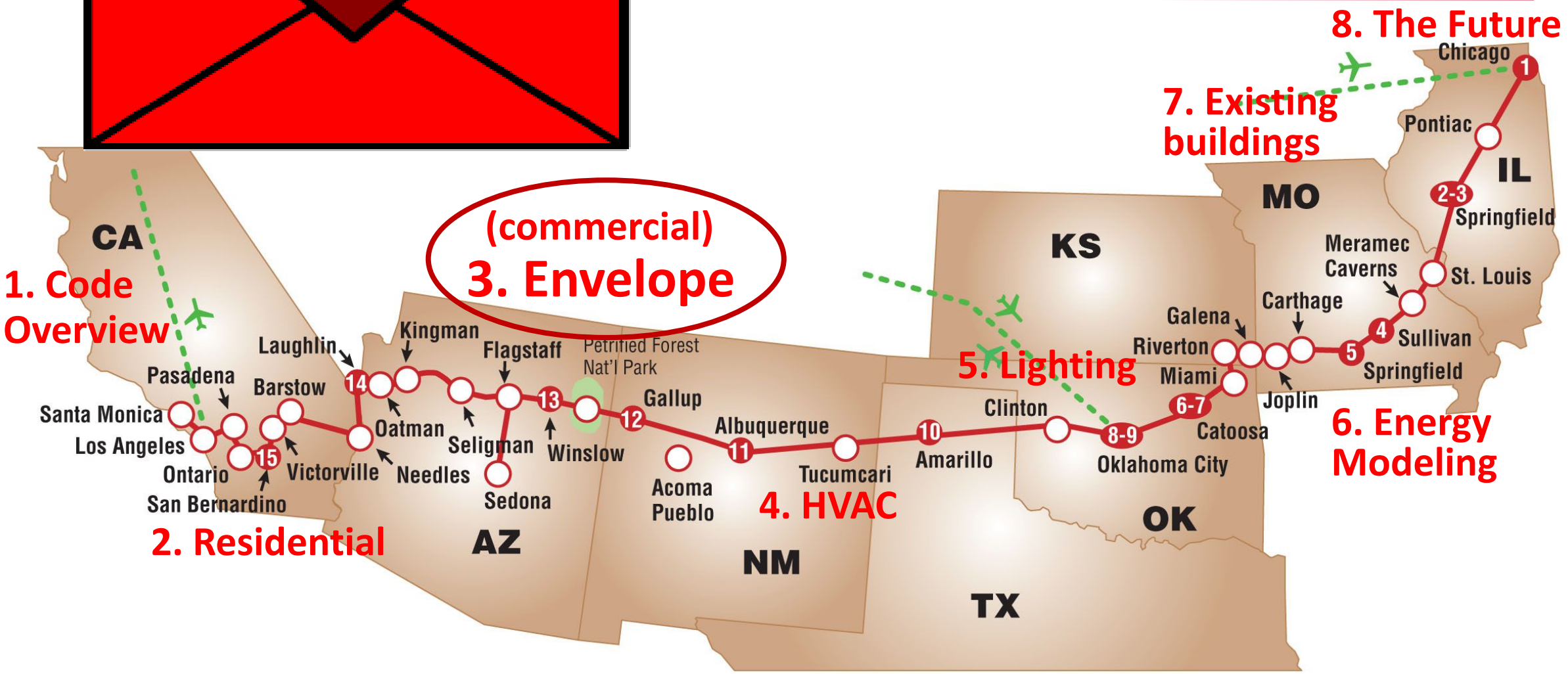
- Inside thermal envelope: no insulation
- Outside thermal envelope: R-8
- Sealed and pressure tested for leaks

Pipes

- Hydronic pipes: R-3 insulation
- Hot water pipes: R-3
  - If 3/4” or larger
  - Or outside heated space
  - Or under slab
  - Or in recirculation system

# The envelope, please





# Separate inside air from outside weather

- R-value tables – only the insulation value
- U-value tables – value of whole assembly
- Fenestration tables – frame and glass together
- Component Performance Alternative
  - “UxA tradeoff”
  - But you probably use Comcheck
- Reflective roofing

The envelope will remain unchanged for generations – build it right today.

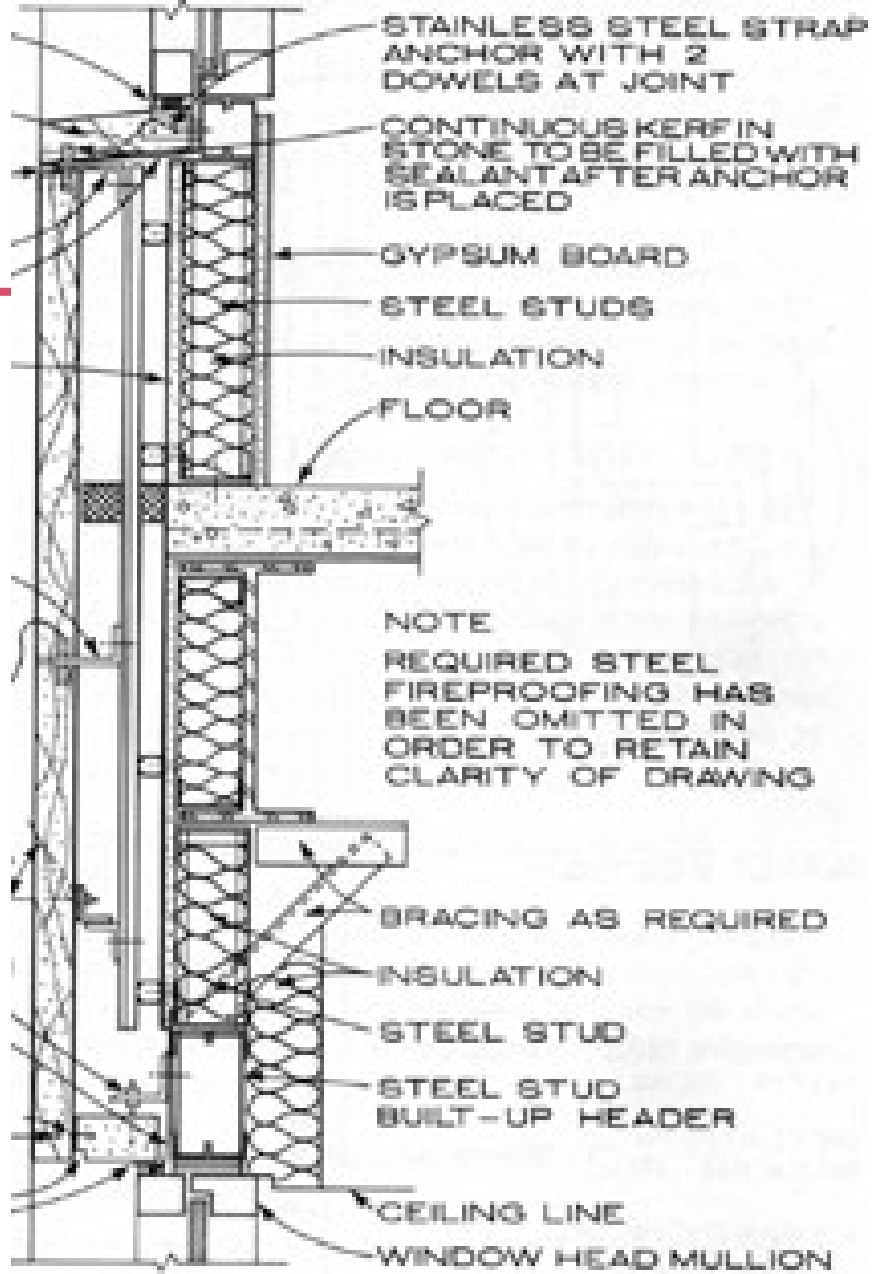



Image: WBDG

# Architects love glass

## 1922 to 2019 = 97 years

<u>Allowable area</u>

- 30% max area
  - Of “above-grade wall” area
- 40% max if 25% of <u>net</u> floor area is in daylight zone
  - Or 50% of floor area for 1-2 story bldg

