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On 2019 Energy Code

Attachment sheet

Additional submitted attachment is included below.

Comments on 2019 Energy Code

Preamble: By overlooking key passive house design variables, and the importance of highly insulated thermal mass,– some of the most cost effective strategies for cutting heating and cooling loads in half in most climate zones are overlooked. For example, If full advanced framing techniques are employed and the framing ratio is reduced to 13% to 17%, and the dollar per square foot of framing cost that is saved is reinvested in blown Optima insulation in the walls, the assembly R-value can be increased by about 40% for the same cost as code compliant construction. In-slab radiant heat adds $15-$20/sf cost to construction and can significantly lower heating efficiencies while preventing cost effective passive home features from performing by interfering with solar heat absorption and the heat storage capacity of highly insulated slabs. Please consider the following suggestions and heat loss calcs relative to building costs. *These thoughts are offered humbly and with the intention of revealing methods to build ZNE homes for the same cost as today's code compliant home.*

Passive House Design:

1) The anecdotal evidence from passive homes all over California makes it clear that over 40% of the cooling loads and 60-70% of the heating loads can be eliminated in most climate zones if full passive house design is incorporated with well-insulated thermal mass. The principle method to achieve this is to install R-7 to R-10 horizontal insulation under the entire slab of the structure as well as vertical perimeter insulation. State approved compliance software does not even allow you to model full slab insulation and the software design is missing significant energy savings for which there is case study evidence. The Passiv Haus Institute software called "PHPP" could be offered as an approved alternative to immediately allow compliance credit in homes that incorporate full passive home features. Obviously, it would be best if CBECC algorithms incorporated these variables.
2) The 2019 CBECC software considers some specific passive house design features such as orientation and window shading, but completely misses the most critical issues: insulation of the thermal mass which most commonly includes free-standing masonry walls or full under slab insulation (R-7 to R-10), including isolation of the floor slab from the perimeter footing. Homes that incorporate this thermal isolation of the mass as well as appropriately designed winter-only heat gain can eliminate 50% of HVAC loads for a minimal cost of about $2.50/sf. THIS BY FAR THE MOST COST EFFECTIVE MEASURE THAT TAKES LARGE LEAPS TOWARD ZNE WITH MINIMAL ADDITIONAL COST. It appears that the modeling and the

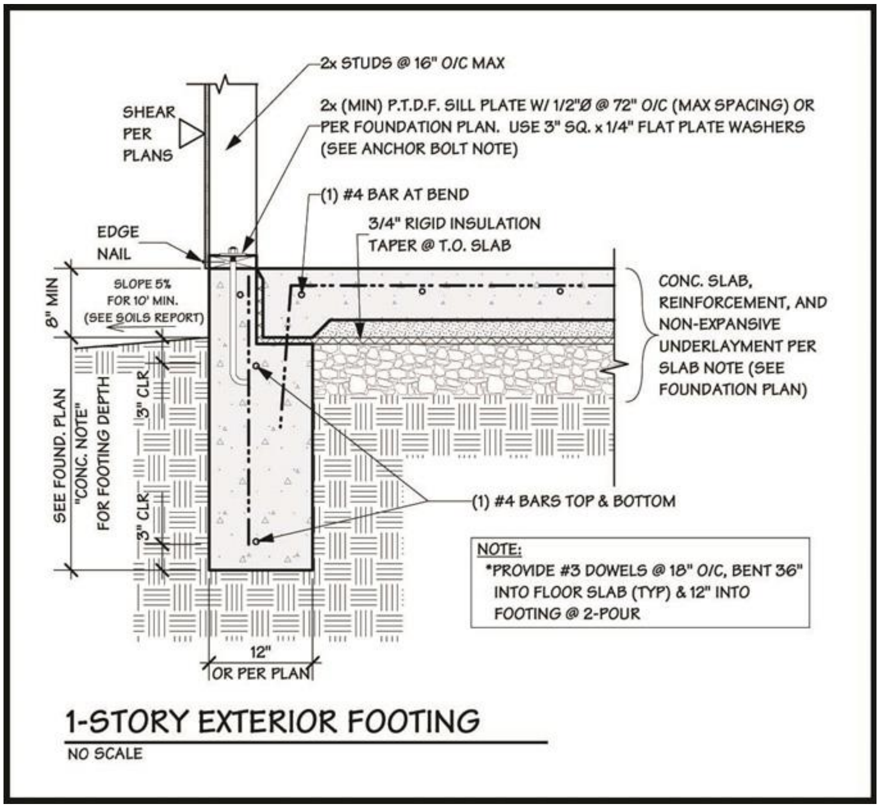
energy code overlook the temperature stabilization impacts of passive home designs that incorporate insulated thermal mass.

