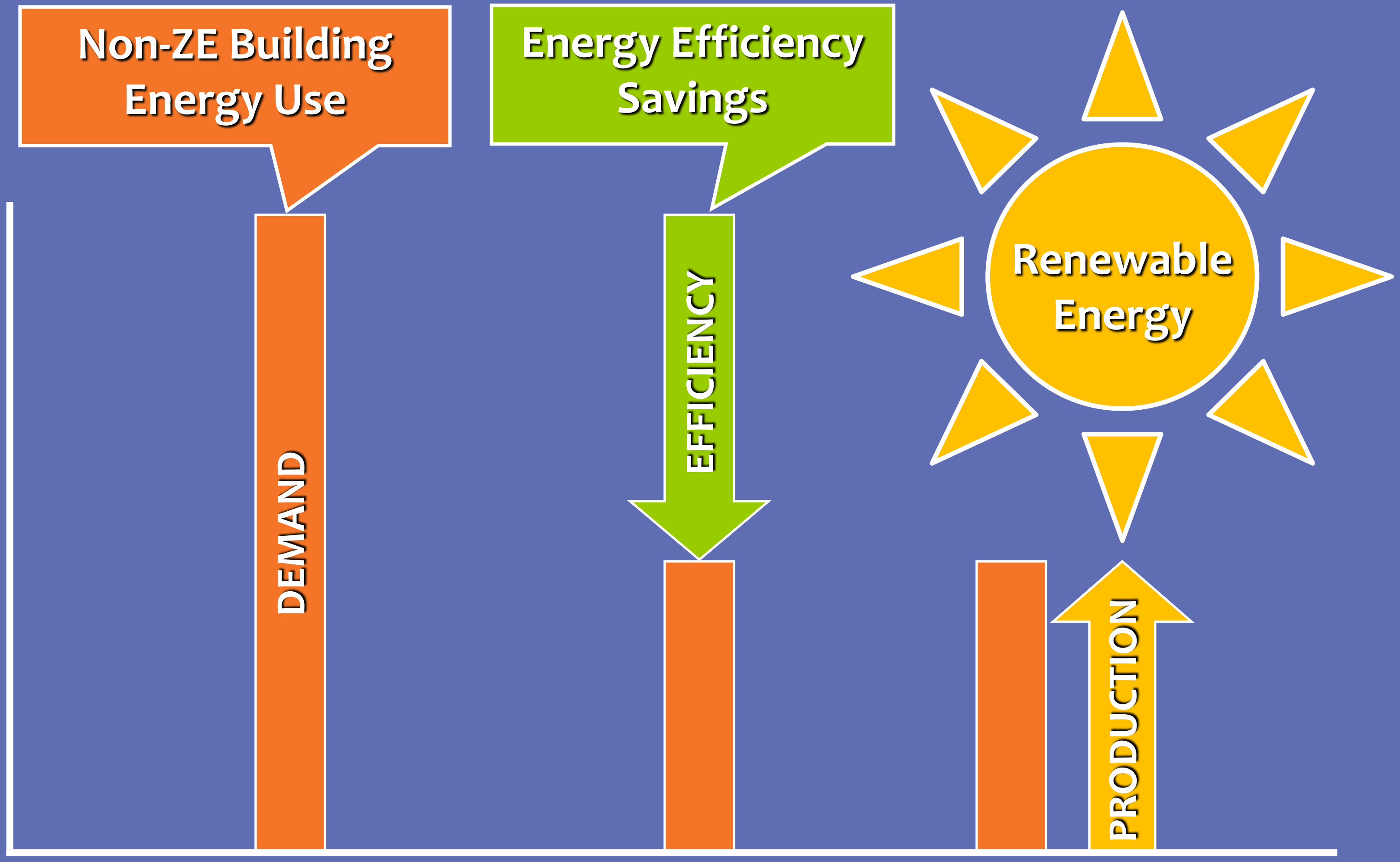
Getting to ZNE*

* Energy *or* Electricity *or* Emissions?

Ann V Edminster
DESIGN AVEnues LLC

In simplest terms, Zero Net [Electricity / Energy / Emissions] or ZNE



means optimizing **EFFICIENCY** to balance **DEMAND** and **PRODUCTION** on an annual basis

(although there are several more specific definitions)

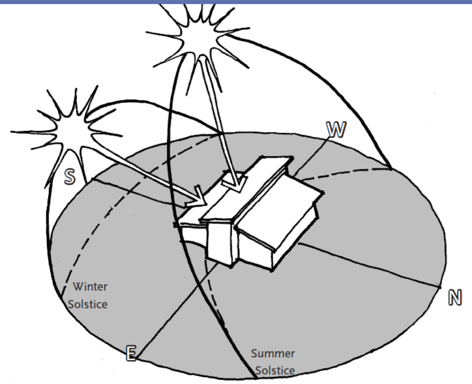
Absolute ZERO isn't always achievable, *BUT*

It's compelling because it is a powerful driver for

EFFICIENCY

The foundation for all definitions: ZNE-ready

1 Efficient form & orientation



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2 High performance enclosure

+

3 Super-efficient mechanical systems

4 Best-in-class electric devices

+

=

ZNE ready

A home that is **designed, built, and commissioned** to be **highly efficient** and capable of operating at ZNE with addition of renewable energy

Efficiency benefits

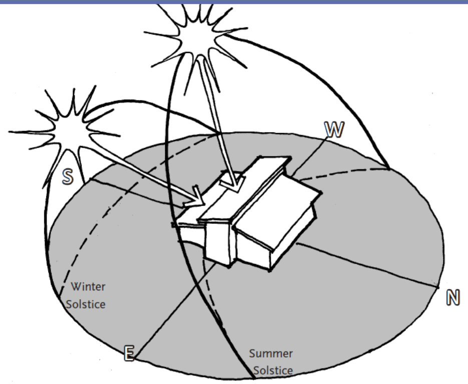
With EFFICIENCY you get:

That's a life safety feature!

- Reduced energy use & utility bills
- Improved comfort
  - → Indoor temperature stays stable longer when the power is out!
- Better indoor air quality
- Quieter interiors
- Faster delivery of hot water
- Protection against rising energy costs
- Lower climate change impacts

ZNE-ready + renewable energy = ZNE

1 Efficient form & orientation



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2 High performance enclosure

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4 Super-efficient electric devices

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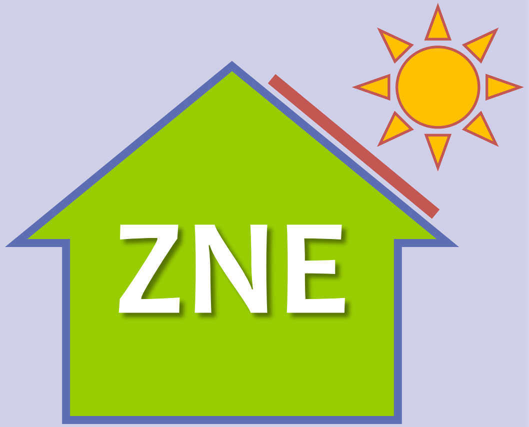
5 Renewable energy system*

=



* To achieve ZNE, renewable energy production must meet the home's total annual energy usage – including ALL FUELS.

Added benefits from ZNE

Add SOLAR to an efficient home and you also get:

- Free energy when the sun is shining
- Power when the grid goes down
  - → *IF you add a battery!*
- Resale value with solar +4% *
- Even lower climate change impacts
- A ZERO-EMISSIONS home
  - → *If ALL the energy you use is from renewables!*

100% renewable energy is available in many utility areas

Image Xana_UKR via iStock

* https://money.com/home-value-solar-panels/

What is a ZNE home, *really?*

SAME VALUE?

SAME PRODUCT?

SAME PRICE?

Consider net cost of ownership

CONVENTIONAL HOME

MORTGAGE → HOUSING $

+

UTILITY BILL → ENERGY $

ZERO ENERGY HOME

MORTGAGE → HOUSING $ + ENERGY $

+

UTILITY BILL → ENERGY $

COMPARE

VS. →

Does ZNE cost more? NOT if it's baked in!

I ask customers to give me $100 more per month and I'll return $300 back to them in energy savings.

- Thrive Home Builders in Denver offered ZNE as an option; it didn't sell.
- Then they designed for ZNE from scratch and made it standard.
- Now their ZNE homes cost the same to build as their homes *without solar*.

Not only that, but ...

- **Offering ZNE has given them unique access to premium properties.**

And … ZNE builders have a market advantage

THE COMMON PERCEPTION
that there is a cost premium for ZNE homes—assumes no fundamental design changes

"The learnings from the [ZNE] homes have improved all of our homes significantly—improved their saleability and improved our position in the marketplace."

~ Ryan Scott, CEO
Avalon Master Builders

Q:

What's the difference between Title 24 and ZNE?

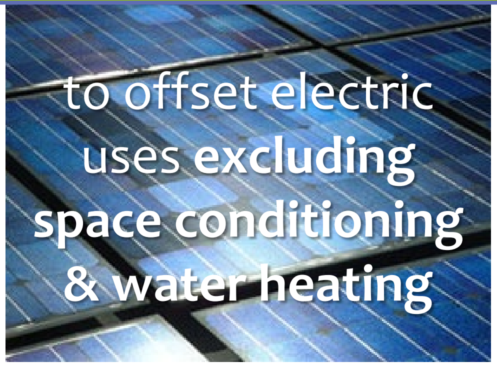
And what are the differences between the three ZNEs: energy, electricity, emissions?

Title 24-2019—Moving toward ZNE

ZNE
ready

+

Photovoltaics (PV)
required



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Title 24
2019

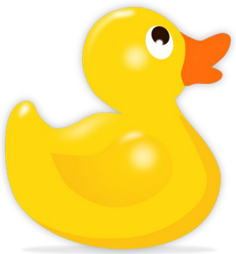
Another
"ZNE" – just
zeroing out
electricity use

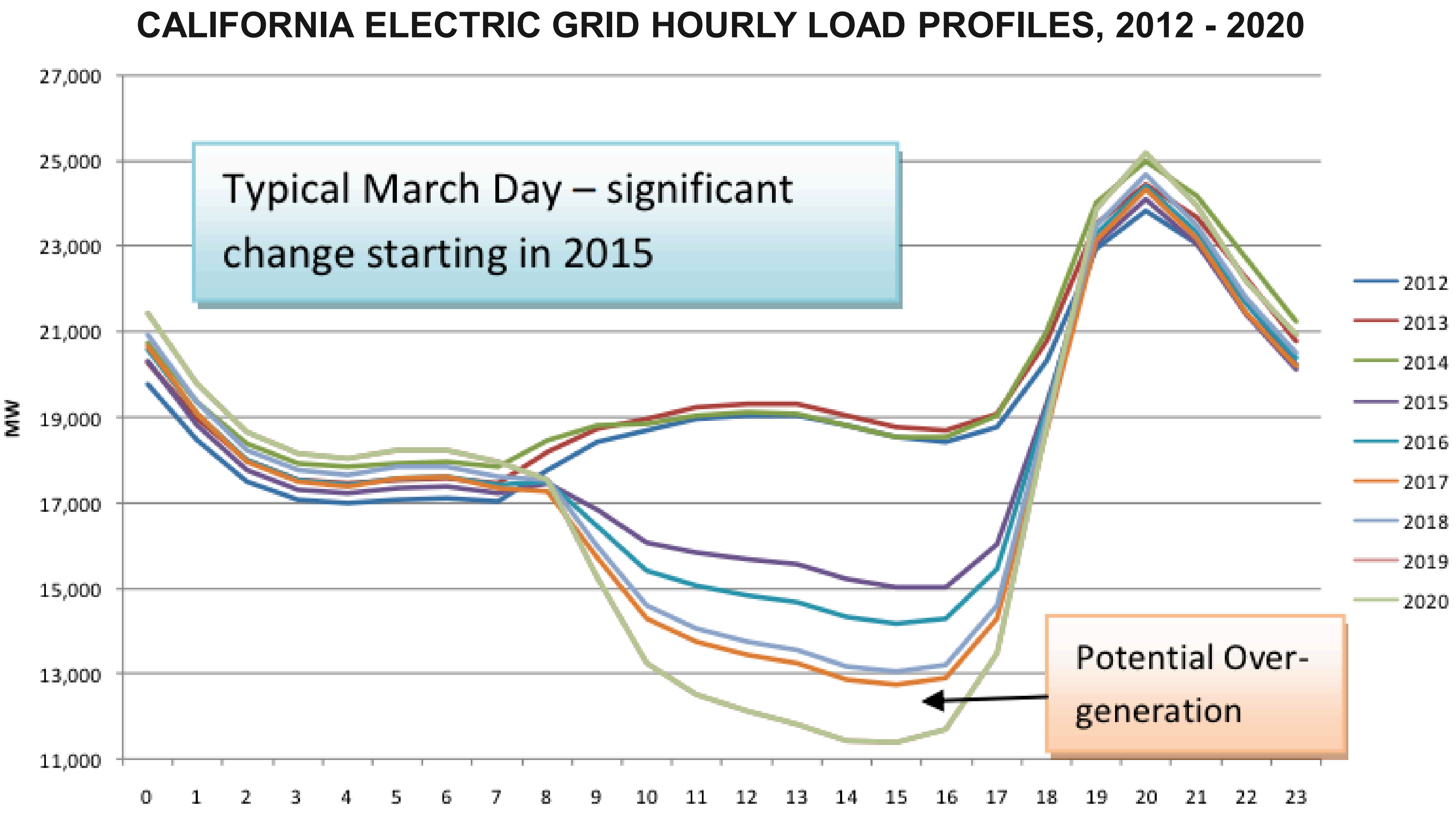
IMPACTS:

- $80/mo avg utility savings
- $40/mo avg mortgage increase
- 50% energy savings vs. 2005 home
- **$1.7B savings to Californians**

Battery storage
encouraged

The ‘duck curve’ phenomenon





- ***Annual*** **ZNE doesn’t balance production with consumption**
- **A clean energy future relies on achieving that balance**

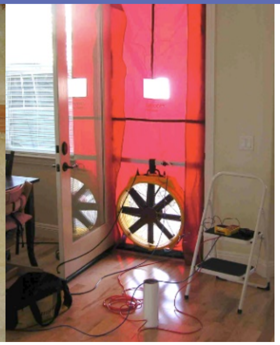
Getting from Title 24-2019 to zero net ENERGY

Title 24
2019

+

MORE PV … enough for **all energy loads**

High-performance installation & commissioning



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ZNE

NOTE: Because PV production can only be credited against **electricity** bills, zero net ***ENERGY*** homes are typically all-electric

What does the E stand for?

It depends on how much renewable energy (RE) you're producing onsite (or buying) —

E stands for:	If RE supplies 100% of the home's annual:	And:
ENERGY	ENERGY use – including **ALL FUELS**	
ELECTRICITY	ONLY **ELECTRICITY** use	
EMISSIONS	**ELECTRICITY** use – and there is **no in-home gas combustion**	The home is **100% ELECTRIC** & uses or buys **100% ZERO-EMISSIONS GRID POWER** (or is off-grid)

Title 24-2019

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Most common use of ZNE

Q:

What's different about designing a ZNE home vs. any other home?

The Devil's in the details

Image: Openclipart via publicdomainvectors.org

Critical factors for achieving ZNE affordably:

- Roof
- Form
- Plan
- Enclosure
- Windows
- Documentation

ROOF: start at the top

- Meeting ZNE dictates a solar production goal—*which* ZERO?
  - Electricity?
  - Energy?
  - Emissions?
- Numbers you'll need
  - Energy use intensity (EUI)
  - Total load (KW DC energy)
  - PV square footage
  - Roof area

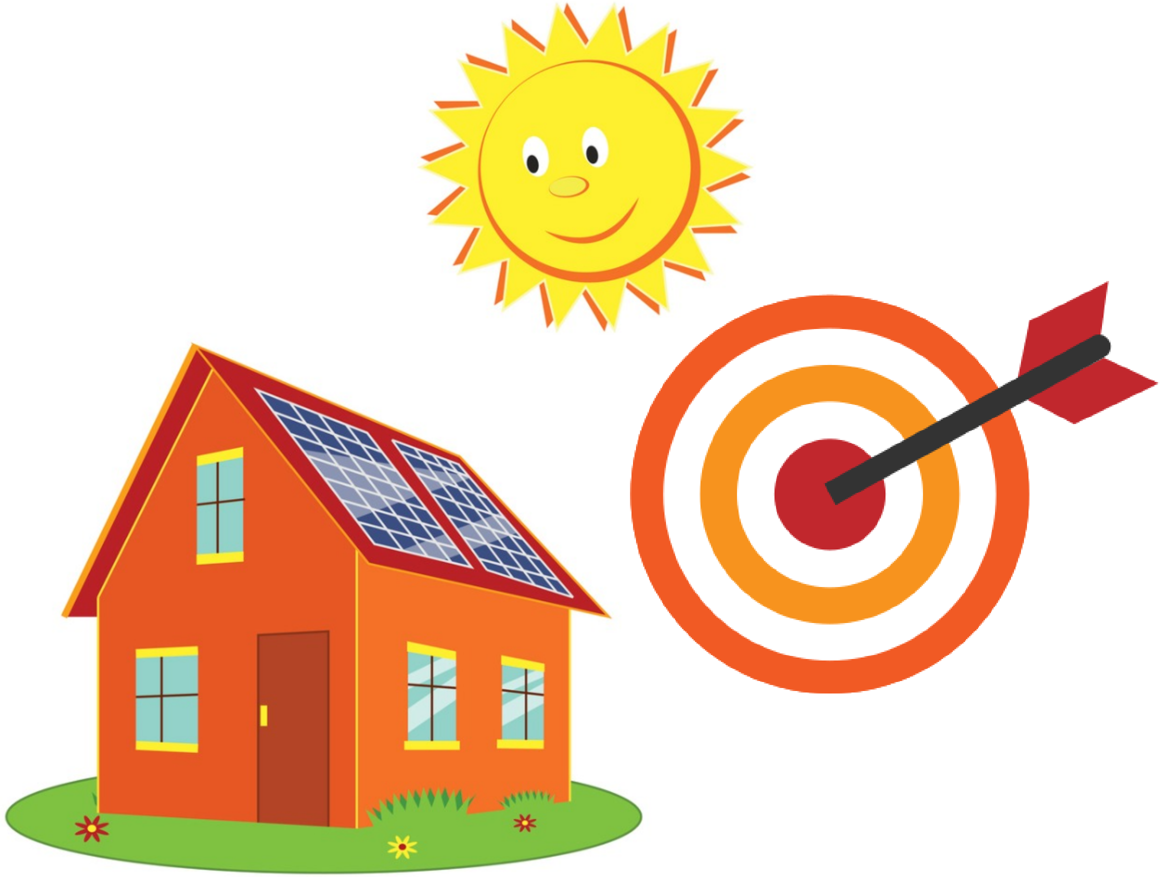


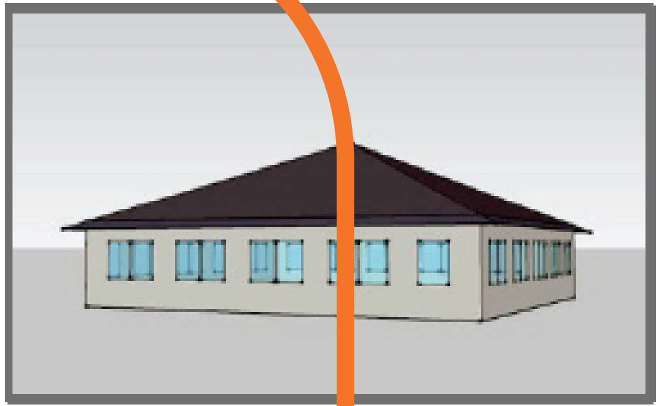
Image Xana_UKR via iStock

Choose a target EUI (Kbtu/sf/yr)

- **What's a "good" EUI for ZNE?**

Single Family Residential

Size:	**2,116**	ft^2
Number of Floors:	**1**	floor



Climate Zones

Site-kBtu /ft²	15	13	12	10	7	3	16
Load:	12.9	16.4	16.6	12.9	11.5	12.7	17.3
Solar:	-12.9	-16.4	-16.6	-12.9	-11.5	-12.7	-17.3
Net:	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Source: *The Technical Feasibility of Zero Net Energy Buildings in California*, Arup, December 2012

Estimate your annual energy LOAD

- **What's the total load in kilowatt-hours (kWh)?**

EUI (kBtu/sf/yr) x House Size (sf)

EXAMPLE: 1,800 sf house in Oakland (Zone 3)

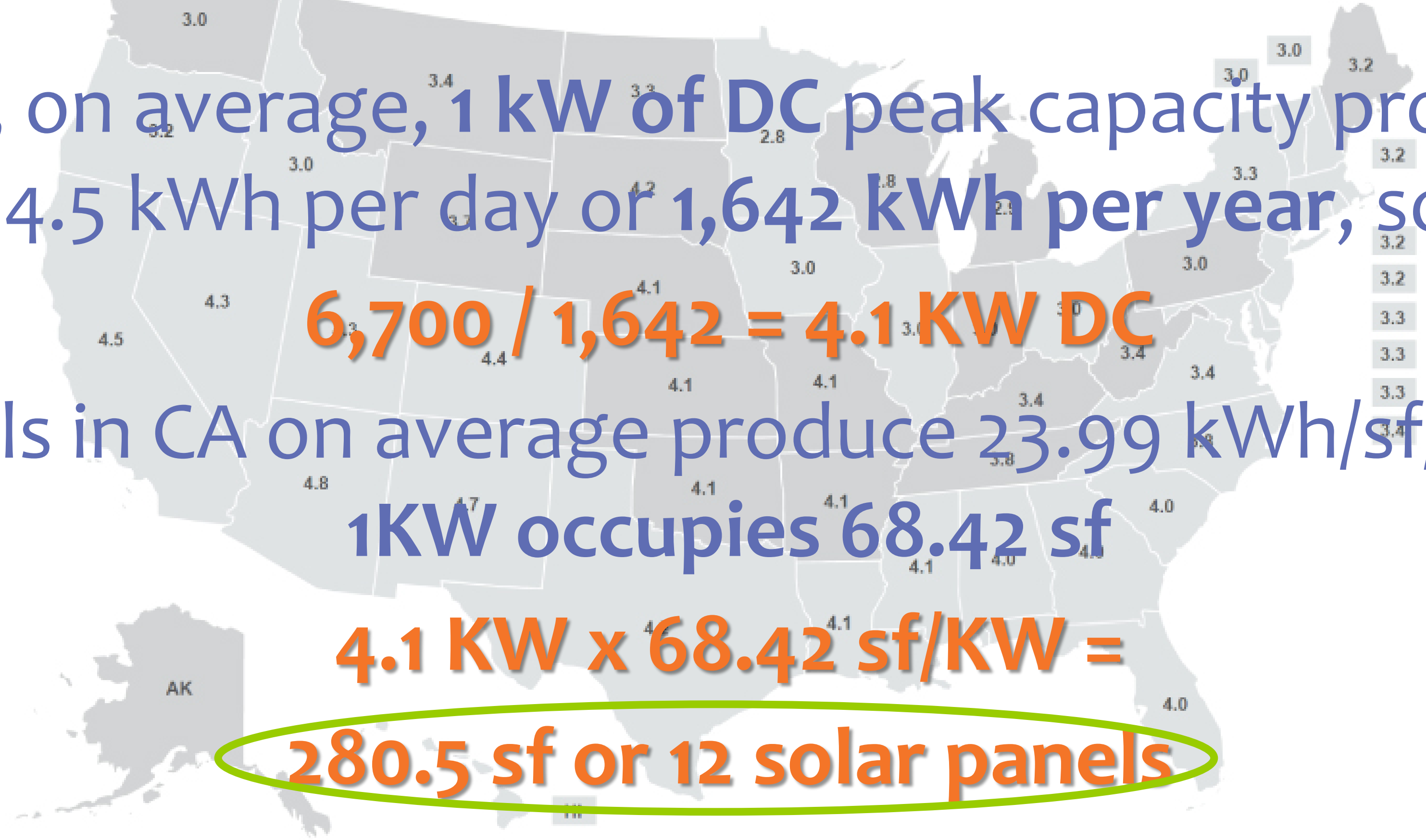
12.7 kBtu/sf/yr x 1,800 sf = 22,860 kBtu/yr