<u>U-value range</u>

- U-0.50 in Miami
- U-0.29 in Fairbanks
- More for entrance doors

<u>SHGC range</u>

- 0.25 in Miami, 0.45 in Nome
- Higher if north-facing or with projections

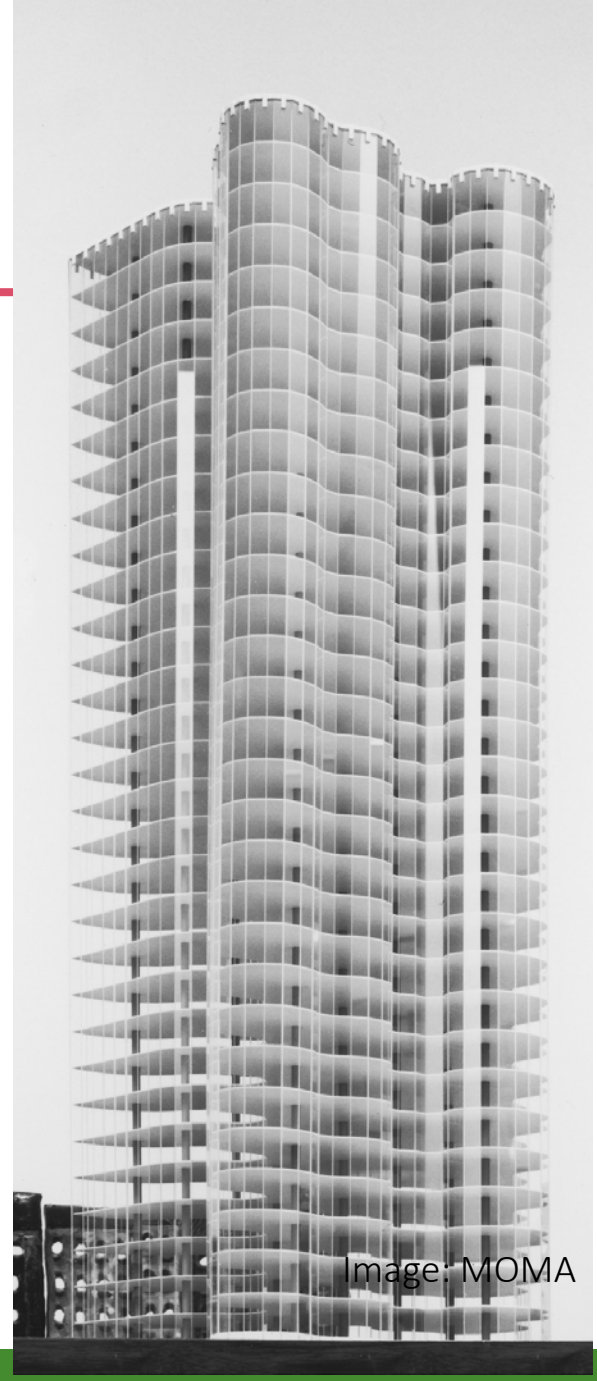


Image: MOMA

# Skylights

- Maximum area – 5% of "gross roof area"
- Minimum area – 3% of "toplight daylight zone"
- "Toplight daylight zone" required to cover half of the floor area*
  - If space over 2,500 SF
  - With 15 foot ceiling

* In office, lobby, atrium, concourse, corridor, storage space, gymnasium/ exercise center, convention center, automotive service area, space where manufacturing occurs, nonrefrigerated warehouse, retail store, distribution/ sorting area, transportation depot or workshop


Image: Flickr Steven Zucker

# Air barrier & testing

- Air barrier required all around thermal envelope
- Made out of air barrier “materials” or “assemblies”
  - But air doesn’t leak through the materials or assemblies!
- Blower door testing *may* be required in 2021 IECC – stay tuned.

Image: Ontario Assn of Architects:

# Vestibules

## North of climate zone 2

<u>All building entrances</u>

- Including adjacent to revolving doors

<u>Exceptions:</u>

- "…not intended to be used by the public"
- Dwelling & sleeping units
- Space smaller than 3,000 SF
- Warehouse doors
- Doors with air curtains

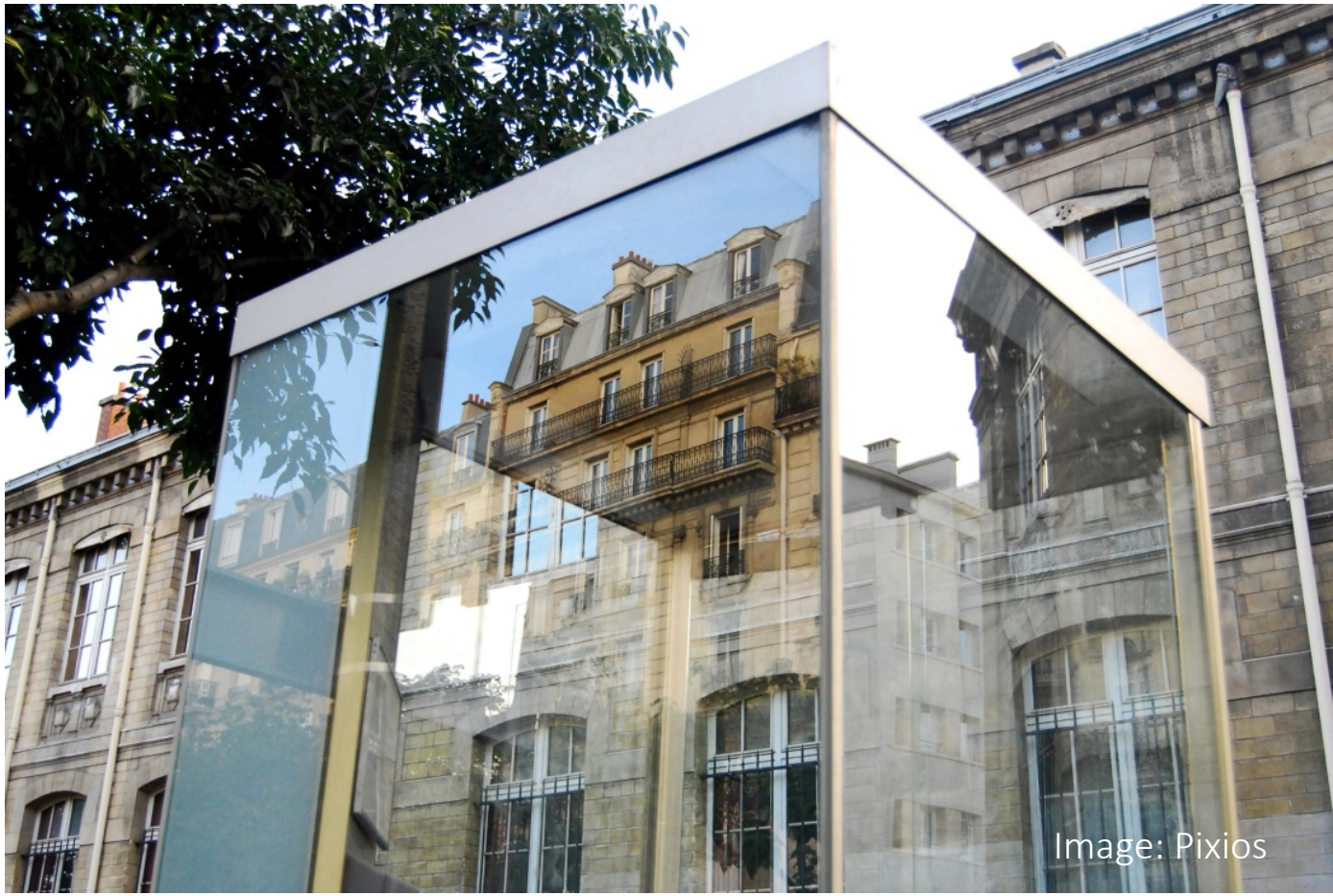


Image: Pixios

# And now, a word about your engineers.

Image: railgiants.org

# Does your engineer know your energy code?

**Your engineers control the building's efficiency.**

- Are they progressive/creative?
  - or stuck in a rut?
- You need engineers that help you move forward
  - Not hold you back
- (Give a written exam in interviews?)

**Hire consultants that will knowledgeably lead and support you, and your clients!**

Ask them:

- Did you select the most efficient system?
  - Or is it the same old VAV/reheat as always?
- Will heating & cooling run simultaneously in offices?
  - Do they expect an "invisible wall" to separate the core from perimeter areas?