3) Full slab insulation and some passive design considerations should be mandatory measures because they are so cost effective.
4) One case study passive house in Grover Beach stays warm for up to two weeks of 40 degree, cloudy weather without using either electricity or gas for heating. The house employs phase change material (PCM) to increase the effective thermal mass of the thermal floor to equal 14" of concrete which when combined with other passive features, can completely replace the need for a gas furnace in most climate zones. The home and does so at a lower cost than a conventional gas furnace system. It is estimated that the PCM technology combined with passive solar design in the home saves the home owner $35k to $40k in fuel and conventional system repair costs over the first 25 years of ownership or an average of $1460 per year with an immediate payback on investment because of initial cost parity with gas heating.

In-Floor Hydronic Heating:

1) In-slab hydronic heating eliminated temperature modulation that an insulated slab provides in passive solar design. In other words, they cost about $28k to $40k ($15-$20/sf) and prevent much more affordable passive heating scenarios from working ($2.50/sf).
2) Not only do the preclude passive solar from working, in-slab radiant grids dump operating at water temperatures of 140 F. dump 70 BTUh to 80 BTUh to ground per square foot when there is no slab insulation (climate zones 1-15) for at least the few hours of system operation. Although there is data on underground warming which eventually slows BTU losses the BTUh losses over the first and second hour are in the range of 70,000 to 110,000 BTUh per hour and as much as 17,000 BTUh when full horizontal R-7 slab insulation is used in a typical single level 1500s.f. home. Of course losses are higher in a larger home. Given the heat loss equation: Q=U*A*Delta-T, it is clear that 4' of horizontal R-7 perimeter insulation required when in-slab hydronic piping is used in climate zone 16 is inadequate to prevent similar losses. In the case of a 1500sf home in CZ16, about 1150 to 1200s.f. of the 1500s.f. slab is exposed to the ground (assumed 57 degree F.). Heat loss through the uninsulated portion of the slab will be 80 BTUh/sf or 60,000 to 95,000 BTUh for the first few hours while the perimeter slab loss will be 11.5 BTUh/sf or 300x11.5=3450. So total BTUs lost over the first hour will still be near 100,000 BTUs!
3) IT MAKES NO SENSE THAT THE 2016 CODE GIVES A COMPLIANCE CREDIT TO HYDRONIC HEATING SYSTEMS DUE TO ELIMINATION OF DUCTS WHEN THE HYDRONIC LOSSES ARE IN FACT MUCH WORSE THAN DUCT LOSSES IN A VENTED HIGH PERFORMANCE ATTIC WHEN SHORT DUCT DESIGN IS EMPLOYED (Q=U.1666*1400A*Delta-T of 50= 11,600 BTUh)
4) Why is so little slab insulation required for hydronic in-floor systems when the first three hour losses are so high and it is relatively inexpensive to install it?

5) In-slab hydronic systems should be discouraged precisely because they aren't cost effective, they prevent cheaper passive features from working properly and they create a high Delta-T at the slab even if there is R-10 insulation under the entire slab. (8BTUh/sf, or 12,000 BTUh on 1500sf slab).
6) Radiant wall panels are much more cost effective (saves $20k compared to in-floor), but must be sized properly relative to water temperature (Delta-T) to achieve sufficient heat transfer. Wall mounted radiant panels and baseboard heaters are only mentioned in passing in the 2016 compliance manual and none of the critical design variables are mentioned.
7) The introduction of the SanCo2 heat pump water heater with a separate outdoor unit makes it possible to design relatively affordable combination systems that integrate domestic hot water with hydronic heating with high COP of 4 to 5.5 and that operate without strip heat with outdoor temperatures as low as -15F. The average home could be heated with the power of four solar panels in most climate zones. However the BTU output of these systems would require extremely low-load shell design. <u>The code makes no mention of this technology.</u>
5) The slab insulation section drawings included in the 2016 Residential Compliance Manual are incorrect. The code requires sand between the horizontal foam and the poured slab to minimize cracking. Also, it is best to angle the top of the vertical foam that runs up the inside of the footing so that it is not exposed at the interior and does not result in damage to flooring materials when subjected to point loads caused by furniture that is often positioned against walls. (See detail below).