Convert kBtu/yr to kWh/yr: divide by 3.412

22,860 / 3.412 = 6,700 kWh/yr

Calculate a solar energy PRODUCTION goal

- **How much PV is needed?**



In CA, on average, **1 kW of DC** peak capacity produces 4.5 kWh per day or **1,642 kWh per year**, so

6,700 / 1,642 = 4.1 KW DC

Panels in CA on average produce 23.99 kWh/sf/yr, so **1KW occupies 68.42 sf**

4.1 KW x 68.42 sf/KW =

280.5 sf or 12 solar panels

Source: https://www.solarreviews.com/blog/how-much-electricity-does-a-solar-panel-produce

Estimate uninterrupted roof AREA

- **How much roof space is that, *really*?**

Typical residential panels are about **65" x 39"** so an array

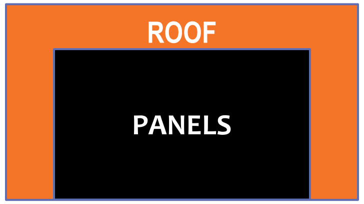
2 panels high by 6 panels wide is

about 11 ft. high x 20 ft. wide

plus 3' on 3 sides for fire clearance

gives a **total roof area** of

14 x 26 ft = 364 sq.ft.



With NO obstructions!

Source: http://news.energysage.com/average-solar-panel-size-weight/

Why uninterrupted roof area matters

Image: https://i.ytimg.com/vi/_ZxPopPSBbA/maxresdefault.jpg

UGH!

Images above: https://greensunnj.com/solar-hall-of-shame/

Images above: https://greensunnj.com/solar-hall-of-shame/

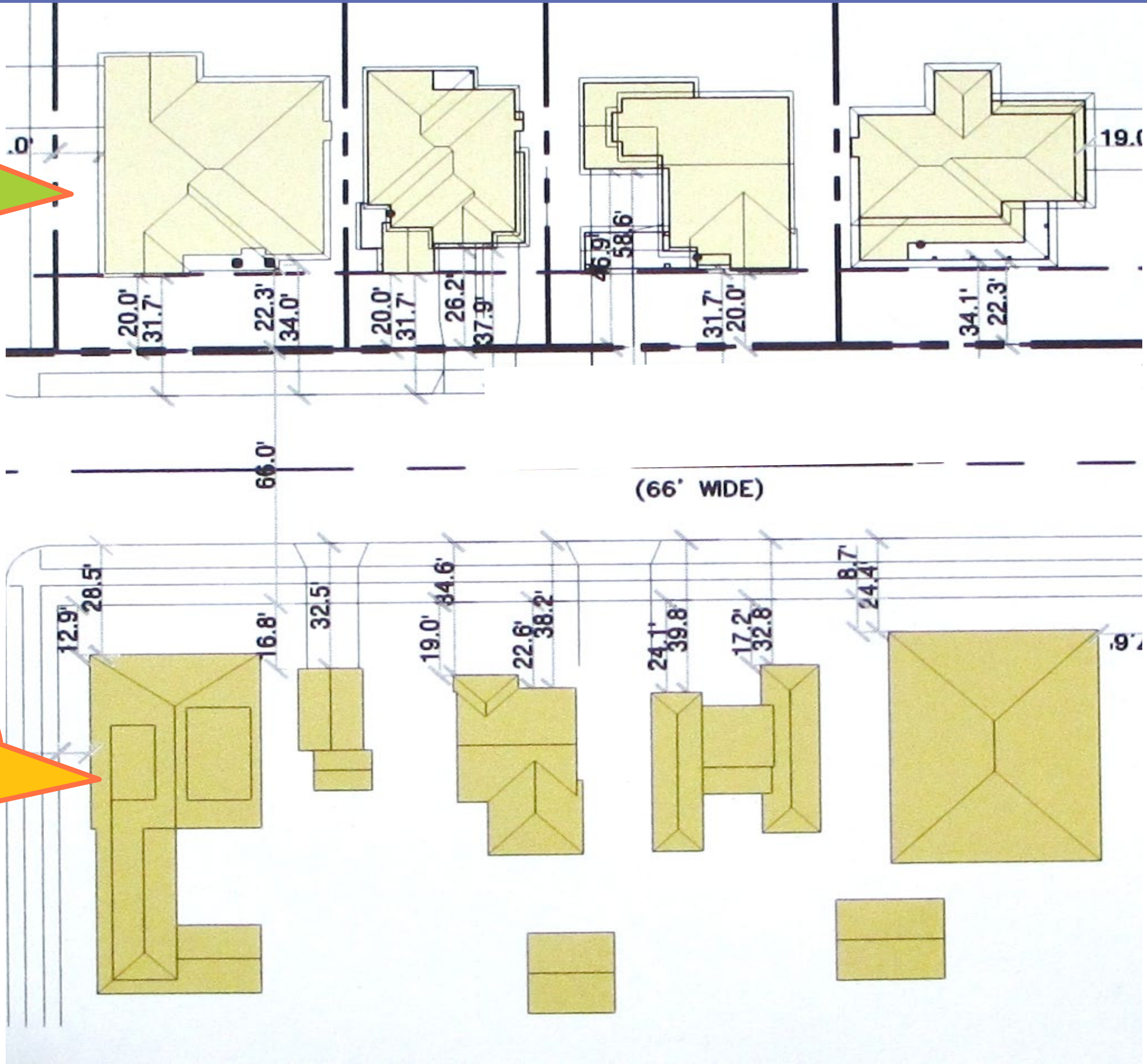
FORM: simplify to save $, reduce risk

REALLY HARD to heat, insulate, & air seal COMPLEX forms! LITTLE space for PVs!

MUCH EASIER to heat, insulate, & air seal SIMPLE forms. PVs fit easily.

The VALUE of simplifying

NEW (more complex)



EXISTING (simpler)

What are the costs of complexity here?

- Design $$$
- Construction $$$
- Liability risks
- Lost solar opportunity
- Higher utility costs
- Potential moisture intrusion

The COST of complexity

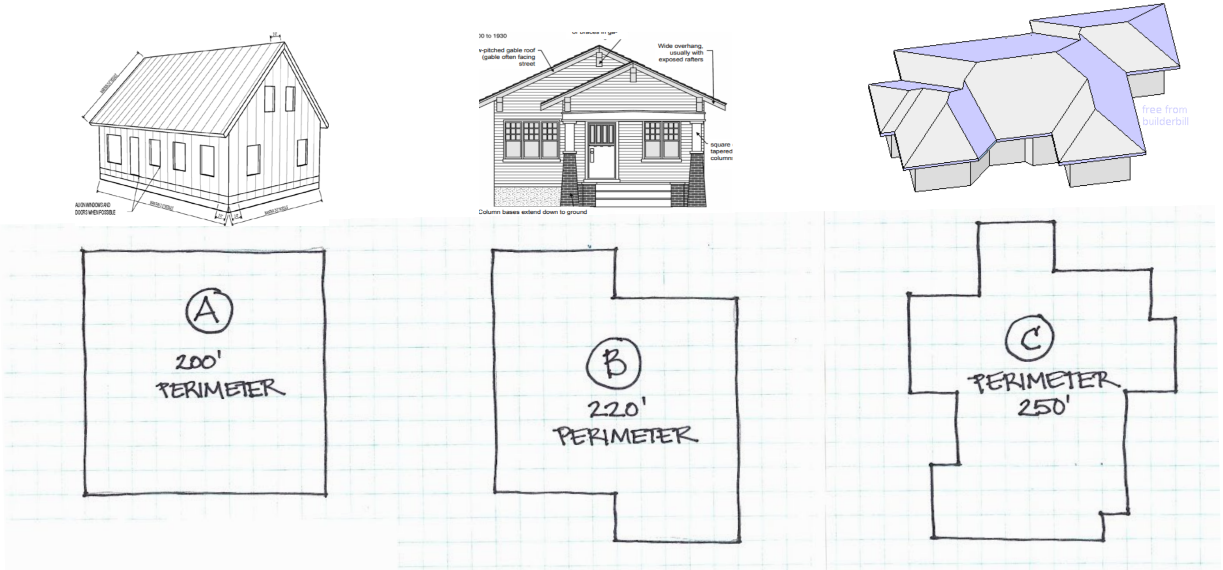
Construction cost assumptions (labor + materials):

- $300 / foot of perimeter
- $500 / corner

Not included:

- Interior impacts
- Roofing impacts
- Design costs
- Occupant utilities

2,500 square foot floor plans



Compare:	Plan A	Plan B	Plan C
Perimeter	200 ft	220 ft	250 ft
Corners	4	8	18
$ increase		**$9,000**	**$15,000**

Image A greenbuildingadvisor.com | Image B greenvillesc.gov | Image C www.builderbill-diy-help.com

PLAN: optimize systems

Key factors for heating, ventilating, air conditioning, and water heating:

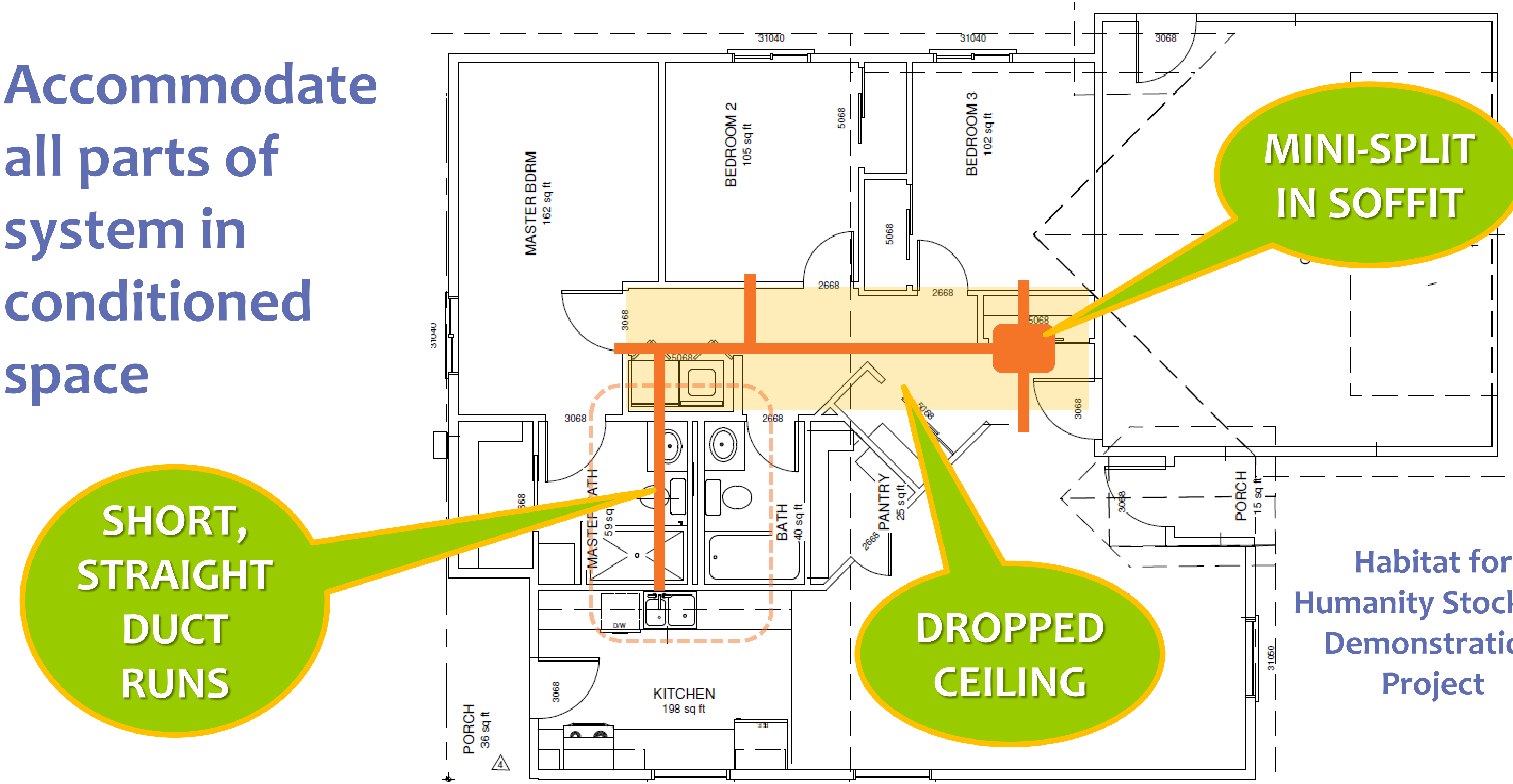
- Locations of equipment and distribution system components
- Proper sizing – ***no rules of thumb!***
- Equipment efficiency
- Distribution system design