# How to reduce HVAC energy use?

- Use efficient system type to start with.
  - But code doesn't actually *require* this!
- Automatically turn systems *off* when you don't need them at all.
  - Like economizer cooling
- Automatically turn systems *down* when you don't need as much.
  - DCV – Demand control ventilation
  - Temp setbacks, optimum start/stop
- Recapture waste energy
  - ERV – Energy Recovery Ventilation
  - Condenser heat recovery

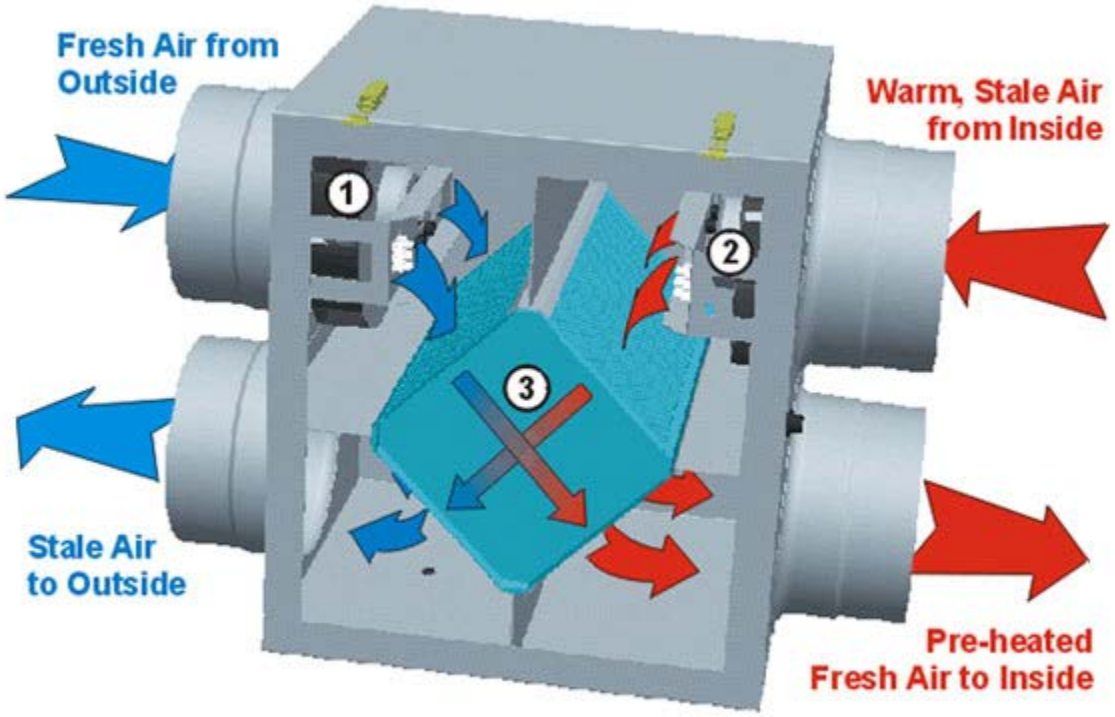



Image: winsomeconstruction

# HVAC code highlights

- ERV Energy Recovery Ventilation
  - Transfers warmth (& maybe coolth?) from exhaust air to incoming fresh air
  - Smaller systems require ERV when:
    - Harsh climate
    - High outdoor air mix
    - 24-hour operation
- Note: Override switch location for temperature setback?
- Duct & pipe insulation
  - Space implications in wall & ceiling cavity
- Radiant heat for outdoor heating
  - With occupancy sensor controls

Image: Wikimedia Commons P199

- Mechanical code sets minimum health and comfort standards
- Energy code limits waste
- You can always build cheaper and worse.
- But the codes demand a quality system.

# “Turn systems down when you don’t need as much”

- DCV – Demand Control Ventilation - turns down ventilation for light load, in spaces like:
  - Classroom
  - Auditorium
  - Conference
  - Courtroom
  - Sanctuary
  - Gym…
- Kitchen exhaust fan control
  - Lower airflow when less cooking activity
- Hotel rooms
  - Temp setback for unoccupied room
  - Further setback for unrented room

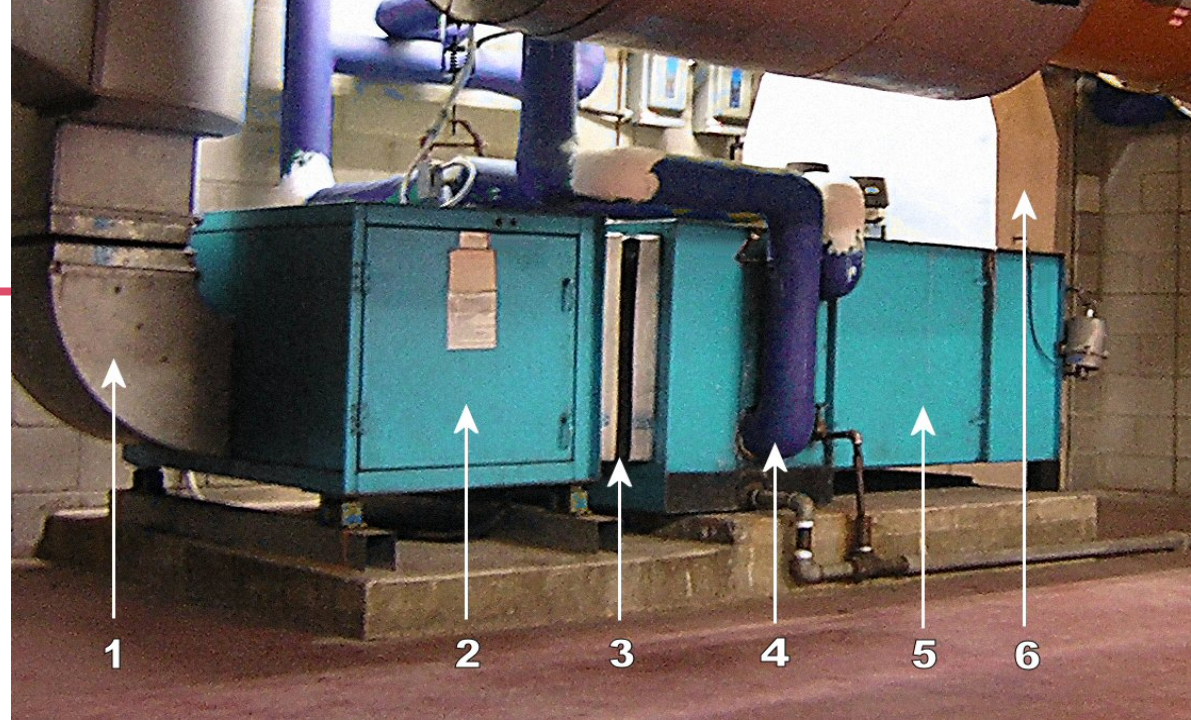



Image: Wikimedia Commons P199

- Fan and pump energy reduction controls for light demand periods
  - Reduce energy use
  - Extend equipment life

# Water heating

- Equipment efficiencies seriously out of date
- New rules for pipe length causing problems
- Lots of rules about circulating hot water systems
- Not to mention pool & spa heaters

Image: The Weingarten Collection

Image: Jonlin

1. Code Overview

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# How to reduce lighting energy use?