Solar Thermal Hot Water Heating Systems:

1) Even the most ardent supporters and installers of solar hot water systems for domestic use or hydronic heating are admitting that HP water heaters combined with enough PV solar to power it is cheaper to install and maintain than traditional solar thermal systems for all single family applications. This has been the case for over 5 years yet the current incentives offered are pushing solar thermal systems when they are more costly and prone to failures. There are high-temp commercial and multi-family scenarios where solar thermal may still make sense. The introduction of the SanCo2 HP water heater is going to encroach on at least some of those applications but cannot be used with solar pre-heating.
2) Prescriptively requiring solar thermal pre-heating in multi-family central systems and in high-rise commercial buildings precludes the use of electric heat pump water heaters which are up to 5.5 times more efficient than direct electric heaters and likely have lower cost and lower TDV than gas heaters in many climate zones and applications. For example if high-rise commercial office space is primarily using hot water for lavatory hand washing, requiring solar thermal preheating with central distribution could be 10 to 20 times the cost of distributing smaller HP tanks with outdoor condensers. The cost of PV panels to power those tanks, the roof area dedicated to water heating, much lower distribution losses and

lower standing losses could result in far lower TDV and minimal impact on peak grid demand, especially if they are powered by solar during peak usage daytime hours.

3) Preheating water with solar thermal systems not only reduces the efficiency of heat pump heaters, it can damage their compressors by preventing sufficient heat extraction from the coil to allow full phase change of the refrigerant. Solar thermal can't be combined with heat pump water heaters without major efficiency compromises as well as system failures.
4) The code should allow flexibility to choose between solar thermal and PV-powered HP DHW systems and allow these design trade-offs to be evaluated and traded off on a case by case basis. It should include in its definition of "solar hot water systems" technologies that employ heat pump water heaters powered by photovoltaic solar panels. Incentive programs as well should be allowed to fund this technology. Otherwise we are forcing more expensive and problematic technologies onto the public when better options exist.
5) Solar thermal is still cost effective for high-temp commercial applications such as laundromats and lower-temp applications such as pool heaters, especially in climates where snowfall is rare.
6) Chart 9-7 in the 2016 Res Compliance Manual erroneously requires solar thermal preheating when HP water heaters replace a gas water in CZ 16. This requirement is fraught with engineering failure modes. Not only is a solar thermal system likely to be frozen much of the winter in CZ 16 and will therefore experience more stress and lower productivity, preheating water for HP water heaters prevents full phase change of refrigerants and causes damage to compressors. The only practical heat pump water heater for this climate zone is the SanCo2, which can perform at a COP of 4.5 to 5.5 and can remain in heat pump mode down to an outside ambient temp of -15f. The 2019 Compliance Manual should avoid recommending solar preheating of HP systems, especially in this climate zone.

Heat Pump Hot Water Heaters:

1) Condenser-integrated HP DHW units need to be located in garages or other attached unconditioned spaces. Because they extract BTUs from the air in the garage and dump that heat into the tank's water, they can make garages quite cold, leading to potential heat loss and condensation on demising walls that are not usually as well insulated as exterior walls.
2) These systems are usually 2 to 3 times more efficient than resistance electric water heaters and have the ability to match TDV of gas-fired water heaters. However, they are loud and many home owners do not like their garages to drop to 40 degrees. Also, most architects don't like putting the main showers next to the garage for compact plumbing design.
3) HP DHW systems that have separate outdoor condensers are about twice the cost ($3600) but do not make garages cold and offer the design flexibility to position the tank in the middle of main baths for immediate hot water to showers and to facilitate compact plumbing design. When powered by on-site solar or wind, these systems are far less expensive and problematic than solar thermal systems which are known to cost $8k to $20k and have far more maintenance and failure mode issues.