INSIST ON:

- **Load calculations**
- **Sizing based on calcs**
- **Complete system specs**

HVAC planning

- Accommodate all parts of system in conditioned space



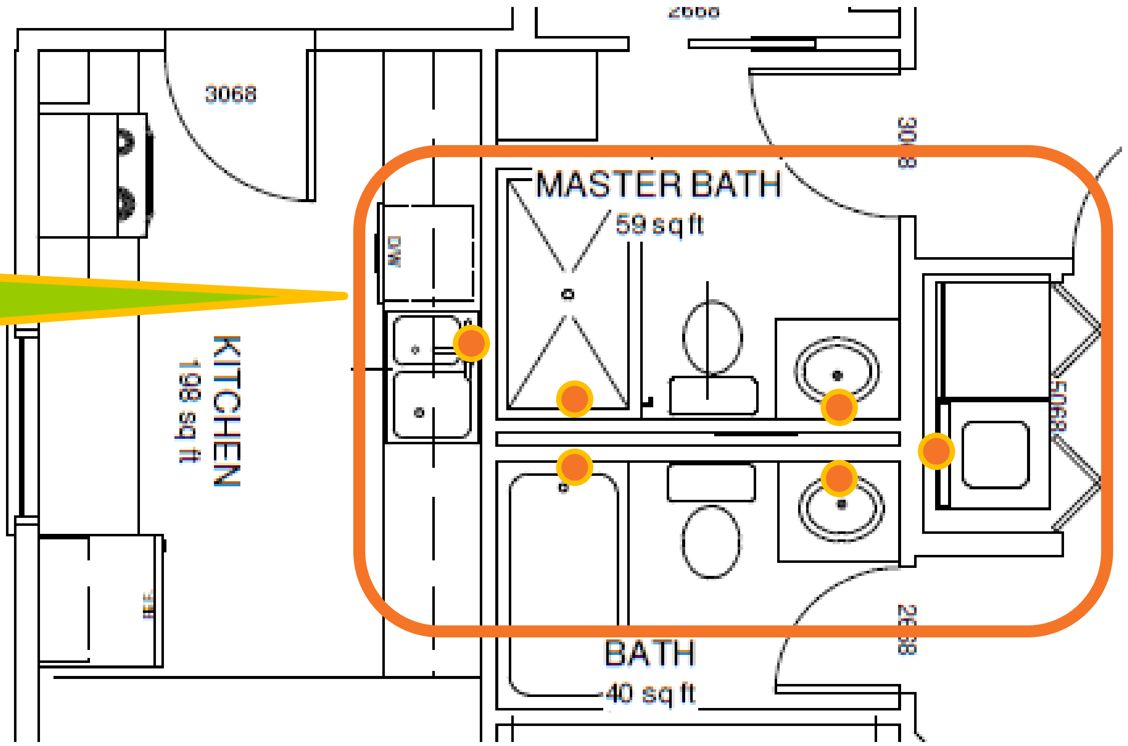
Habitat for Humanity Stockton Demonstration Project

PLUMBING planning

- Keep it compact!

LONGEST HOT WATER PIPE

12 ft.



Habitat for Humanity Stockton Demonstration Project

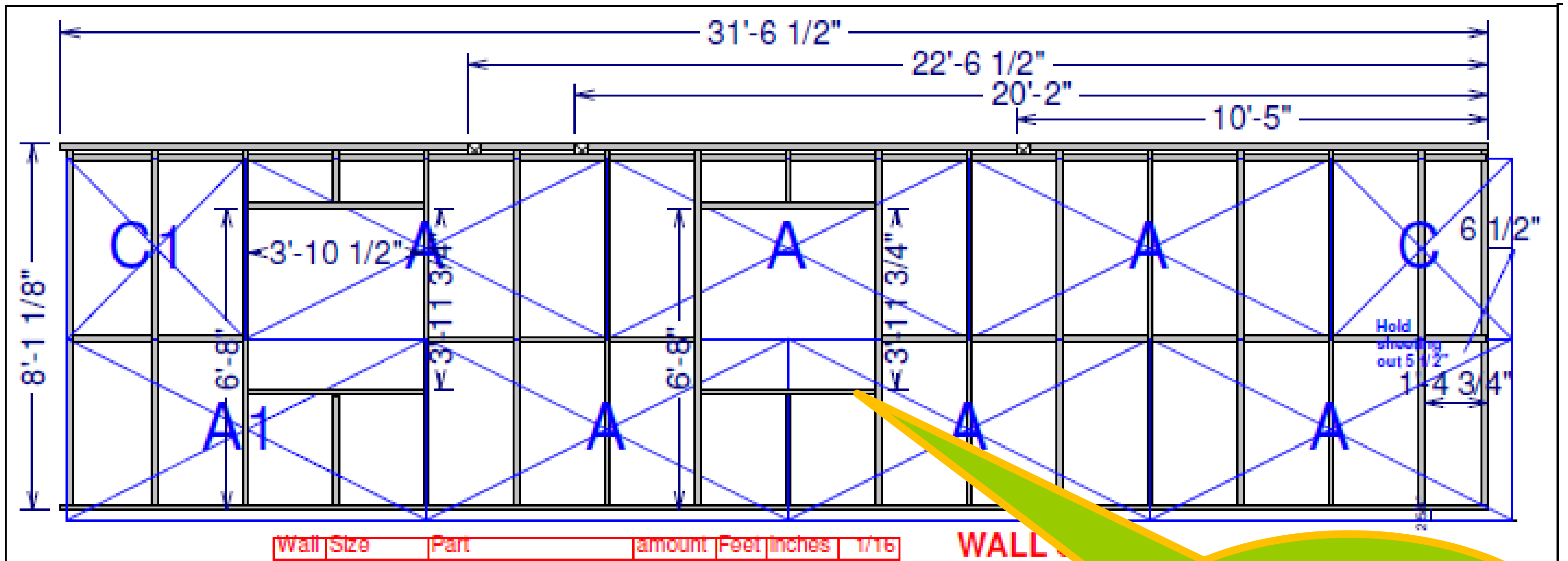
ENCLOSURE: design holistically

- High performance relies on attention to assemblies & continuity—
  - Framing
  - Insulation
  - Barriers

FRAMING: minimize thermal bridging

Advanced framing:

- Studs 24” o.c.
- Openings aligned with framing
- Windows ordered to fit stud spacing



Studl and sheeting cut back 1 1/2"" for wall K notch K sheetingand foam for bottom plate

Wall	Size	Part	amount	Feet	inches	1/16
J	2X6	Top & bottom plate	2	31	6	8
J	2X6	Studs	15	7	10	2
J	2X6	Top crippels window	2	1	2	2
J	2X6	Bottom crippels 40	2	2	5	4
J	2X6	Sill	4	3	10	8
J	1/2" OSB	Sheet A	6	8	0	0
J	1/2" OSB	Sheet A1	1	7	11	6
J	1/2" OSB	Sheet C	1	4	0	0
J	1/2" OSB	Sheet C1	1	3	11	6

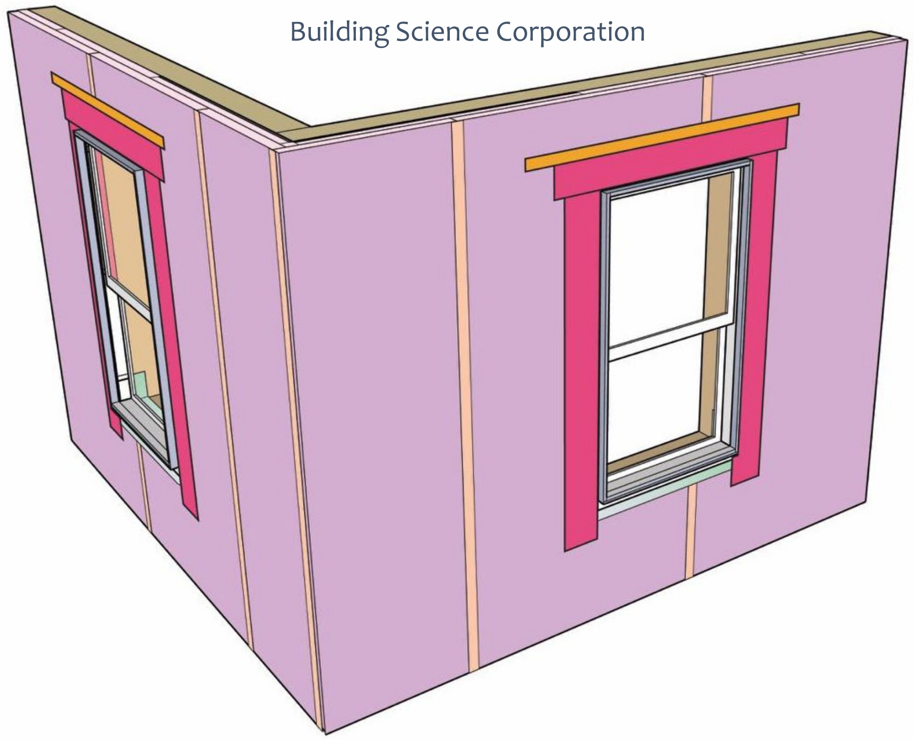
DRAWINGS SHOW EVERY WALL & EVERY MEMBER

OPENINGS ALIGN WITH FRAMING

Habitat for Humanity Stockton Demonstration Project

INSULATION: cavity *and* exterior

- **Cavity insulation:**
  - Above-code R-values when feasible
  - Always ensure quality installation
  - Avoid batts ***unless** using …*
- **Exterior insulation:**
  - 2x the effective R-value of cavity insulation
- ***Both*, ideally:**
  - Choose low-carbon materials: cellulose, wool, mineral wool, cork, etc.

