Small Firm Forum:
2019 Energy Code Solutions for Small Homes
9/10/20

Presented by Dan Johnson, AIA
Collaborate@BeyondEfficiency.us
Agenda

Course Description
This presentation will look at particulars of the 2019 California Energy Code as it relates to residential additions and new houses, including Accessory Dwelling Units. We will discuss trigger points for insulation, water heating, and ventilation that have changed since the 2016 code. We will discuss common Energy compliance strategies for this project type. We will discuss electric space-heating and water-heating options to replace the gas-fired equipment that designers may have specified in the past.

Objectives, Learning Goals
After attending this program, participants will be able to:
1. **Apply** the 2019 California Energy Code to a residential project to understand requirements that are new or unfamiliar this code cycle;
2. **Describe** the parts of a home or addition, especially Accessory Dwelling Units, that are affected uniquely by the 2019 California Energy Code;
3. **Discuss** the pros and cons of different approaches to compliance, seeking design flexibility and ease of constructability; and
4. **Identify** HVAC and water-heating solutions to eliminate gas combustion from the project.
Topics Being Discussed Today

Solar PV Requirement

Mechanical Ventilation ("IAQ Fan")

Wall Insulation

Electric space heating

Electric water heating

2019 Energy Code issues:
- Triggers: Type & Size
- Solar PV requirement
- Mechanical ventilation
- Wall Insulation

Jurisdictions with Gas-free mandates:
- Electric space heating
- Electric water heating
Triggers: Project Type

Quiz: Which of these projects are “New Construction” in the Energy Code? Which are “Additions”?

[Diagram showing different types of projects marked A to E, including Converted Garage, Detached ADU, Attached ADU, Basement Conversion, and Converted Garage.]

Hausable.com
Triggers: Project Type

Answer Key:

[Diagram of various housing projects with labels for conversion, additions, detached ADU, attached ADU, and basement conversion.]
### Triggers: Project Floor Area

<table>
<thead>
<tr>
<th>Type of project:</th>
<th>Solar PV</th>
<th>IAQ Fan</th>
<th>Wall Insulation</th>
<th>Hot Water</th>
<th>Space Heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>New, ground-up, including ADUs</td>
<td>Yes, always</td>
<td>Yes, always</td>
<td>2x6 + R4 + QII</td>
<td>HPWH*</td>
<td>Heat pump</td>
</tr>
<tr>
<td>Home Addition</td>
<td>No</td>
<td>1000 ft²</td>
<td>+Exceptions: 1000 ft², 700 ft²</td>
<td>Flexible</td>
<td>Flexible</td>
</tr>
<tr>
<td>ADU conversion (existing space)</td>
<td>No</td>
<td>Yes, always</td>
<td>+Exceptions: 1000 ft², 700 ft²</td>
<td>HPWH*</td>
<td>Heat pump</td>
</tr>
<tr>
<td>Remodel only (no new space)</td>
<td>No</td>
<td>No</td>
<td>Insulate cavity</td>
<td>Flexible</td>
<td>Flexible</td>
</tr>
</tbody>
</table>

*HPWH = heat pump water heater*
Sufficient solar PV panels are required to match the standard electric consumption of a gas-fired home.

1. Compliance software re-creates your Proposed design using the Prescriptive envelope, and gas-fired heat & hot water

2. Software calculates the annual electricity consumption

3. Software calculates a solar PV size to match this annual electricity

4. The designer must match this PV size (with exceptions)
# Solar PV Requirement for New Construction: Prescriptive

## Solar PV Size Requirement in kWdc

<table>
<thead>
<tr>
<th>New Construction, single detached home</th>
<th>Conditioned Floor Area, ft²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>250</td>
</tr>
<tr>
<td>Climate Zone</td>
<td></td>
</tr>
<tr>
<td>North Bay - 2</td>
<td>1.4</td>
</tr>
<tr>
<td>Cool Bay - 3</td>
<td>1.3</td>
</tr>
<tr>
<td>South Bay - 4</td>
<td>1.4</td>
</tr>
<tr>
<td>Deep East Bay - 12</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Poll: what size PV arrays are going on to your projects? Cannot credit PV against envelope etc.
Mechanical Ventilation ("IAQ Fan") Requirement