4) There should be a prescriptive option for HP DHW units given the push toward ZNE.
5) There should be a requirement for HP DHW ready, requiring a 240V dedicated circuit for a future HP unit as well as a condensate drain path.

Please Make Compact Design, Reduced Pipe Diameters and Pipe Insulation Mandatory:

1) Compact design should be mandatory in new construction. It is so easy to do if you have a green field to begin with and it greatly increases customer satisfaction and efficiency while lowering cost. It is particularly easy to place the main water heater tank between the primary and secondary showers which is where the homeowner wants hot water in 5 seconds and where water demands are highest. Few home owners care if they get hot water as quickly at the laundry, kitchen sink or wash basins, but all of these fixtures can be clustered around the plumbing core, especially in two story design.
2) Compact plumbing design can cut rough plumbing costs in half. It eliminates the need for recirc systems of any kind and can cut line losses and as a result standing losses. Because the cost is lower, and it can reduce 20% or more of the energy used in a home depending on climate zone, it should be a mandatory measure.
3) Gary Klein's research for the CEC on water and energy savings with reduced pipe sizes (1/2" trunks and 3/8" branches) seems particularly relevant as it costs less, greatly reduces pipe surface area and heat loss, and reduces wait times further. These should be mandatory measures.
4) Pipe insulation is far less expensive to do if compact plumbing and reduced pipe diameters eliminates 50% of the pipe surface area. This should also be a mandatory measure. Let's embrace the cost effective strategies.

Wall Assemblies:

1) Advanced Framing benefits are generally underestimated. Conductive heat loss and reduced cost of full advanced framing make it worthy of becoming a mandatory measure on single and two story structures. If cost savings of advanced framing is invested in compressible blown fiberglass products that assure elimination of air gaps,
2) Localized blown urethane foam should be required around steel hold-downs to assure insulation around these highly conductive elements that are likely to create air gaps and thermal bridging around them if they are not sprayed with foam.
3) Energy code should include discussion of minimum building standards for attachment of exterior foam especially as it pertains to vapor drive and suspended siding loads. The code mentions ¾"-1" minimum penetration of fasteners into framing,
4) The energy code does not address or discuss vapor drive entrapment in wall cavities as it relates to permeability of exterior foam and the need for capillary breaks between the exterior moisture barrier and the XPS foam to facilitate drying of the assembly and vapor

drive release. Most concrete siding manufacturers require air gaps in the assembly behind the siding to allow drying; otherwise concrete siding products are known to fail. Illustrations need to include these details. The assumption is made that vapor drive is not an issue if there is exterior foam to mitigate against condensation in the wall assemblies, however, exterior foam does not eliminate all thermal bridges in the assembly, such as framing protruding through the foam at window and door openings and in eaves. Also, it is conceivable that occupants may leave for a winter vacation leaving the heat turned down low enough to result in condensation in wall cavities at the interior surface.

5) The code should provide some discussion of exterior foam attachment requirements and make recommendations for angling exterior fasteners upward and use of large washers or batts to distribute the point loads the fasteners which simultaneously creates capillary breaks or rain screens to allow the assembly to dry and release vapor drive as required by manufacturers. The failure to attend to any of these details can lead to catastrophic water damage and failure of the assembly as well as voiding of some product warranties.
6) The code should also provide a more detailed checklist of air sealing measures at the vapor barrier and drywall, including the use of fire-retardant caulking to seal the back of J-boxes and subpanels as well as the joint between J-boxes and the drywall, especially in projects where exterior foam is required.
7) Cost trade off analysis of exterior foam **(see attached Xcel file showing cost versus R-value trade-off analysis)**: As a GC, I have had the experience of using exterior foam systems, and knowing the many man-days that it takes to cover a 2000 s.f. home with foam with custom metal flashings and window details. It is clear to me that it is far more cost-effective to use thinner exterior foam systems such as Kingspans DC14 which is an exterior foam with an integrated rain screen that staples on and is far more cost-effective if used with higher R-value blown wall insulation such as Optima that yields a wall cavity R-value of R-23 (in 6" stud assembly, with minimal air gaps and more predictable install quality). I have a cost versus performance 10-page spread sheet for various wall assembly designs that I am happy to provide.