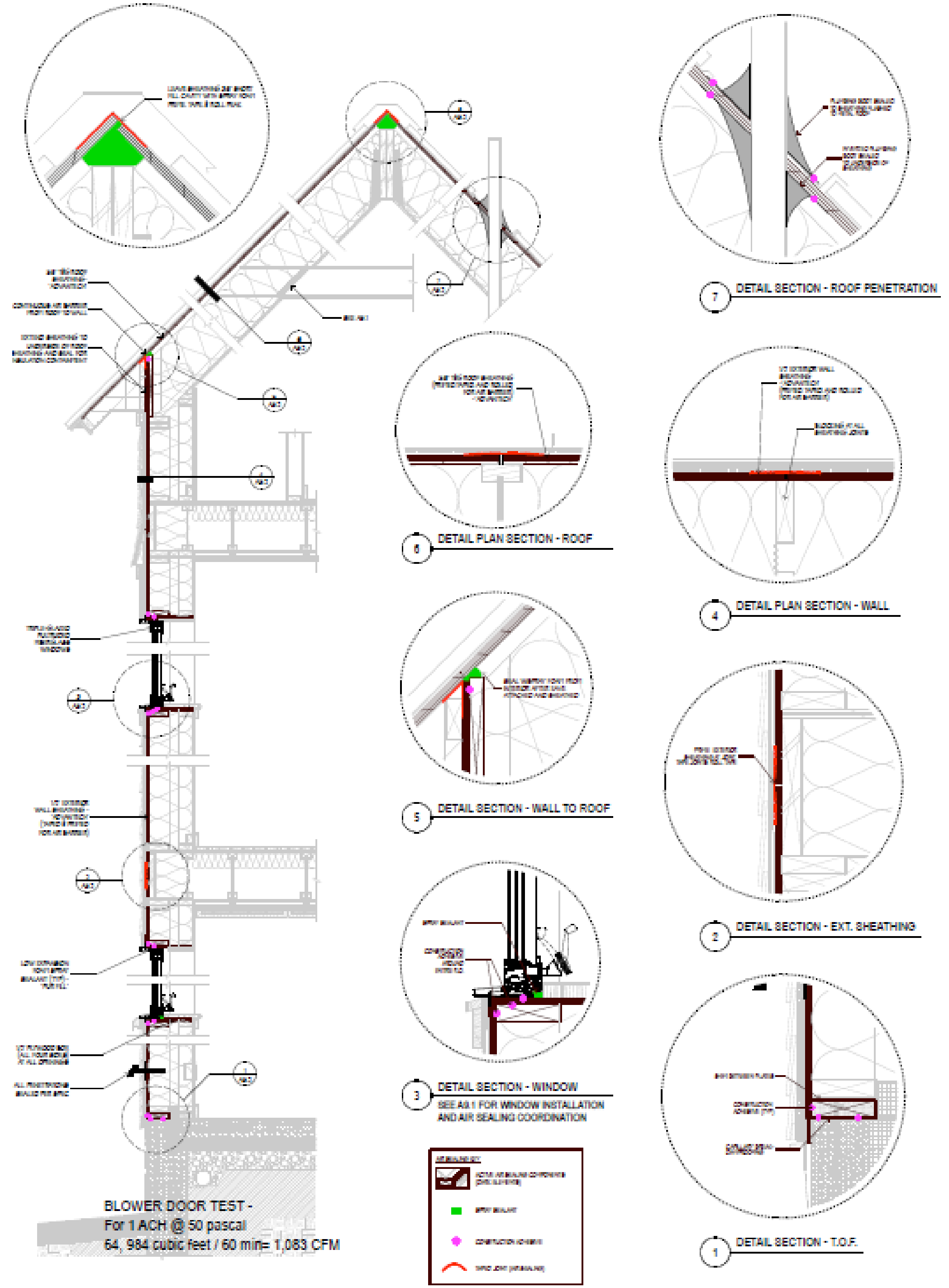


BARRIERS: continuous!

- **Ensure continuity of:**
  - ✓ Air barrier
  - ✓ Water barrier
  - ✓ Thermal barrier

… throughout the enclosure!

Special thanks to Coldham & Hartman Architects
for sharing this download ➔
http://www.candharchitects.com/projects/college-of-the-atlantic-kathryn-w-davis-student-village/
(click on Project Details)



WINDOWS: think specs *and more!*

ALSO: ▪ Number ▪ Size ▪ Location + Orientation + Exposure ▪ Type

Window SPECS

High performance means:

- **LOW thermal values**
  - U-value ≤ 0.27
  - SHGC (solar heat gain coefficient) ≤ 0.24
- **HIGH visibility**
  - VT (visible transmittance) ≥0.40
    (while maintaining low U & SHGC!)

If SHGC is too high, ZE homes can easily overheat

Window STRATEGIES

Questions:

- How many?
- What size(s)?
- Where?
- Where NOT?
- Types of operation

Answers:

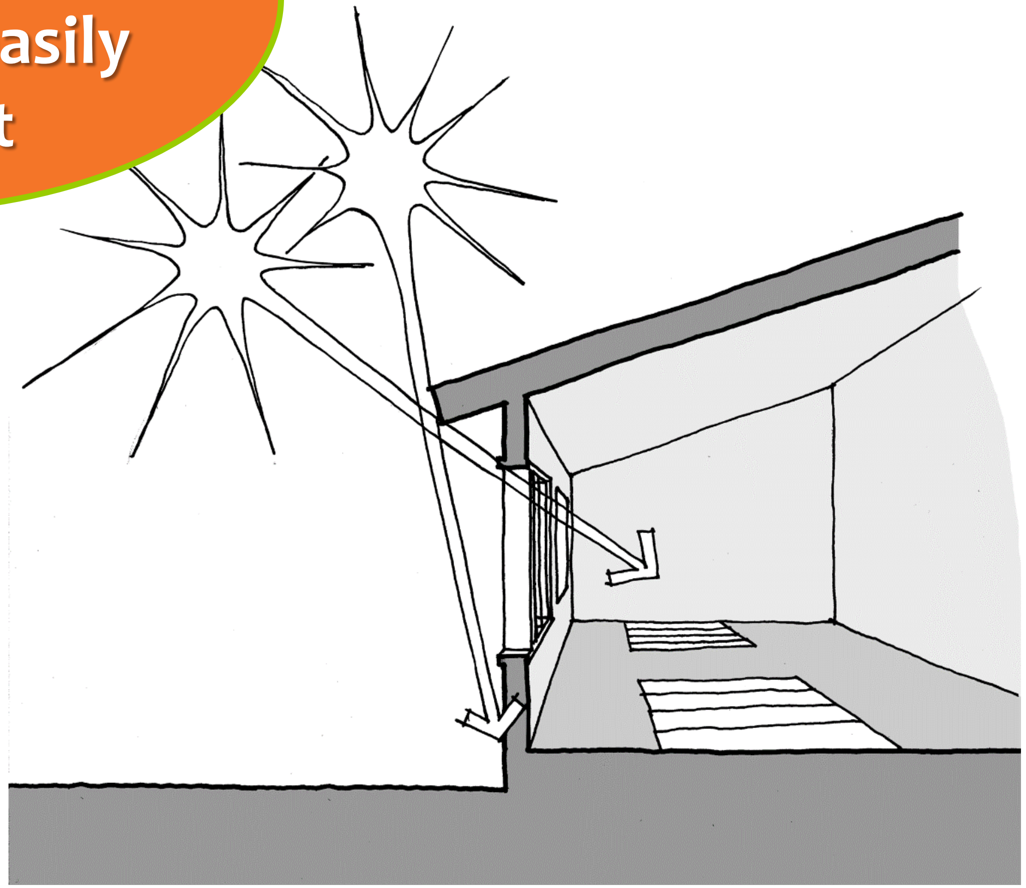
- Fewer rather than more
- Fit within framing
- Views, cross-ventilation, egress
- Where heat gain is a problem (west, below knee level, etc.)
- Hinged whenever possible (vs. sliders)

Window SHADING

Shading principles

- Overhangs have limited effect at low sun angles
  - West & east façades
  - Spring & fall hot spells
- The lower the glass, the harder it is to shade
  - Occupants' knees can't enjoy the view
- Limit skylights—also hard to shade

If shading is inadequate, ZNE homes can easily overheat



SHADING OPTIONS

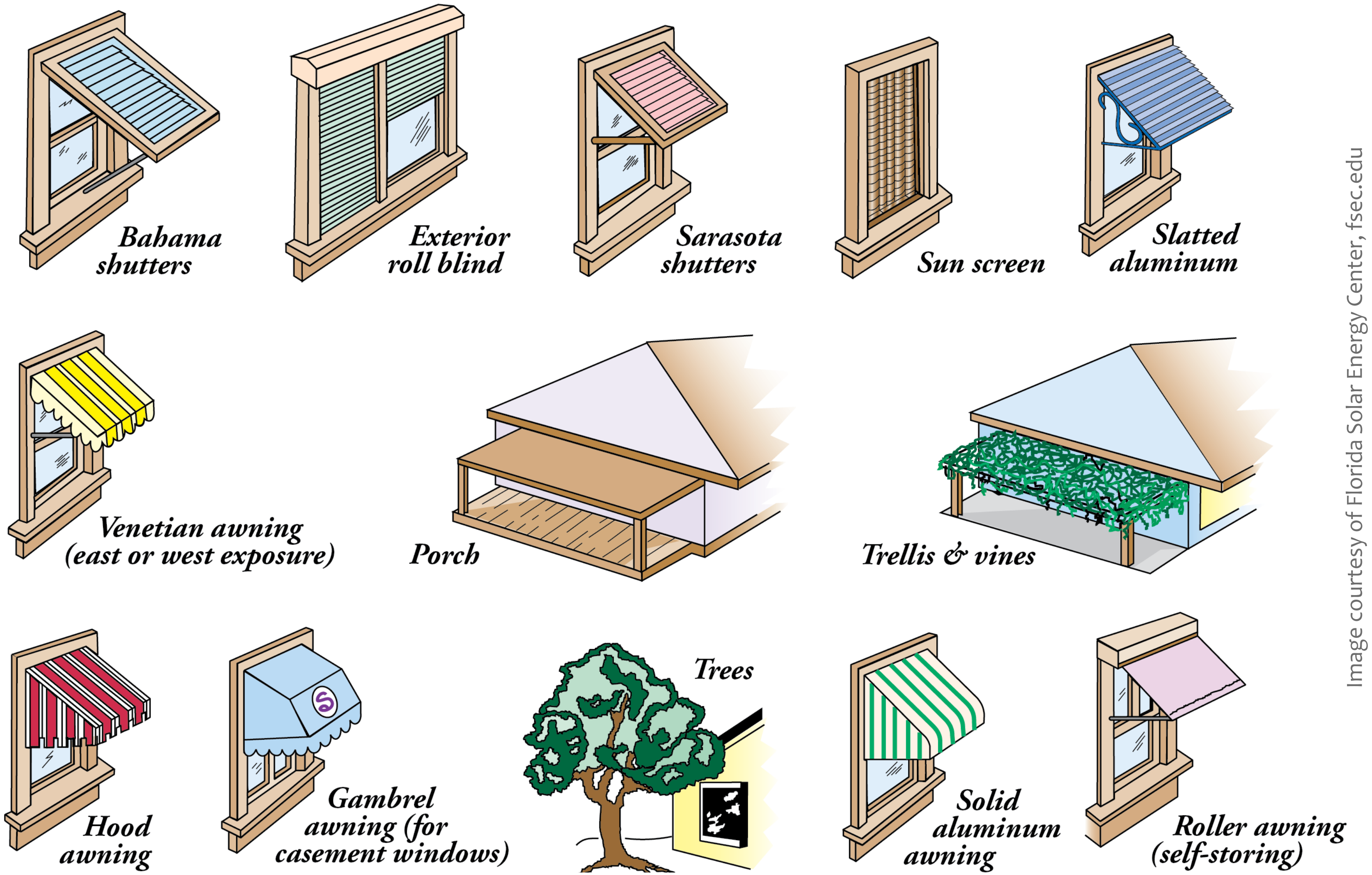


Image courtesy of Florida Solar Energy Center, fsec.edu

DOCUMENTATION: make it stick!

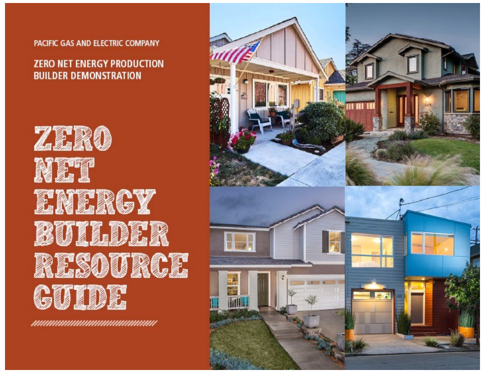
Contract documents are BINDING!