1. Use efficient lamps and fixtures to begin with
2. Automatically turn lights *off* when you don't need any
    1. Manual switches
    2. Occupancy sensors
    3. Time switch controls
3. Automatically turn lights *down* when you don't need as much
    1. Daylight responsive controls
    2. 50% reduction switching

# Occupancy sensors required in:

- Most enclosed spaces 300 SF or less

…and:

- Classrooms
- Private offices
- Restrooms
- Warehouses
- Conference & meeting rooms
- Employee lunch & break rooms
- Storage & janitor rooms

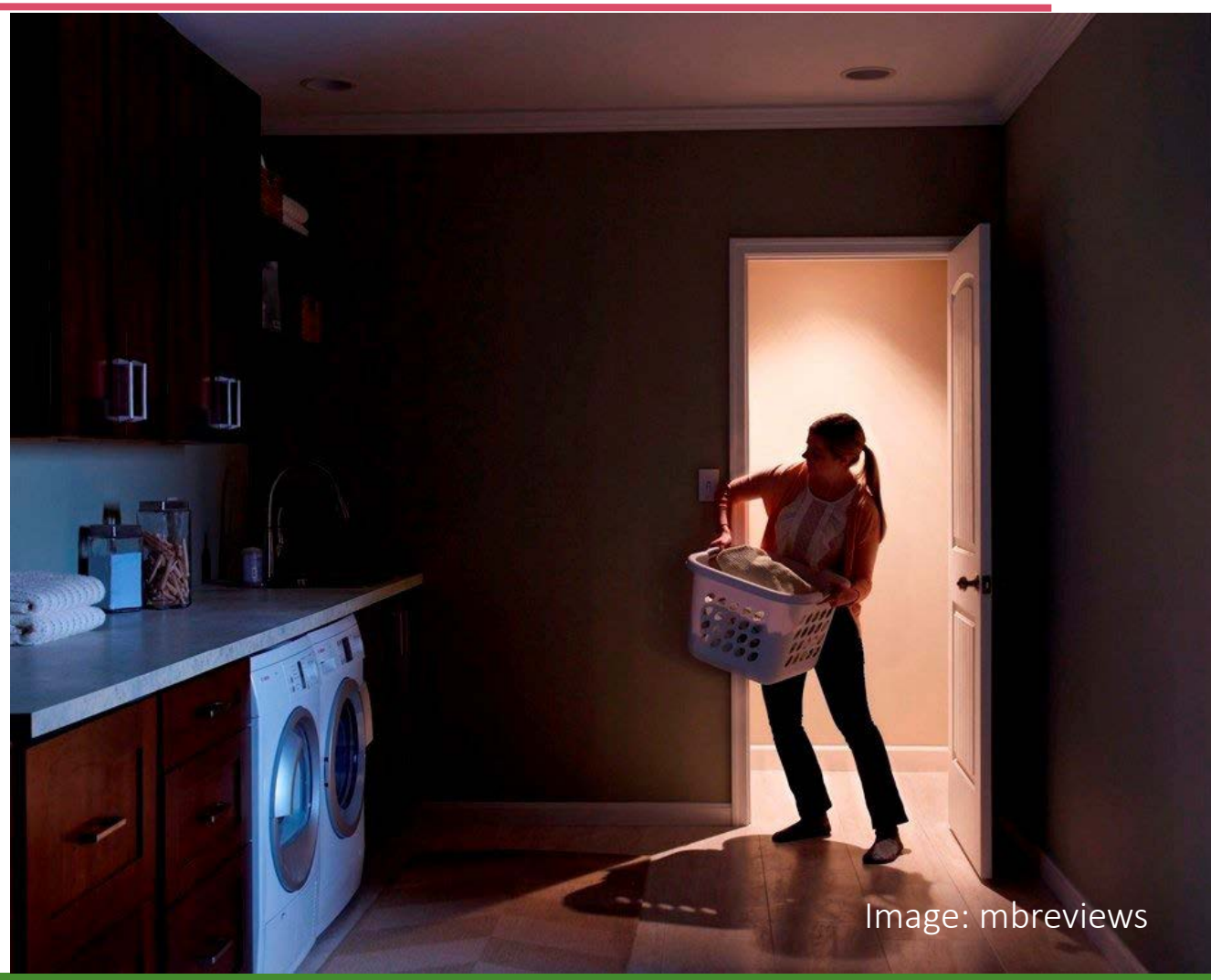


Image: mbreviews

# Time Switch Control req'd everywhere except:

- Areas with occupancy sensors
- Lighting for 24/7 use
- Security or emergency use
- Dwelling units (apartments)
- Sleeping units (hotel rooms, dorm rooms, etc.)
- Egress stairs and corridors
- Patient care areas

# Daylight responsive controls required in daylight zones (duh-oh!)

Except:

- Space with less than 150 watts of lighting
  - So, private office & conference
- Security or emergency use
- Egress stairs and corridors
- Space with very low lighting power density

Continuous dimming required in:

- Classroom
- Office
- Lab
- Library

(Because, “stepped dimming” is pitiful)

# LLLC: “Luminaire-Level Lighting Control”

## Cheaper & better?

- LED fixtures
- Onboard daylight-sensing control
- Onboard occupancy sensor
- Calibrated at factory
- Wireless controls
- Individually adjustable with hand-held remote
- Less expensive without all that control wiring?

# Display case, demo lights

## …and “indoor horticulture”

- Separate switching required for:
  - Display, display case & accent
  - Plant grow lights
  - Food warming



# Interior Lighting Power Allowance

**These are not ambitious values.**

Every design is likely to pass

- Building Area Method or
- Space-by-Space method
  - "Common" space types or
  - "Building Specific" space types
- Additional allowance for retail display
- Long list of exceptions

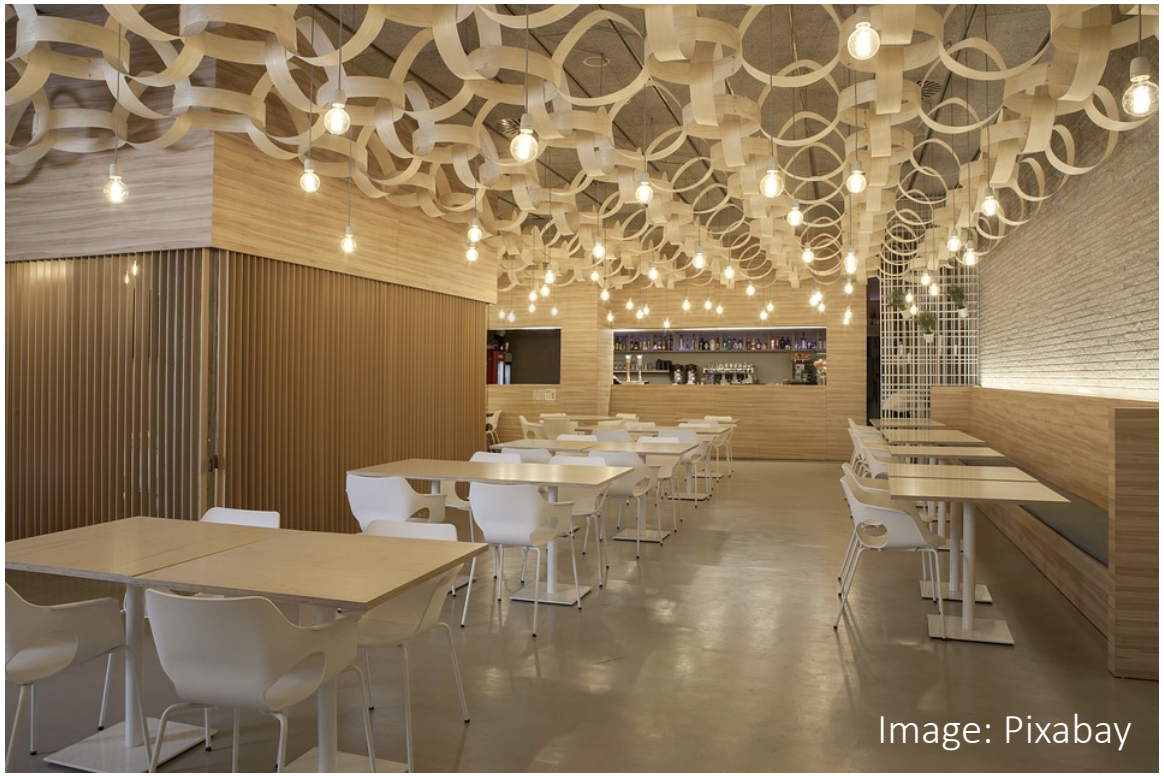


Image: Pixabay

# Exterior Lighting Power Allowance Table

- You get the base site allowance
  - 500, 600, 750, or 1300 W
- plus Tradable surface allowance
  - Parking, walks, stairs, entries, sales areas
- plus Nontradable surface allowance
  - Facades, ATMs, gatehouses, emergency loading zones
- Exempt lighting
  - Traffic, signage, theatrical, athletic, temporary, industrial, transportation, storage, theme parks, public monuments, historic landmarks