Radiant Barriers:

1) The code currently requires radiant barriers below the OSB deck only if there is no below deck insulation. The 2016 Compliance Manual explains that below deck radiant is not needed if there is below deck insulation because the barriers don't work without an adjacent air gap. The problem is that the Oak Ridge Lab research on this indicates that the reflective surface of the radiant barrier must face up with a gap above it to mitigate unwanted heat gain. The photos of the radiant barrier at the roof deck show the shiny side pointing down with the air space below as a method to mitigate unwanted heat gain, contrary to Oak Ridge National Lab research. (Perhaps there is something I am missing here?)

2) Ironically, the intent that is described in the text of the CEC code is contrary to how the radiant barriers are pictured. For best results, the radiant barrier should be integrated into the waterproofing membrane underneath concrete tiles so that the reflective surface faces upward into the airgap below the tile.
3) Below deck membranes should face upward into an airgap below the roof deck to be effective. Oak Ridge tested this and developed a product that achieves this configuration but it was never commercialized (at last notice). Their tests showed the best effect when this below deck gap was vented at the eave and at the ridge or peak of the roof.
4) The radiant barrier facing downward may make sense in heating load climates as it should help retain heat in the attic, but I have heard that the effect is minimal. Has the CEC tested identical homes with and without radiant barriers, and with barriers facing up into an air-gap above as Oak Ridge has? If so, can you send me a copy of that research paper?

High Performance Attics – Vented

1) Clearly, high performance attics are a great strategy to mitigate against high temperature differences between attic and duct temperatures. If high performance attics are designed to mitigate against heat gain through the ducting in the summer, then they should also minimize the heat loss in the winter, especially in climate zones that experience winter and summer extremes. If vented attics meet the vent area requirements, then they will be quite cold in winter, especially if deck insulation prevents solar heat gain from heating them up. The code requires above or below deck insulation in climate zone 16 which is alpine and has predominantly heating loads. This seems illogical. Winter heat losses are probably equal to or greater than summer heat gain in this climate zone. <u>Deeply burying ducts in 24” of R-60 insulation would be less expensive and mitigate against year round losses in climate zones that experience both hot and cold extremes.</u>
2) If the goal is to reduce the delta-T from attics to ducts, it would be more cost effective to significantly increase ceiling insulation from R-38 to R-60 in climate zones 4 and 8-16 <u>and</u> require that all ducts be deeply buried. The heat loss equation doesn’t lie. If deeply burying ducts makes the effective R-value R-25, then the heat loss equation dictates that R-60 attic insulation over deeply buried ducts with a total surface area of 1400sf in a 140 degree F. attic has about the third of the duct losses as the same size ducts that are R-6 in a 110 degree attic: Q=U.04*1400*Delta-T80=4480BTU versus: Q=U.166*1400*Delta-T 50=11,666.
3) The cost of additional blown insulation at the ceiling plane (R-60 instead of R-38) is about 45 cents per square foot, far less even with heel trusses than the cost of roof deck insulation (about $1.00/sf of floor area). Furthermore, lower attic temperatures can be achieved with $200 solar attic fans to lower attic temperatures without deck insulation.
4) Deck insulation seems most necessary if unvented attics and cathedral ceilings are preferred. They are also necessary under habitable roof decks over living space where vapor drive and cold temperatures can cause condensation in ceiling assemblies.

5) The CBECC model seems to be biased toward HPAs in all climate zones. Much higher credit is given to HPA options over deeper ceiling insulation with deeply buried ducts when the heat load equation seems to indicate otherwise. Requiring deck insulation in in vented HPAs in climate zone 16 as well in as in other climates that see an equal amount of extreme cold and hot conditions, seems to mitigate only extreme summer heat gains and does nothing for winter heat losses. It seems less cost effective than other options, such as eliminating ducts completely, given year round conditions.