They should include everything that is needed to achieve ZNE—

- ✓ Drawings
- ✓ Details
- ✓ Specifications
- ✓ Testing & verification requirements

Contract document SCOPE

	ITEM:	VERIFY IN FIELD:
☑	Air barriers	In place
☑	Air sealing	Comprehensive
☑	Advanced framing	Matches specs
☑	Window NFRC sticker	Match specs
☑	Cavity insulation	Properly installed
☑	HVAC load calculations	Checked
☑	Duct design	Checked
☑	Lighting	All LED/high-efficacy



Ensure contract documents:

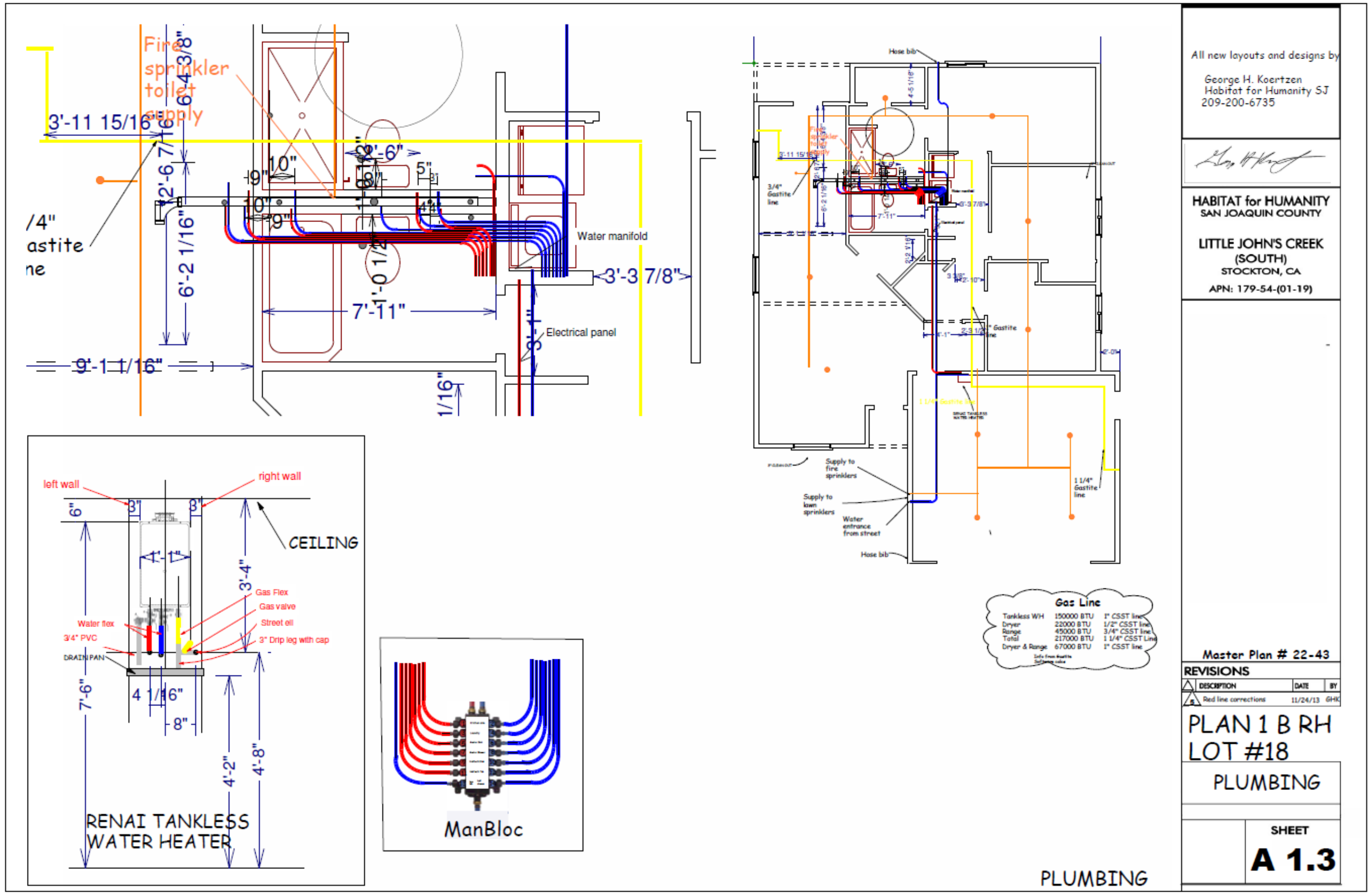
- **Clearly communicate your goals**
- **Specify procedures, timelines, metrics**
- **Include:**
  - Performance testing of key building features and equipment *during construction*
  - Operational testing and verification of performance of all key systems *at completion*

RESOURCE:
PG&E Zero Net Energy Builder Resource Guide
(free download including many resources with live links)

DRAWINGS—not *just* the usual

All the usual PLUS:

- **Wall framing elevations**
  - Exterior
  - Interior
- **Complete mechanical plans**
  - Heating & cooling
  - Ventilation
- **Complete plumbing plans**
  - Schematic
  - Manifold installation

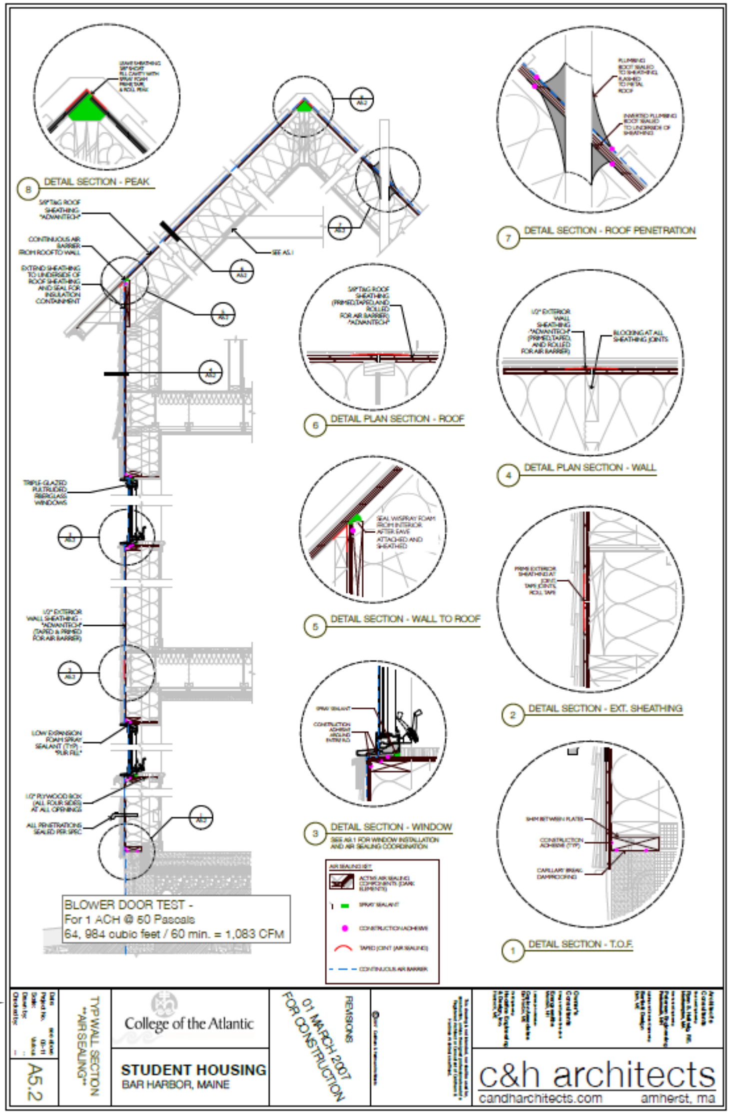


AIR LEAKAGE control documentation

Include:

- **Air leakage target** for the construction crew
- Air sealing **cross section**
- **Details** for air barrier, connections, & transitions
- **Specs** for air sealing products, installation methods, & quality management procedures

RESOURCE (free download)
Air sealing drawing by Coldham & Hartman Architects ➔



Q:

And what about building a ZNE home—how is that different from conventional construction?

The CONSTRUCTION Phase

- **Clear GOAL communication (*again!*)**
- **Team problem-solving!**
- **Monitoring progress—**
  - Performance testing of key systems *during construction*
- **Ensuring proper performance upon completion—**
  - Commissioning
  - Verification

Image: completehome.com.au

Quality

QUALITY MANAGEMENT is the responsibility of the CONSTRUCTION CREW— not the HERS rater!

Monitor performance *during* construction!

Measuring & Verifying Performance

Validate achievement of system specifications

- Test as you go—hit the targets—and
- Verify on completion

Sample report—commissioning done at Habitat for Humanity Stockton ZNE demonstration home

Download report HERE

Table 4-3. Sample mechanical and enclosure commissioning report, Stockton, CA[11]

MINI-SPLIT

Daikin heat pump model RXS09LVJU, ¾ ton, SEER 24.5, HSPF 12.5
Daikin ducted air handler FDXS09V95, 30' line set (no refrigerant adjustment required)
Wired thermostat Daikin ENVi, web-enabled

Duct leakage	13 CFM_{25} (hard to seal return)
Duct leakage to outside	0 (not measurable, less than 9 CFM_{25})
Check for refrigerant leaks	450 psi overnight test, 92-micron evacuation
Static pressure	+7.7 Pa (hard to measure, poor plenum access)
Fan watt draw	50 watts (high fan speed, 10-watt resolution)
Total air flow	378 CFM (high fan speed, sum of the supplies)
Room air flows (CFM)	
■ Living	104
■ Kitchen	51
■ Master bedroom	95
■ Bedroom 2	56
■ Bedroom 3	72
Bedroom pressurization with air handler fan on high	
■ Master bedroom	+2.5 Pa
■ Bedroom 2	+1.8 Pa
■ Bedroom 3	+2.8 Pa

ENERGY RECOVERY VENTILATORS

Panasonic FV-04VE1 (2 units, each rated 40 CFM exhaust, 30 CFM supply, continuous operation)

	Hall ERV	Living Room ERV
Static pressure	-21.0 Pa/+11.3 Pa	30.9 Pa/+9.6 Pa
Fan Watt draw	24.3 Watts	22.2 Watts

BATHROOM EXHAUST FANS

Panasonic FV-11VQC5

	Master Bath	Hall Bath
Rated fan speed (not selectable)	110 CFM	100 CFM
Humidity set-point	70% RH	70% RH
Occupany timer set-up	turn off 5 minutes after occupant leaves	turn off 5 minutes after occupant leaves
Standy by Watt draw	0.6 Watts	0.7 Watts
Watt draw when operating	22.2 Watts	22.4 Watts
Static pressure	+19.3 Pa	+17.1 Pa
Measured air flow	111 CFM	109 CFM

ENCLOSURE

Air infiltration	330 CFM_{50}
Air infiltration, ventilation system sealed	250 CFM_{50}, 1.53 ACH_{50}
House pressures when exhaust fans are on:	
■ Single bathroom fan	-12.8 Pa
■ Both bathroom fans	-30.6 Pa
■ Both bathroom fans + kitchen range hood	-36.2 Pa
Non combustion appliances in conditioned spaces	

MEASUREMENT EQUIPMENT

- Fan Wattage – Kill-A-Watt P3 installed at electrical panel
- Air handler Wattage – Extech 380940 clamp-on watt meter, 10-watt resolution
- Exhaust air flow – The Energy Conservatory Exhaust Fan Flow Meter
- Supply air flow – The Energy Conservatory Flow Blaster power flow hood
- Manometer – The Energy Conservatory Digital pressure gauge, DG-700

Q:

What kind of growth and change have you seen happening in ZNE home building?