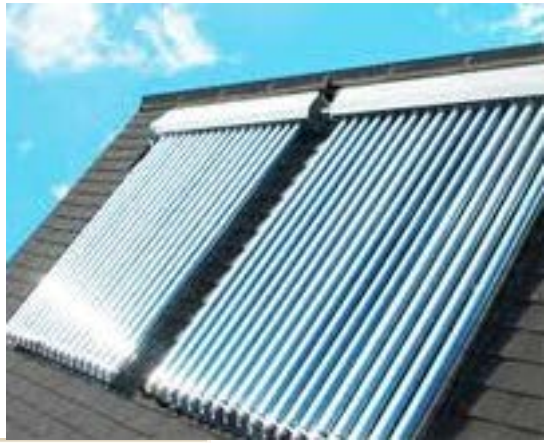
Image: Wikimedia Commons by famartin

# A few things probably *not* in your code:

## Controlled Receptacles

- Private offices, open offices, classrooms etc:
- 50% controlled by time clock or occ sensor
- Off-hours override switch for occupants


## Renewables



## Metering & Sub-Metering

- Meter incoming gas & electric
- Sub-meter lights, HVAC, water heating, plugs
- Graphic display shows energy use over time

# C406 Additional Efficiency Options
## (not in ASHRAE 90.1)  (new construction only)

### Buildings **Pick 1**:

1. HVAC efficiency (+10%)
2. Lighting power (–10%)
3. Digital lighting controls
4. Solar – 0.5 W/sf
5. DOAS
6. Water heating
7. Envelope UxA (–15%)
8. Air leakage 0.25 cfm/sf

### Tenant spaces **Pick 1**:

Either 1, 2, 3, 5 or 6

or

Be located in a building that has 4, 7, or 8

### 2021 code?:

Change to point-based system based on occupancy and climate zone

Image: Zmenu

# Energy Modeling: Opportunity for monkey-business?

# Do performance Path buildings = prescriptive path buildings?

Of course! …except:

1. Rapidly-evolving technology
2. HVAC system type selection
3. Myth of the “code minimum” building
4. Short vs. long measure lives


Image: Jonlin

# Rapidly-evolving technology

- Technologies evolve quickly…
  - LED lighting
  - EC motors
  - Data storage
- …but code requirements stay preserved in amber
- …& federal preemption rules slow down progress

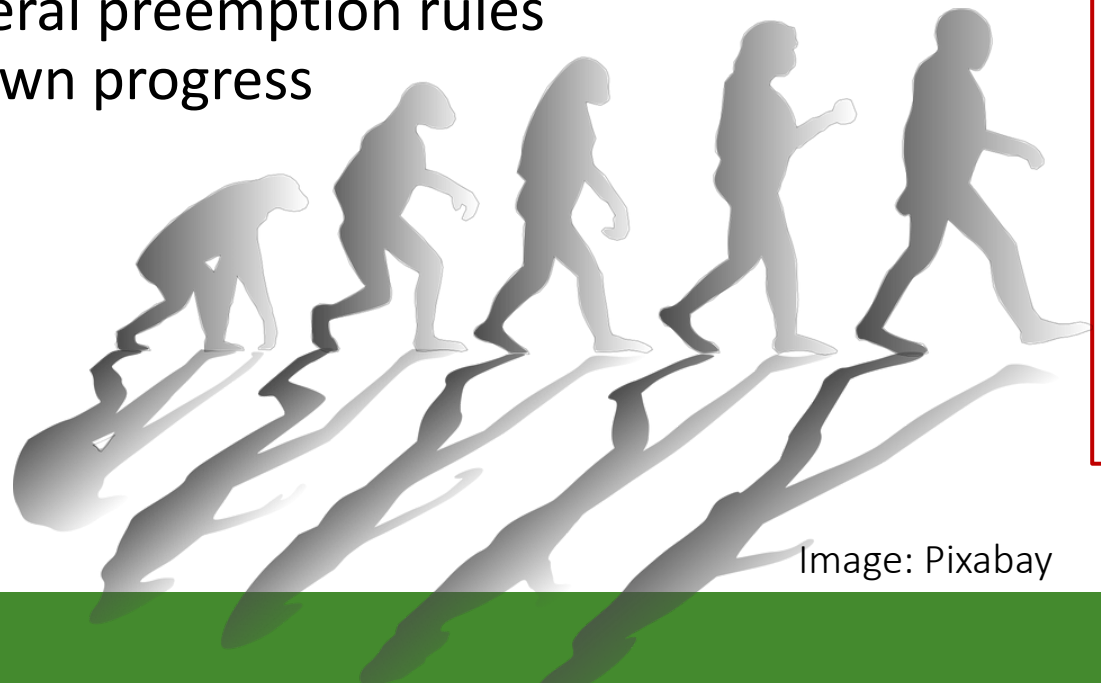


Image: Pixabay

The decade passes:

2009 lighting data collected

2010 ICC proposal deadline

2012 IECC published

2014 states adopt 2012 code

2017 final 2012 code permits

2019 lighting packages bought

10 years later!

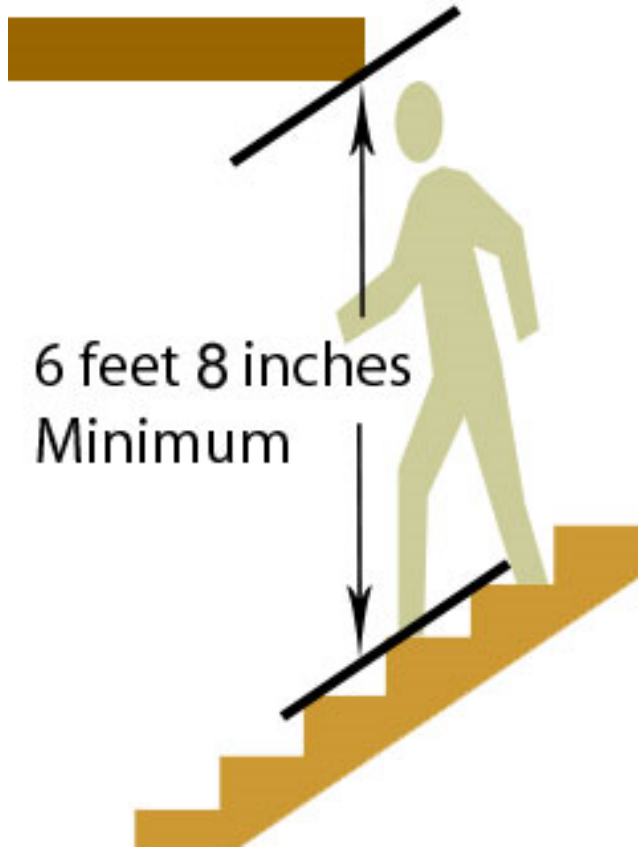
(and could be 12 – 15 years)

# Code *baseline* HVAC system: based on *proposed* system

- No penalty for choosing *lousy* HVAC system type
- No reward for choosing *great* system type
- Baseline adjusts to accommodate *anything*
- (ASHRAE Appendix G mitigates this)

# The myth of the “code-minimum” building

- Some building components just meet minimum code
  - Like insulation R-values
- Others are normally *better* than code:
  - Lighting power
  - Fan power
  - Condensing gas boilers
- Systems *<u>we were going to use anyway</u>* are “traded” for a worse envelope



# Short vs long life

## the envelope is forever

- Envelope deficiencies persist 50 – 100 years
- HVAC upgraded to new code every 20 – 30 years
- Lighting every 15 years


Image: Flickr Tim Green

# Energy modeling: "Total Building Performance"

- "Mandatory" vs. "Prescriptive"?
  - Provisions shown as "mandatory" can't be traded in the energy model
  - Clarifying this in 2021 code
- Proposed design: just like it says
- Standard reference design: Every component is the worst allowable by code
- **Make your SRD as bad as possible!**
  - So that we can have huge windows and no slab insulation
  - After all, we *are* architects!