Unvented Attic Design Variables:

1) Vapor drive and humidity control in sealed, unvented attics may be an issue. Case study research has shown that humidity tends to migrate to the peak of the roof in cathedral ceilings and it is likely that humidity accumulated in unvented attics as well. It would cost less than $150 to install a 30cfm fan with a humidistat that exhausted air from the peak to the outside with make-up air entering through a duct with a gravity damper.
2) Whole house fan systems normally vent to the attic, and in the case of an unvented attic, would have to be ducted directly to the outside through an end gable or dampered roof cap.
3) Unvented attics should only be recommended in extreme climate zones (11-16). They should not be regarded as part of “conditioned space” as they are “indirectly conditioned”, and insulation at the ceiling plane should not be reduced or eliminated.

A Basic List of Air Sealing Measures Should be Mandatory:

1) All projects should require a broader range of air sealing measures to prevent vapor drive into wall assemblies (potential mold) and to increase efficiency in a manner that is far more cost effective than most other measures: (See suggested air sealing checklist below.)

AIR-SEALING QC CHECKLIST

CLIENT NAME/ OWNER OF RESIDENCE:________________________

ADDRESS:________________________ DATE:____________

Insulation Contractor:____________________ Air-sealing Forman: ____________________

Air-Sealing Precautions:	Checked by(print name)
Protect finish surfaces and concrete floors as needed	
Protective gear: particle mask, disposable gloves required (see Note 1)	
Air-Sealing Tasks	Checked by(print name)
Use hi-temp 3M Fireblock (Home Dep.) to seal outside of J-boxes (No fire-block inside of boxes)	
Seal all switch and plug boxes to drywall (Fireblock or latex caulk. After drywall install)	
Air seal light boxes to drywall at ceiling.	
Cover all holes in metal J-boxes with high-temp aluminum tape	
Seal all holes in bath fan enclosures with hi-temp aluminum-butyl tape	
Use hi-temp 3M Fireblock or fire-rated foam outside of J-boxes (Orange Great Stuff at HD or equivalent)	
Air seal all plumbing holes in drywall around pipes under sinks	
Air seal all plumbing penetrations at top plate	
Air seal all electrical penetrations at top plate	
Air seal all top plates at drywall (Joints between wood and drywall at tops of walls known to cause 2/3 leakage)	
Where there is no attic access, seal drywall to top plate as it is installed on new construction	
Seal drywall to bottm plate as drywall is installed on new construction	
Seal bottom plate to slab or floor with caulk or use sill gasket (best practice on new construction)	
Air seal skylight shafts	
Air seal skylight tubes at attic side of drywall being sure not to glue the lens (removable for cleaning)	
Make sure all open chases are sealed at ceiling plane. (Chase is a mech. syst. Cavity in wall assembly)	
Air seal duct pass-throughs at drywall ceiling, range hood ducts, etc.	
Air seal all duct registers to drywall penetrations (either using foam from the top, caulk or tape from bottom)	
Air seal all knee walls/living space	
Air seal all subfloor penetrations	

NOTE 1: Urethane foams are toxic and absorb through skin. Exposure is associated with rashes and increased cancer rates. If applied to wall, floor or ceiling assemblies in thicknesses greater than 2" at a time, uncatalyzed material trapped in the foam can outgas carcinogenic gasses over time, resulting possibly in structure being condemned.

NOTE 2: Do not tape or otherwise air seal at OSB sheathing plane. (Construction adhesive OK where required for shear) Sealing OSB is an unnecessary additional expense and is not required to achieve tight building standard (ACH50=2.0-2.5)**, AND it inhibits drying through vapor permeable water barriers such as Tyvek. We highly recommend use of rainscreen products in conjunction with exterior foam to allow wall assembly drying.**

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If all of these measures are performed diligently, achieving 2ACH50 is all but certain.

2) The biggest challenge may be getting recessed sprinkler heads UL approved that do not leak air and that prevent vapor drive from getting into cathedral ceilings. The state should move quickly to encourage sprinkler head manufacturers to solve this product development challenge. In the meantime above deck exterior foam should be required on all cathedral ceilings and below roof decks that are over habitable space to prevent condensation in these types of ceiling assemblies.