How ZNE got started …

Super-insulated homes in the US began in response to 70s and 80s energy crisis

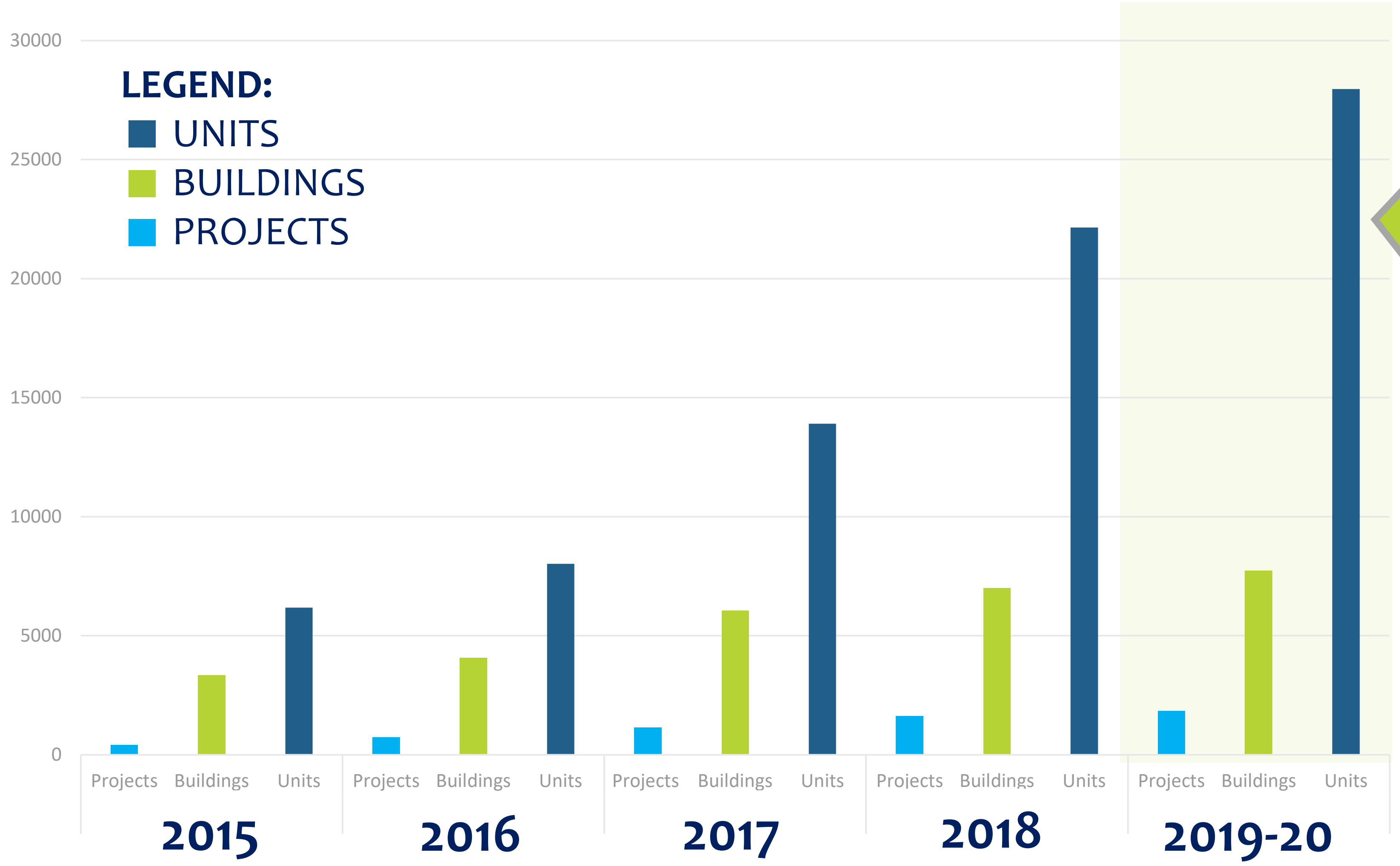
Passivhaus (Passive House) developed in Germany in the early 1990s

In 2006, Habitat for Humanity–Metro Denver documented the first US house operating at ZNE

As of mid-2019, >22,000 “ZNE-ish” homes inventoried in the US and Canada

Enter projects at **www.teamzero.com/inventory-of-zero-energy-homes**

Zero Energy Homes 2015-20: US & Canada



28,000 units
27% growth over prior inventory
&
7,800 buildings
1,900 projects
(numbers rounded)

EEBA TEAM ZERO

Inventory definition of ZERO

Team Zero's inventory includes all residential developments designed to achieve energy performance *in the realm of zero*:

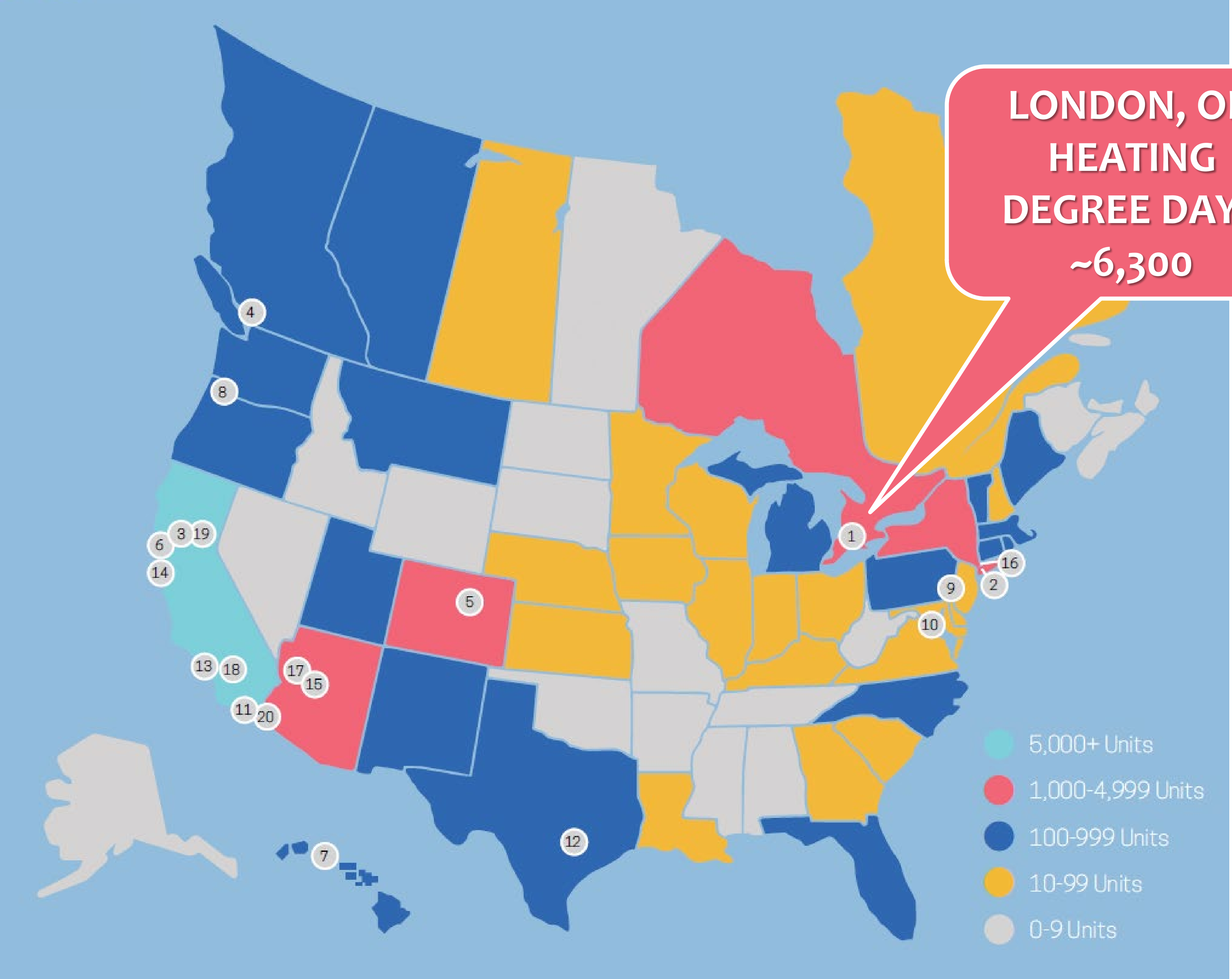
- Zero energy ready
- Zero energy
- Net positive

COMING:
Zero net carbon
Zero embodied carbon

- Completed
- Under construction
- In design
- In planning (planning numbers omitted from graphs)