Required?
New construction – YES
New ADU – YES
Addition <1000 ft² – NO
Addition >1000 ft² – YES, retroactive to include existing home
Mechanical Ventilation ("IAQ Fan") Requirement

<table>
<thead>
<tr>
<th>System type</th>
<th>Exhaust</th>
<th>Source of Fresh Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code minimum IAQ fan</td>
<td><img src="image1.png" alt="Exhaust" /></td>
<td>Leaks &amp; Cracks</td>
</tr>
<tr>
<td>Better</td>
<td><img src="image2.png" alt="Supply fan with filter" /></td>
<td>Supply fan with filter</td>
</tr>
<tr>
<td>Best:</td>
<td><img src="image3.png" alt="Heat-recovery ventilator with filter" /></td>
<td>Heat-recovery ventilator with filter</td>
</tr>
<tr>
<td>• No cold drafts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Compliance credit</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Ventilation Rate Formula

Fan Flow $Q = 0.03 \times (\text{Floor Area ft}^2) + 7.5 \times (\# \text{bedrooms} + 1)$

Example

$Q = 0.03 \times (400) + 7.5 \times (1+1)$

$Q = 27$ cubic feet per minute (CFM)

30 CFM provided (continuous bath exhaust fan)
Quiz: Which is the 2019 Prescriptive Energy Code wall for new homes in the Bay Area?

- 2x4 (16"oc) U=0.083
- 2x6 @ 16"oc U=0.066
- 2x6 @ 16"oc U=0.059
- 2x6 (16"oc) + 1" Rigid (R4) U=0.048
- 2x6 (16"oc) + 2" Rigid (R8) U=0.040
Wall Insulation

This can pass for an ADU conversion if 2x4 is existing, (E) siding not removed.

This can pass for an ADU conversion if 2x6 is existing, (E) siding not removed; can pass in New Constr. if the house is small.

Prescriptive standard for New Construction + QII Verification.
ADU garage conversion, 363 ft².
2x4 R15 walls, 2x6 R21 roof.
Exception: existing studs & siding (couldn’t pass with gas hot water)

Second story addition, 1157 ft².
2x6 R21 walls, 2x10 R30 roof.
(No exceptions available, barely passing!)

Both use heat pump water heaters (HPWH)
New ADU, backyard site, 560 ft².
2x6 R21 walls, 2x10 R34 roof.

New home, rural site, 2156 ft².
Staggered stud R25 walls, 2x10 R34 roof.

Both use heat pump water heaters (HPWH) and space heating
Floor area less than 600 ft² is dominated by water heating

Floor area greater than 1500 ft² is dominated by space conditioning
# Wall Insulation Examples: New Construction ADU

## 2019 Energy Code Standard vs. Proposed Design

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall:</td>
<td>2x6, R21, + R6 continuous insulation, + QII inspection</td>
<td>2x6, R21.</td>
</tr>
<tr>
<td>Roof:</td>
<td>R30</td>
<td>same</td>
</tr>
<tr>
<td>Water heater:</td>
<td>Heat Pump, tank-type, EF-2.5</td>
<td>Heat Pump, tank-type, EF-3.7</td>
</tr>
</tbody>
</table>

### Results

<table>
<thead>
<tr>
<th></th>
<th>31 TDV*</th>
<th>47 TDV</th>
<th>90 TDV</th>
<th>73 TDV</th>
<th>121 TDV</th>
<th>120 TDV</th>
<th>PASS!</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space heating:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water heating:</td>
<td>90 TDV</td>
<td></td>
<td>121 TDV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>

*TDV = Time Dependent Value, the scoring metric

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2019 Energy Code issues:
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Jurisdictions with Gas-free mandates:
- Electric space heating
- Electric water heating
The West Coast Electric Grid is Increasingly Carbon-Free

WA: 100% carbon-free by 2045

CA: 100% carbon-free by 2045

These data were made available by the Energy Information Administration

https://www.reddit.com/r/MapPorn/comments/aapz43/by_state_comparison_of_renewable_resource_energy/

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Gas-Free Mandates for New Construction
Water Heating Choices

1. “Split” Heat Pump
   - Most flexible option, $3000-7000 installed

2. Unitary Heat Pump
   - Least expensive option, $2500-5500 installed
   - “Retrofit Ready” versions this year from Rheem and AO Smith: 120V, less expensive