Fenestration – Section 110.6 a&b:

1) No exceptions to Section 110.6a should be made for field fabricated doors and windows. Since it is extremely difficult to verify compliance with NFRC-400 or ASTM E280 in the field, field fabricated doors and windows should not be allowed. Air leakage at doors and windows that are not properly sealed can be significant due to differential pressures around various sides of a structure in high wind conditions. Such air leakage has the potential of completely negating the effectiveness of other very costly measures such as high performance attics and exterior foam insulation. At very least, if field fabricated doors and

windows are allowed, blower door testing by a HERS rater should be required to verify whole house leakage rates below 2.0 ACH at 50pa depressurization or a similar stringent standard.

Installation of Field-fabricated Fenestration and Exterior Doors. Field-fabricated fenestration and field fabricated exterior doors may be installed only if the compliance documentation has demonstrated compliance for the installation using U-factors from TABLE 110.6-A and SHGC values from TABLE 110.6-B. Field fabricated fenestration and field-fabricated exterior doors shall be caulked between the fenestration products or exterior door and the building, and shall be weather stripped.
EXCEPTION to Section 110.6(b): Unframed glass doors and fire doors need not be weather stripped or caulked.

2) All doors and windows should be weather stripped and caulked especially fire doors through demising walls that separate garages or shops from conditioned space. The code currently allows open combustion appliances to be located in garages, as well as continuously operating exhaust fans supposedly to meet IAQ and ASHRAE 62.2 standards. This combination of circumstances could depressurize the conditioned space leading to backdrafting and CO infiltration. Clearly, fire doors must be sealed.

Section 120.1 IAQ & ASHRAE 62.2:

v. Multifamily attached dwelling units shall have mechanical ventilation airflow provided at rates in accordance with ASHRAE 62.2 section 4.1.1, and comply with one of the following subsections ai or bii below.
a. A balanced mechanical ventilation system shall provide the required dwelling-unit ventilation airflow.
b. A continuously operating supply ventilation system or a continuous operating exhaust ventilation system shall be allowed to be used to provide the required dwelling unit ventilation airflow when the following condition is satisfied:
I. Dwelling-unit envelope leakage shall be less than or equal to 0.3 cfm/ft^2 of envelope surface area as confirmed by field verification and diagnostic testing in accordance with the procedures specified in Reference Nonresidential Appendix NA2.3.

1) Although it makes sense to give the infiltration credit of 2ACH50, given the tighter building envelopes we are building today, it does not make sense to meet ASHRAE 62.2 with anything but a dedicated, balanced fresh air ventilation fan with a heat exchanger. Infiltration is not ventilation, and infiltration from walls, crawlspaces and attics is not likely to produce fresh air.
2) THERE ARE SIGNIFICANT SAFETY CONCERNS with supply only or exhaust only ventilation: A supply only scenario can force humid interior air into the wall assemblies where it may accumulate for long periods of time and condense in areas where exterior foam is thin and thermal bridges are inevitable. New peer-reviewed medical research associates a variety of interior molds with a much wider range of medical conditions including heart disease, neurological dysfunction, arthritis, bronchitis, edema and flu symptoms. (See survivingmold.com). Exhaust only scenarios will depressurize the home and can cause combustion flues to backdraft and fiberglass or cellulose particulate infiltration from the attic and wall cavities. If there is a crawlspace, there is a statistical probability that 40% of

the “fresh air” entering the home will come from the crawlspace, obviously not a good idea. These issues also highlight the importance of providing air sealing checklists that include sealing all electrical J-boxes and caulking the base of the drywall to prevent infiltration or exfiltration at these points.

3) The most affordable ERV model, the Panasonic FV04VE1 costs only $320 and would meet the requirement in most small homes given the infiltration credit. This cost is about the same as two bath fans, and includes a 70% efficiency heat exchanger.
4) Page 4-69 in the 2016 Compliance manual offers example 4-14 which appears to state that a bathroom exhaust fan that doubles as an ASHRAE 62.2 IAQ fan is required to have a label on the switch to inform the occupant that the fan should be running whenever the home is occupied. If that is true, then all any house requires to meet 62.2 is a label on the bathroom fan. I believe this to be a misinterpretation of Section 4.4 of 62.2 quoted on page 4-68 of the Res Compliance Manual which states that a “fan-on switch of a conditioning system must be appropriately labeled”. This section applies specifically to CFI -IAQ systems, which are so inefficient they should be prohibited. Fans providing fresh air should run continuously or intermittently and not be shut off as normal exhaust fans.
5) Bath exhaust fans should be controlled by timers with humidistats so they turn themselves on when humidity in the room builds up to control moisture, and potential mold and vapor drive at the source. Humidistats should be a mandatory measure.