- Single-family
- Multifamily
- Market-rate
- Affordable

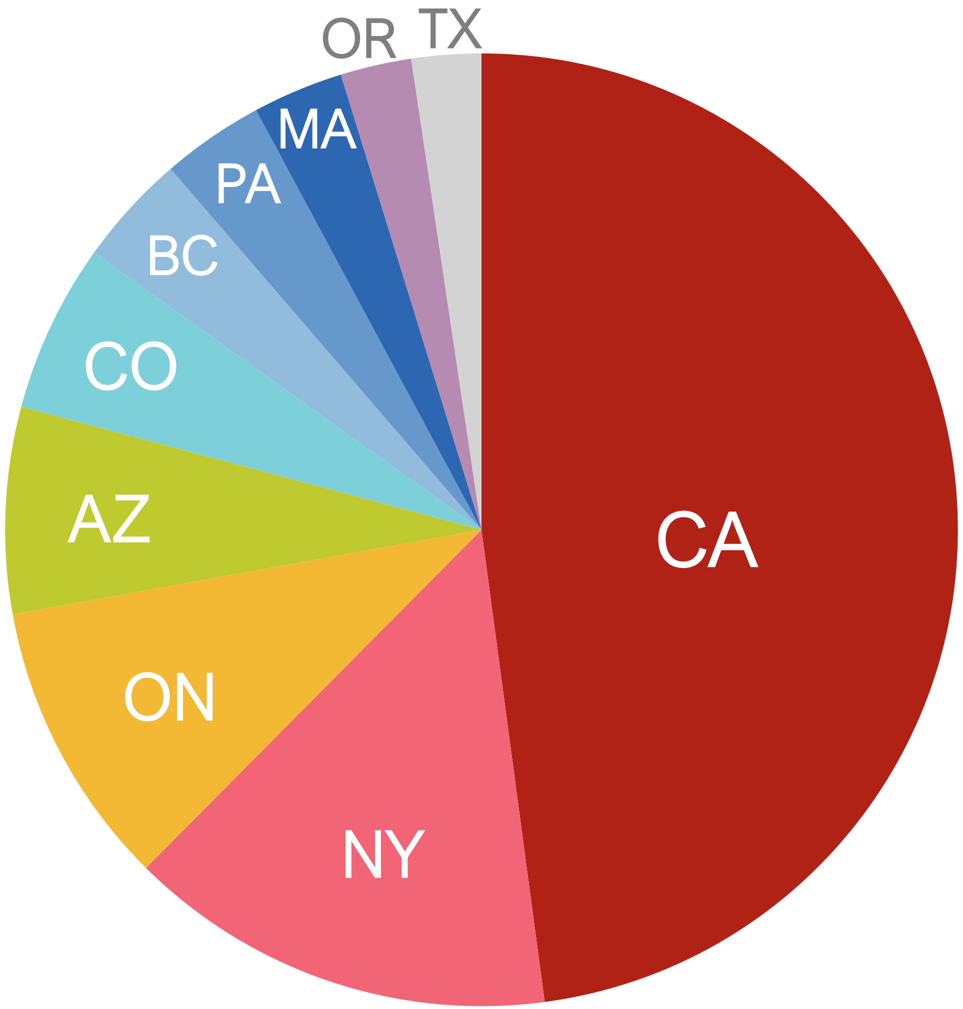
ZNE homes come In all flavors



ZNE homes can be found in all climates

EEBA TEAM ZERO

Market leaders – some are small but mighty

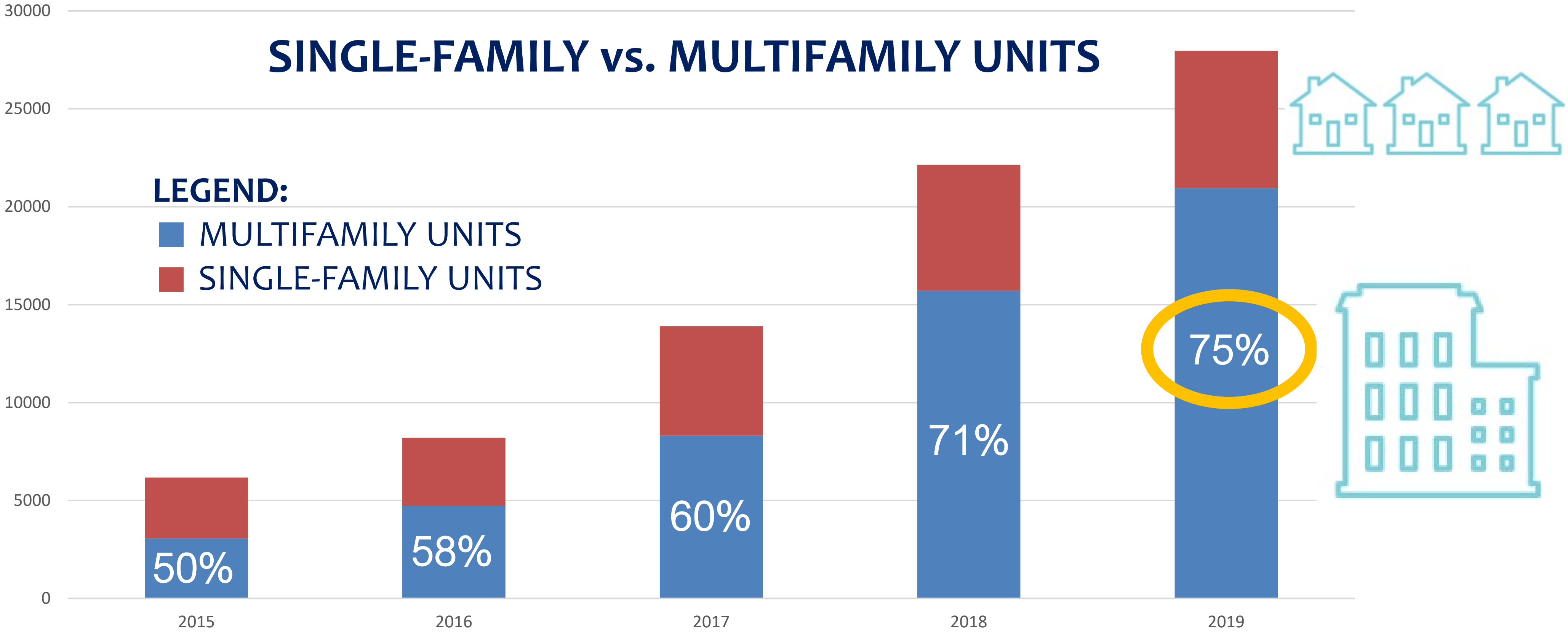


STATE/ PROVINCE	NO. UNITS
CA	10960
NY	3332
ON	2225
AZ	1603
CO	1311
BC	869
PA	794
MA	704
OR	552
TX	540
All others	4674

SAME TOP 10 as last year!

Multifamily continues to dominate growth

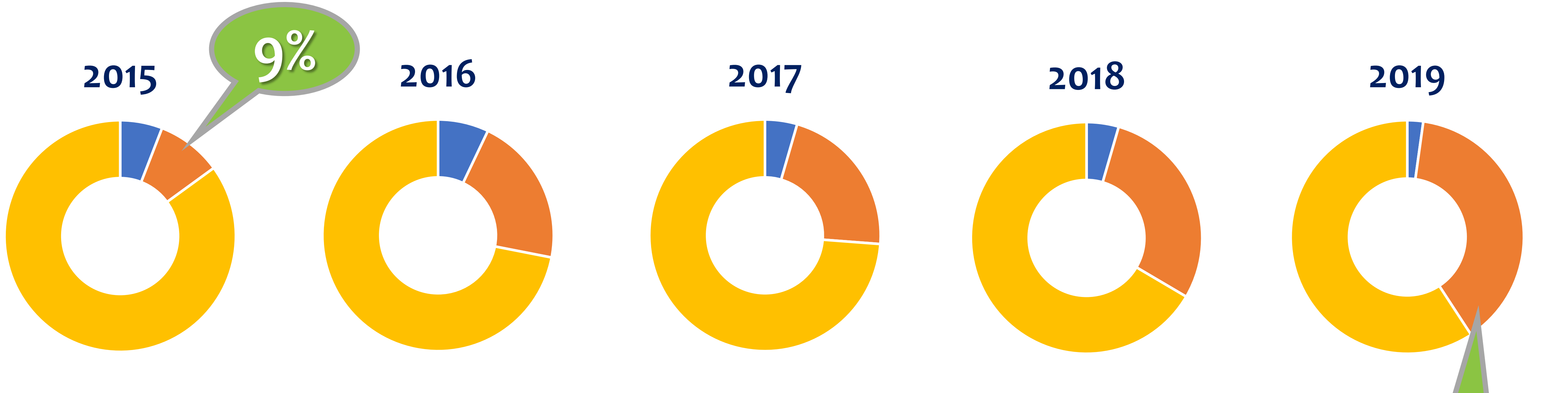
and 95% of all units are in projects of 2+ units!



EEBA TEAM ZERO

More projects are achieving ZERO!

moving upward from zero energy *ready*



Add to the inventory!
www.teamzero.com/
inventory-of-zero-energy-
homes

EEBA TEAM ZERO

Emerging features of ZNE homes

Battery storage

+

Electric vehicles

+

Performance monitoring devices

+

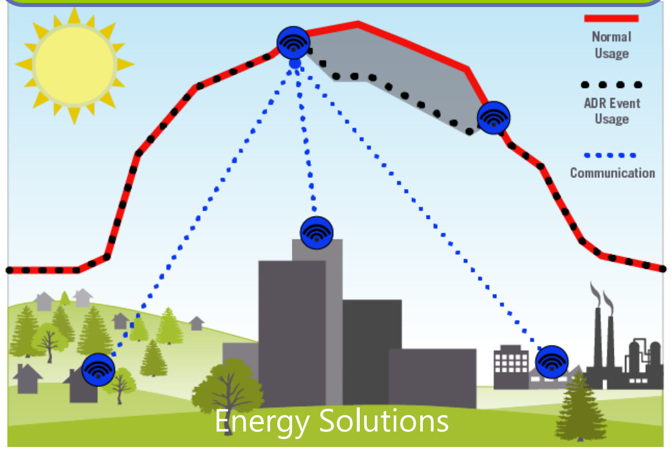
All-electric-ready service panel

Solar-ready + circuits for:

- Water heater
- Clothes dryer
- Induction range
- Heater/air conditioner
- EV charger

+

Demand response



- Real-time data
- Actionable information

Zero *emissions* homes have a big role to play

We have 12 years to limit climate change catastrophe, warns UN

Urgent changes needed to cut risk of extreme heat, drought, floods and poverty, says IPCC

Overwhelmed by climate change? Here's what you can do

▲ A firefighter battles a fire in California. The world is currently 1C warmer than preindustrial levels. Photograph: Ringo HW Chiu/AP

2 years ago!

BUILDINGS represent 40% of global greenhouse gas emissions – and of the SOLUTION.

~ Architecture 2030

The ‘decarbonization’ wave is building!

gtm: Solar Grid Edge Storage Wind Trending Podcasts White Papers Webinars

ENERGY

California Nears Tipping Point on All-Electric Regulations for New Buildings

Even utility PG&E, with its thousands of miles of natural-gas distribution pipelines, is calling for ending gas hookups for new buildings.

JUSTIN GERDES | JULY 29, 2020

10

In 2019, California mandated solar on most new homes. Next up: building electrification.

As of December 2020:

40 local governments in CA either incentivize or mandate all-electric new construction—

- **>4,000,000 people**
- **>10% of CA population**

What cities and state(s) will be next?!

GREEN BUILDER®

BUILDING A BETTER WORLD

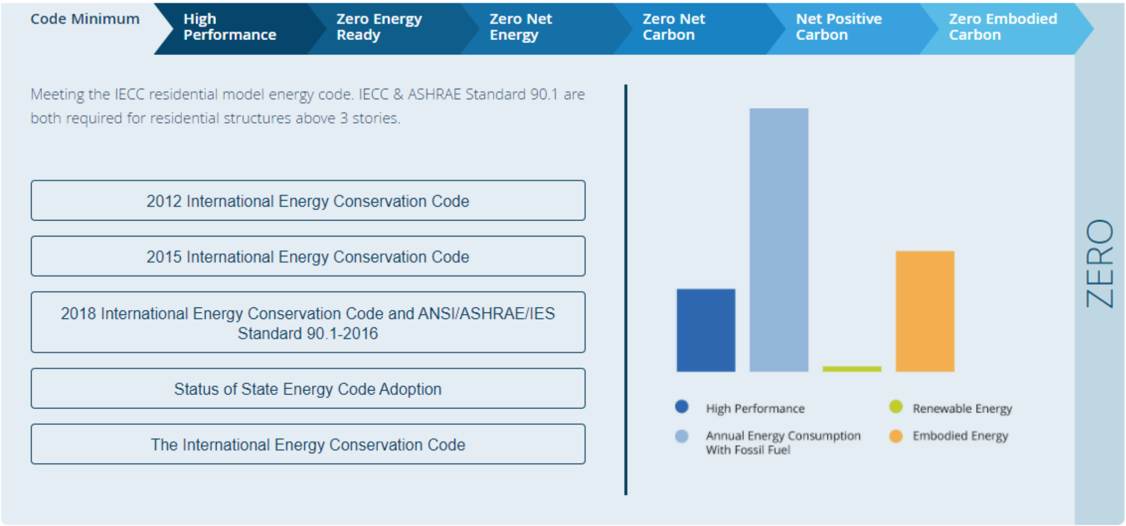
GREEN BUILDER | COGNITION SMART DATA | PUBLICATIONS | KEY TOPICS

July 28, 2020

The net zero energy building (NZEB) movement has hit critical mass… **it's the way all homes will be built in the near future.**

It's expected that the global market for net zero energy structures will explode to $78.8 BILLION by 2025.

Information Resources

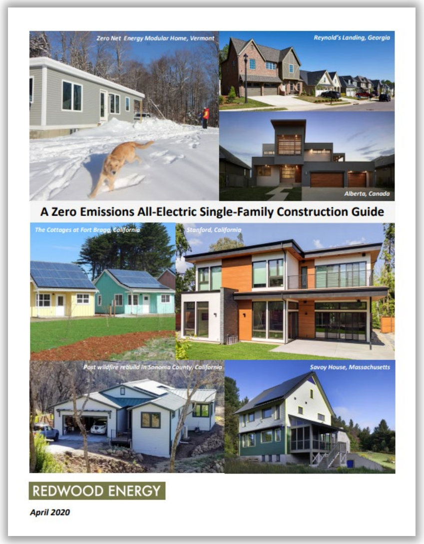


Team Zero's Gateway to Zero

Online here

zero energy project

Online here



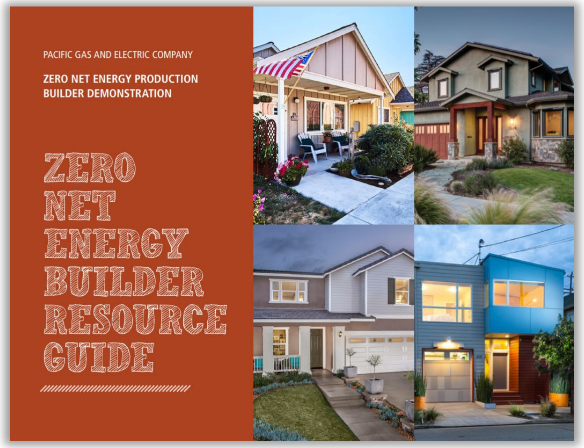
All-Electric New Home Guide

Download here

ZNE Primer for Architects

Download here

Each of these includes MANY other resources!



ZNE Builder Resource Guide

Download here

Thank you!

AnnEdminster.com

- Zero energy consulting
- Design team facilitation
- Writing, research, advocacy