Modeling Considerations:

- Many software packages – each produces different results
- Often can't model complex systems
- Nobody can know them all – difficult for code officials
- Drawings often don't match model
- Most modelers use ASHRAE 90.1 instead of IECC
  - "Energy Cost Budget" method or "Appendix G" method

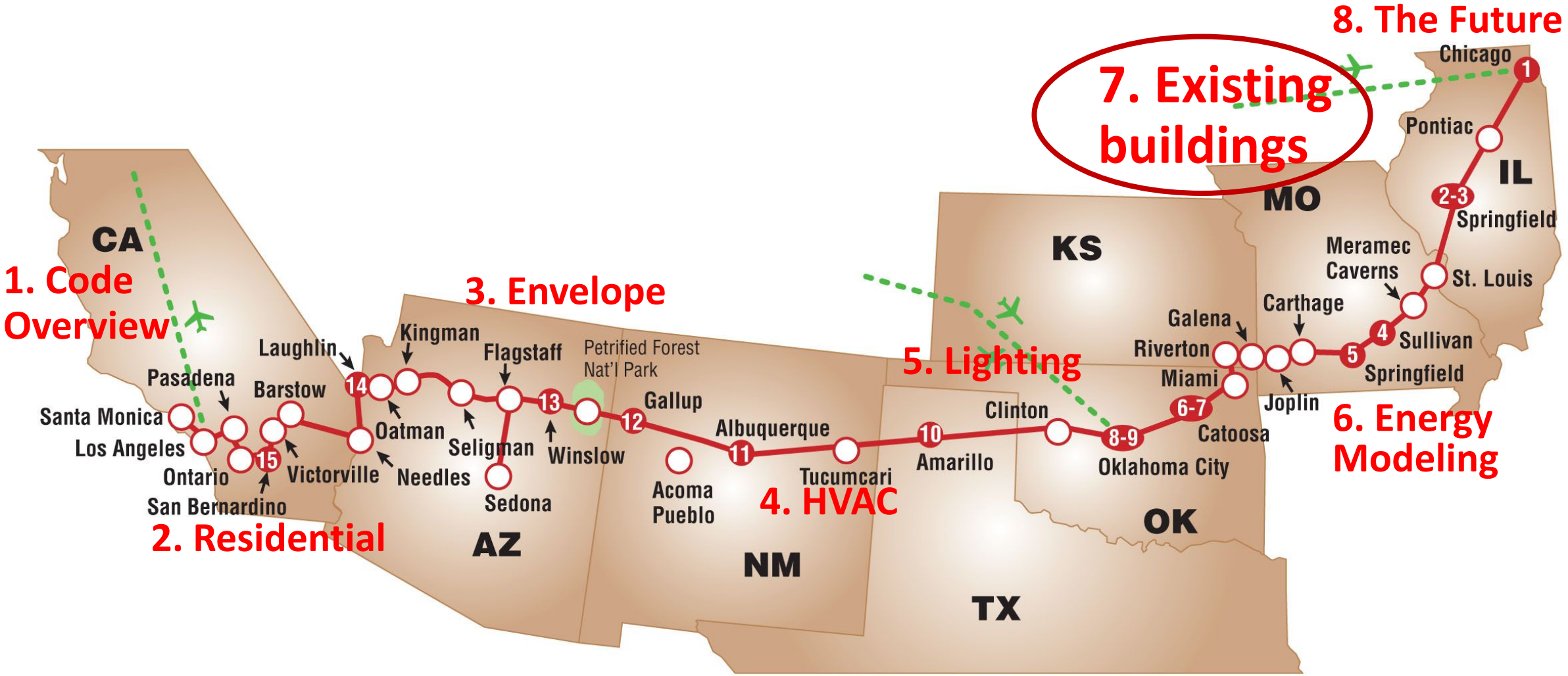
# Energy Metric: Carbon, Site, Cost or Source?

- IECC & ASHRAE 90.1 use Energy Cost
- Portfolio Manager likes Source Energy
- LEED uses Source Energy & Carbon Emissions
- WA is switching from site energy to carbon
- California uses TDV, switching to EDR
  - Time-dependent valuation, energy design ratio

Image: Maxpixel.net

Image: Flickr Jon Sullivan

# And what about the other 98% of buildings?



# Existing Buildings

- (Almost) anything built to code can stay that way
- (Almost) anything *new* must comply with new code
- "Repairs" can replace like with like

- Historic buildings: Never harm the historically significant fabric of the building

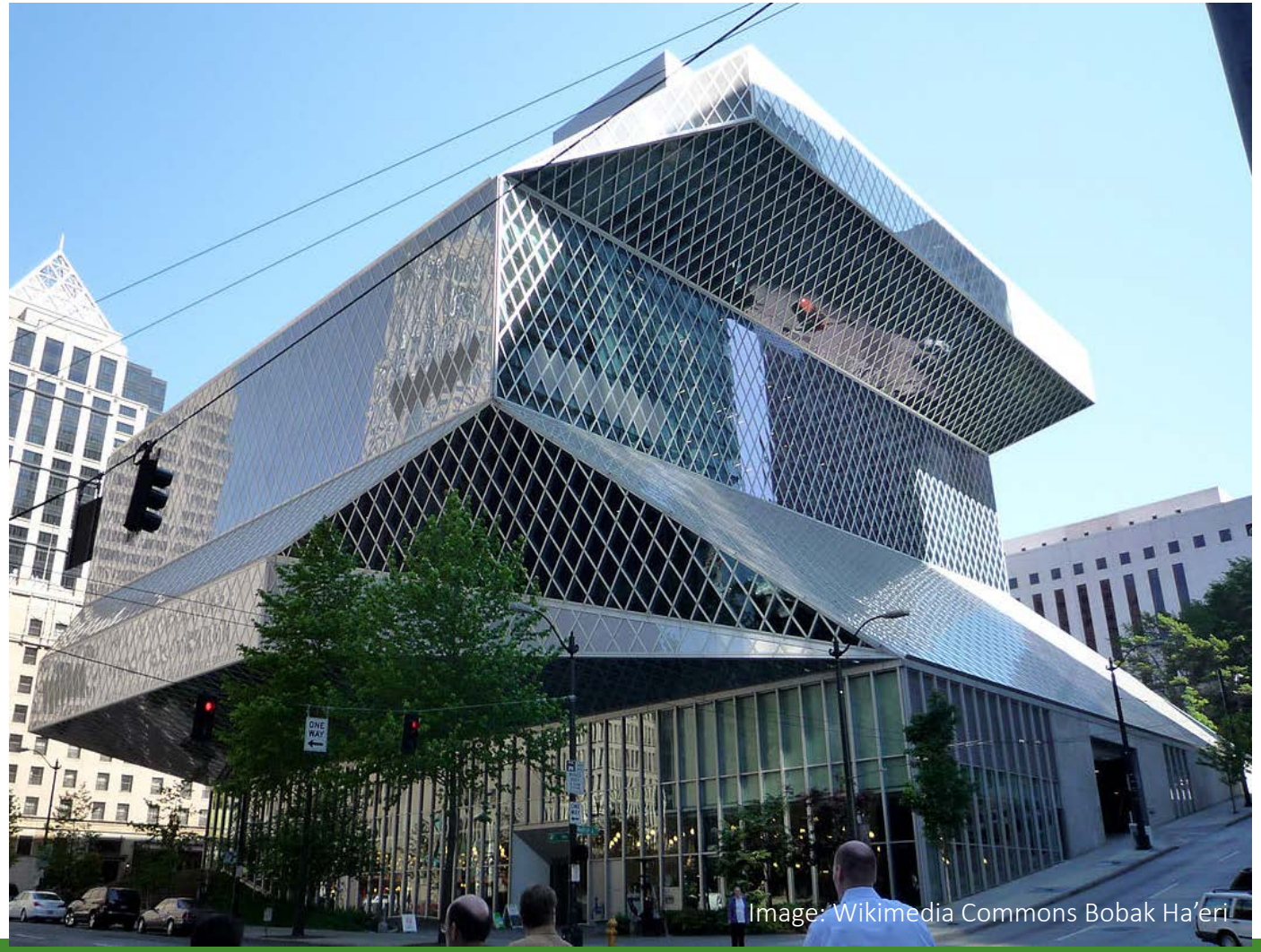


Image: Wikimedia Commons Bobak Ha'eri

# Additions

- Either addition alone complies or whole building complies
- Fenestration max area options:
  - Area complies for whole building
  - Area complies for addition alone
  - Or else whole building complies via energy modeling or UxA tradeoff