3. Solar Thermal + Electric Resistance
   - Smallest option (least interior space)

4. Tankless Electric alone
   - Energy Code penalty cannot be overcome in performance calculation
   - Exception: replacing existing water heaters where no gas is connected
### Water Heating Comparison

<table>
<thead>
<tr>
<th>Model</th>
<th>Best for…</th>
<th>Tank venting?</th>
<th>Installation cost*</th>
<th>Pollution vs. gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. “Split” Heat Pump</td>
<td>Most flexible; no tank venting; high efficiency</td>
<td>none</td>
<td>$3000-$7000</td>
<td>↓ 60-80%</td>
</tr>
<tr>
<td>2. Unitary Heat Pump</td>
<td>Least expensive</td>
<td>Locate “outdoors,” or duct the cool air to a pantry</td>
<td>$2500-$5500 (lower for “retrofit ready” models?)</td>
<td>↓ 60-80%</td>
</tr>
<tr>
<td>3. Solar preheat + Electric resistance</td>
<td>Resiliency; Least indoor space</td>
<td>none</td>
<td>$5900+</td>
<td>↓ 50-90%</td>
</tr>
</tbody>
</table>

*Your results may vary

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Small homes & ADUs: provide an “outdoor” closet for storage tank

Collected screenshots showing “outdoor” HPWH tank locations
Bigger homes & remodels: Provide a **central indoor** closet for storage tank
Location-based considerations for a heat pump water heater

Considerations based on Energy Code scoring

Air conditioning Climate Zones 2, 4, 12:
- Locate the Heat Pump Water Heater **indoors**, behind a louvered door, or duct the air-conditioned exhaust to:
  - a pantry, or
  - behind the refrigerator

Historically cool-summer Climate Zone 3:
- Locate the Heat Pump Water Heater in an “**outdoor**” closet…
- Especially if using electric-resistance heat
- Or, use a custom solution
Space Heating Choices: Two paths

A. Heat Pump

B. 1) Electric resistance + 2) Heat-recovery ventilation + 3) Good insulation
<table>
<thead>
<tr>
<th>Space Heating: Pro/Con</th>
<th>Best for…</th>
<th>Efficiency</th>
<th>Installation Cost</th>
<th>Operating Cost</th>
<th>Lifecycle cost</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Heat Pump</strong></td>
<td>Best for homes &gt;1000 ft² and/or lots of exposure to outdoors, <em>Provides A/C</em></td>
<td>300-400%+</td>
<td>Roughly the same as gas-fired heat; <em>large variation in bids</em> $$$</td>
<td>Roughly the same as gas-fired heat, depending on many factors $</td>
<td><strong>$$</strong></td>
</tr>
<tr>
<td><strong>B. Electric resistance heat + HRV + insulation</strong></td>
<td>Best for homes &lt;600 ft² and/or highly insulated <em>No Cooling</em></td>
<td>99% Max</td>
<td>Inexpensive to install $</td>
<td>3x the running cost of the heat pump $$$</td>
<td><strong>$$</strong></td>
</tr>
</tbody>
</table>
Heat Pumps: Distribution Choices

Ducted Forced Air  Mostly single-zone

Radiant Floors

Ducted Mini-Split  Slim, horizontal; multiple zones

Ductless Mini-Split  Many styles; multiple zones
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Extra slides follow…
Our 2020 Envelope Work: eliminate foamed plastic, achieve high R-values

**Exterior walls**
Staggered stud
2x4 @ 24”

**Rois**
Unvented, dense-pack cellulose ≥ 2x10

**Foamed Plastic**
- HFCs – climate impact
- Flame retardants
- End-of-life

**Natural Rigid Insulation**
- Great stuff!
- Expensive = not for every project
Advice #1: “Boxy But Beautiful” #BBB
Solar PV Requirement

Is California unique in the % of grid electricity generated by solar PV?

Percentage of State’s Electric Power Sector Generated by Solar in 2017

14.2%

Data Source: U.S. Energy Information Administration

Percentage of Total U.S. Electric Power Generation from Solar: 1.3%
When did this solar explosion begin?

Source: California Energy Commission, staff analysis November 2018