Image: National Park Service

# Alterations

- Change in space conditioning – entire building complies with whole code, except:
  - UxA can be 10% higher
  - Energy model can be 10% higher
- Additional glazing area
  - If total area less than 30%, just follow code
  - If 30 – 40%, OK if 25% (or 50%) of floor area is in daylight zone
  - If over 40%, use energy modeling or component performance
    - If glazing area is unchanged, use that area in std ref design


Image: Wiokimedia Commons Caroline Culler

# Change of Occupancy or Use

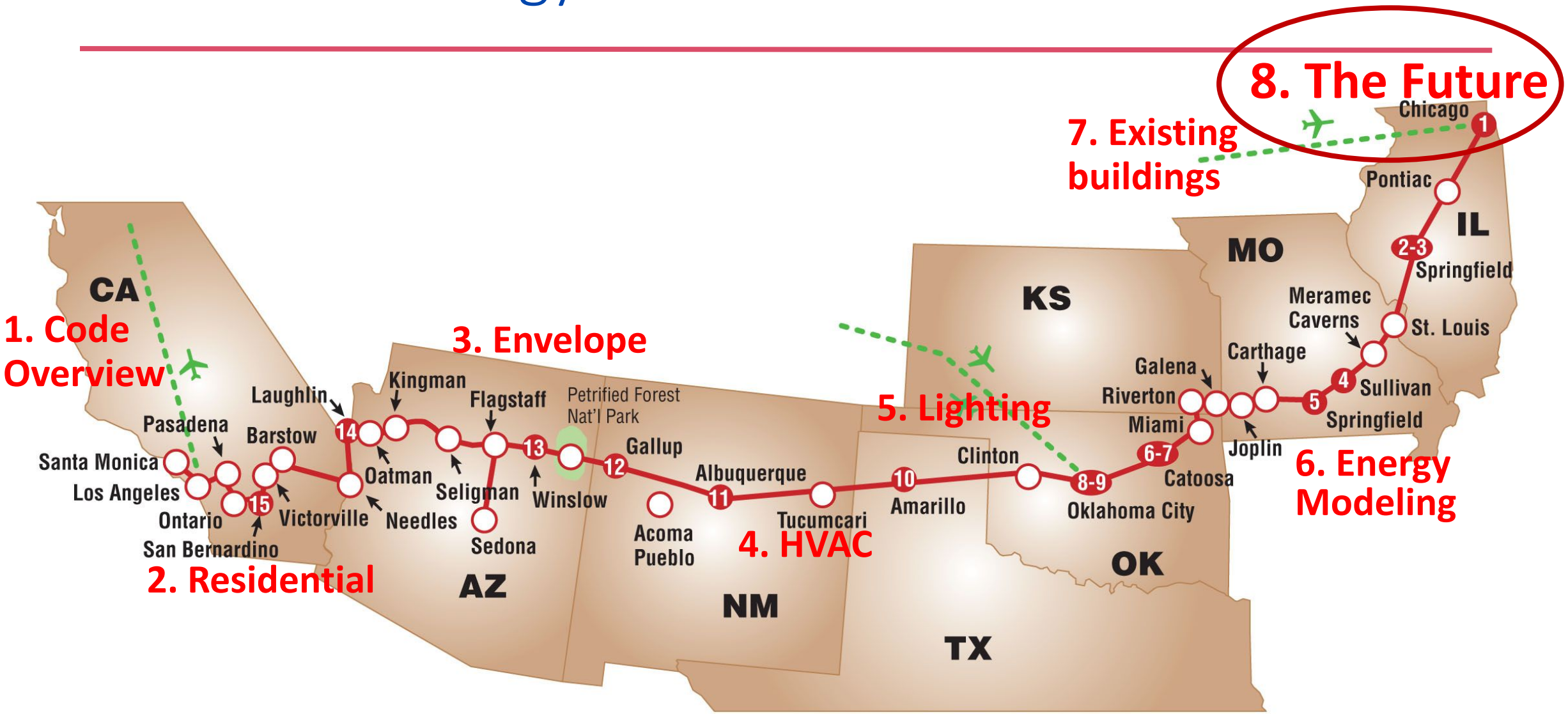
"…increase in demand for either fossil fuel use or electric energy…"

Exceptions:

- Target UxA can be 10% higher than Proposed UxA
- C407 Proposed Design can be 10% higher than it would be otherwise

Image: Wikimedia Commons Junkyardsparklea

# Where is the energy code headed next?



# Future Trends: We really have no idea

- Code *development* doesn't guarantee code *adoption*
- IECC: Resistance to change
- Especially challenging for residential
  - No official target or policy for efficiency
- Supplemental "above-code code"?
- Move to performance-based code?
  - Maybe a *systems* performance code?
- Required renewables?
  - Net metering not always available
- Does code *drive* new technologies?
  - …or just *adapt* to them?
- Is "net zero" a reasonable goal? Net zero what?

"Predictions are tough, especially about the future."
Yogi Berra

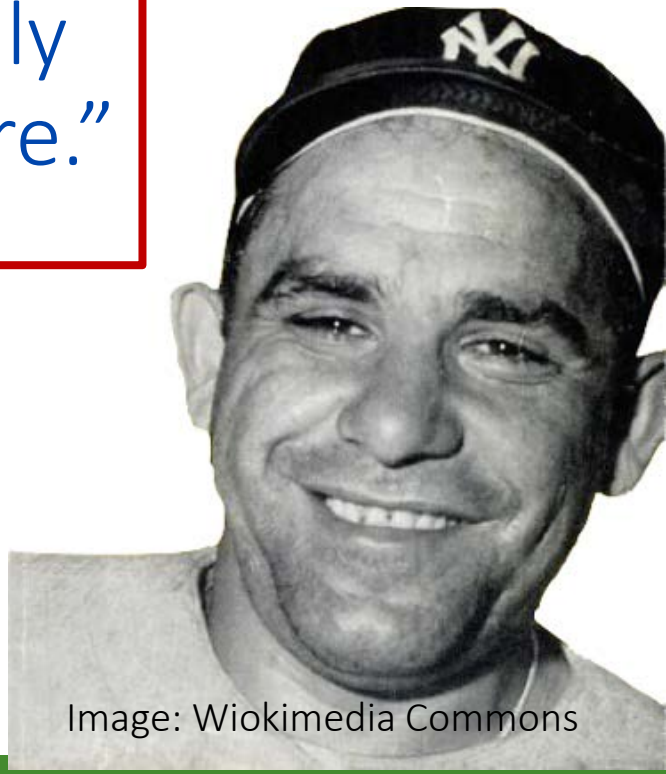
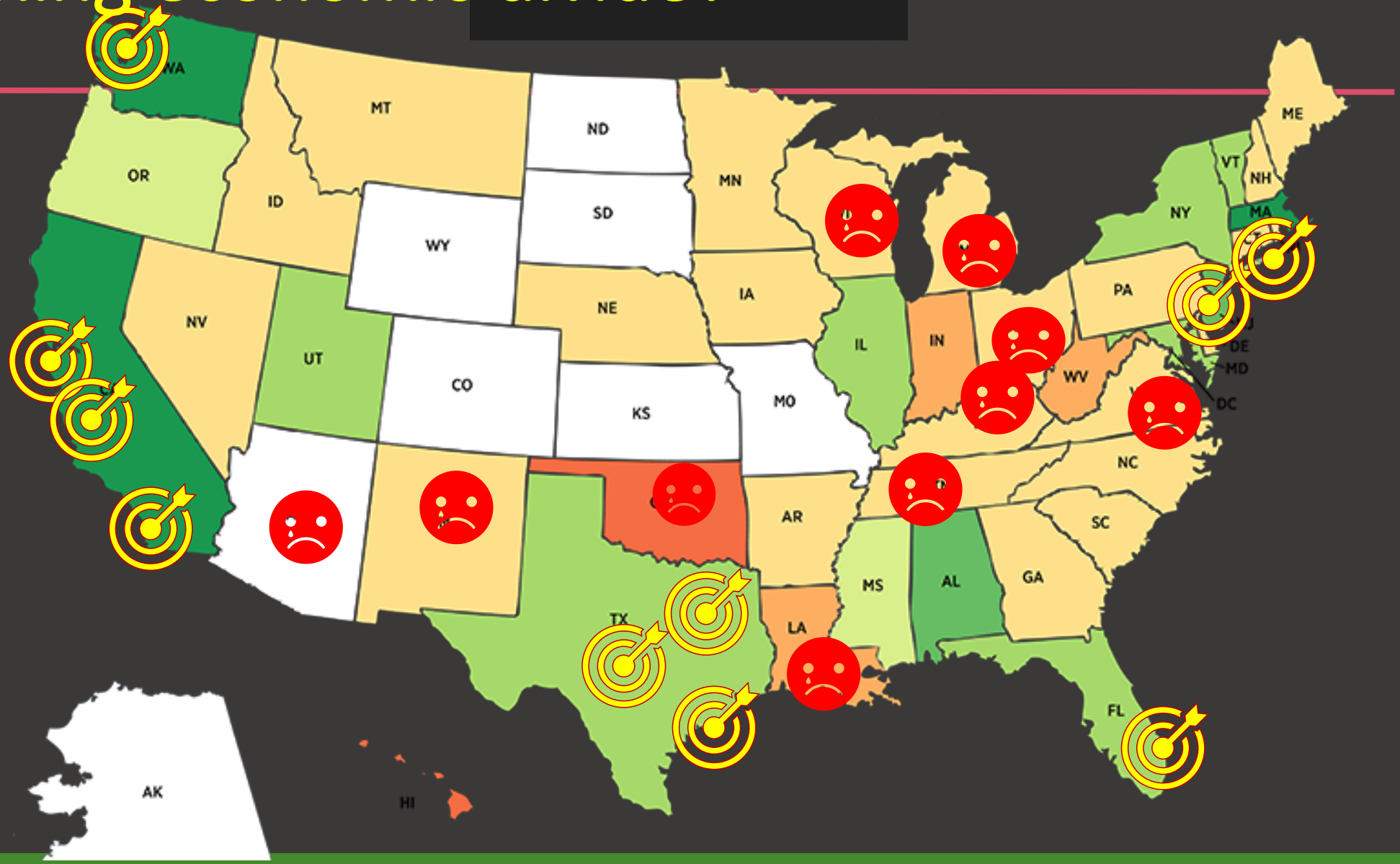


Image: Wiokimedia Commons

# A widening economic divide?



# A public service announcement from the New Buildings Institute:

**22.6**

Site EUI

# “That which exists, must be possible.”

Mark Frankel, NBI

# Energy is not our only value.

## Energy policy should not compromise cultural values

- **Health** (sunlight, clean air & water)
- **Comfort** (temperature, humidity)
- **Environment** (local pollution, carbon emissions)
- **Durability** (long-lasting materials and equipment)
- **Quiet** (equipment, traffic)
- **Beauty**

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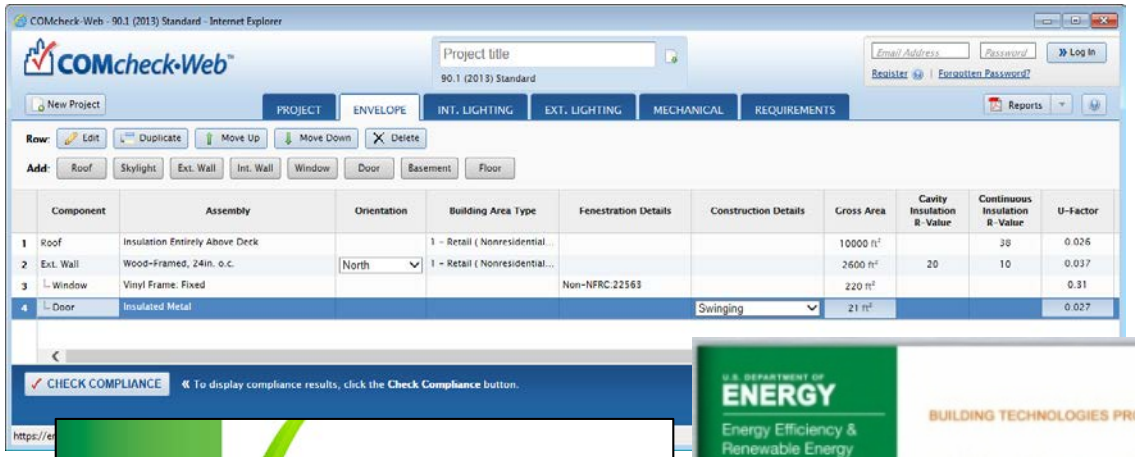
**206-233-2781**

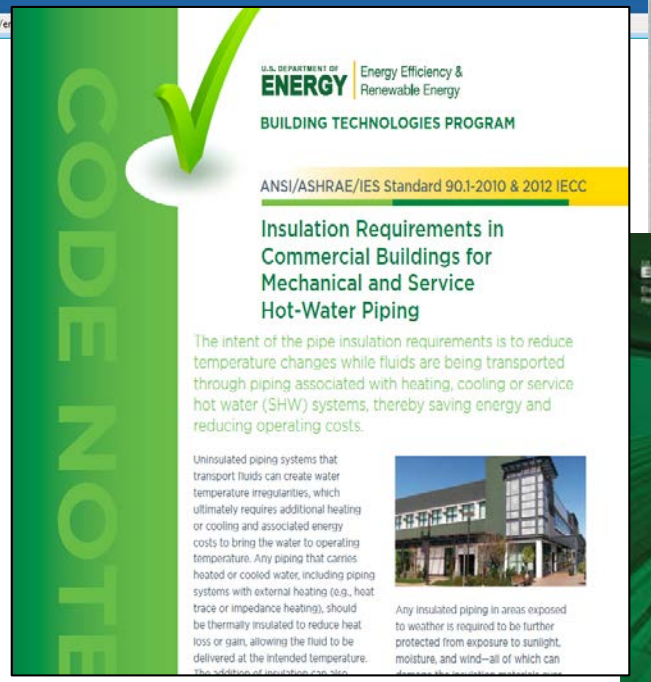
Image: City of Seattle

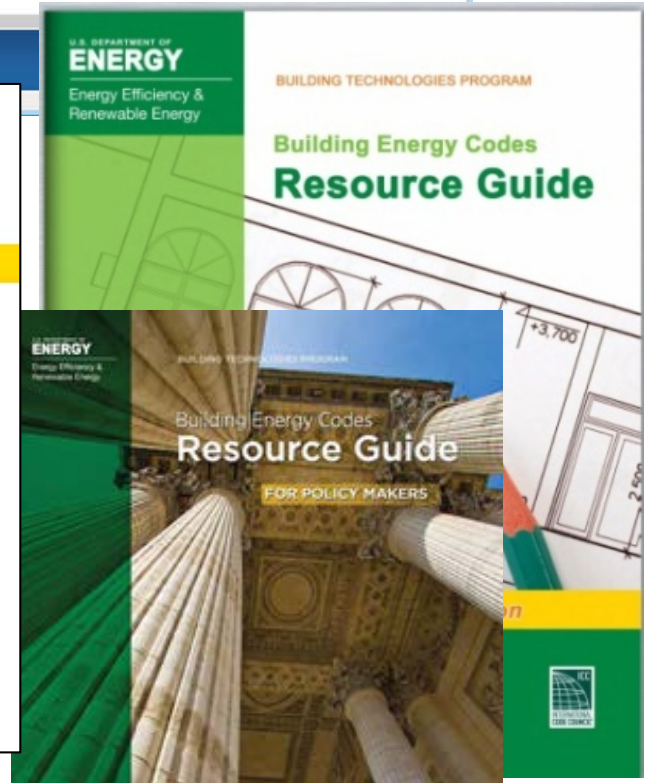
# U.S. DOE: Building Energy Codes Program

- Compliance software
- Technical support
- Code notes
- Publications
- Resource guides
- Training materials

www.energycodes.gov

# THANK YOU!

Building Energy Codes Program

www.energycodes.gov

BECP help desk

https://www.energycodes.gov/HelpDesk