Rainwater Catchment -Section 110.10:

EXCEPTION 1 to Section 110.10(a): Single family residences that have installed one of the following three sets of equipment: ...3. an occupant controlled smart thermostat complying with Joint Appendix 5 along with at least one of the following: … D. a rainwater catchment system designed to comply with the California Plumbing Code and any applicable local ordinances, and that uses rainwater flowing from at least 65 percent of the available roof area.

1) An averaged sized home (1600s.f.) will have about 2000s.f. of roof area. In an area with moderate rainfall (19 inches per year) will generate over 23,000 gallons a year. If we are to catch “at least” 65% of that, we need a rain catchment that can hold 15,400 gallons of water and which would occupy over 2000 cubic feet requiring for example, a tank 12’ diameter tank over 20’ tall with a cost of $9800. Given that the code does not suggest that this water be used for anything but gardening it is an impractical suggestion for most tract homes and will be eliminated from nearly all projects.
2) 2) There are tall and narrow tanks that are designed to fit under the eaves of a house (2’ x 6’ x 6’) that hold approximately 500 gallons and cost less than $800 each. The option should include one or two of those “for gardening purposes only”. Below grade cisterns are extremely cost prohibitive and expensive to maintain because the fill with leaves and silt which causes pumps to fail. Options such as this need to be practical. Underground cisterns

should be avoided as they will not be maintained and will cost a great deal more that above ground storage.

Minimum Solar Area – Section 110.10b

1) Orientation is so important to solar output as well as to the feasibility of passive solar design that the code needs to make it explicit to developers and planners that whole communities. Suggesting that it is appropriate to orient solar panels within 110 and 270 degrees is a significant compromise in a retrofit situation. If we have a greenfield opportunity with new construction, we should be recommending due south orientation and restricting orientation to within 20 degrees of due south (160-200) to keep the high cost of solar cost-effective in its actual output.
2) Furthermore, streets and lot proportions in ZNE communities need to be laid out to maximize the cost-benefit equation of imposing ZNE standards. If we don't actually emphasize the variables that are important to making ZNE design work in a manner that is cost effective, it will be a matter of time before the National Association of Home Builders will beat back these regulations and take us back to the conventional status quo. The importance of designing ZNE communities, orienting streets, making lots have longer frontages on streets with east-west orientation to accommodate passive solar design, and placement of shade trees and shrubs where they will not impact solar access should be repeated in several places in the code to be sure both planners and developers are maximizing the cost effective methods of getting to ZNE.
3) It is insufficient to allow a dedicated solar area that is incapable of meeting net zero requirements for single family and low-rise multi-family structures. The 250 s.f. minimum allowance allows 14 standard PV panels (assuming precise proportions) which would have a 4 kW output under the best scenarios. This is enough to provide plug loads and lighting in most homes but does not handle hot water and HVAC demands let alone future EV charging.
4) The typical three-bedroom home is going to need a 10kW solar array to offset all energy used onsite at a minimum. This will require 640 s.f. , preferably facing south and all in one block uninterrupted by roof jacks to save cost and improve appearance.
5) It is not all difficult to design homes that can accommodate two to four times that solar area. I recently built a with condominium –like proportions with 1200s.f. on three levels and only 800 s.f. of total roof area. We were able to allocate 450 s.f. to the solar array by <u>extending the south eave over a roof deck and combining plumbing vents and daylighting them on the north side of the roof.</u> To reduce the minimum to 150s.f. for a three-story 2000s.f. home is an extremely low bar and is not in line with the real goal of achieving ZNE design in this code cycle. Combining plumbing vents should be suggested or encouraged by the code as a practical solution.

Combustion Appliance Safety:

1) It is clear that wood stoves cannot meet any definition of "zero carbon". Even if we calculate CO2 absorbed by the 20-acre parcel surrounding the cabin heated with a wood stove, the person living in this environment has a daily driving cycle, usually not with an EV, that more than uses up the carbon credit of their oak forest. They are also extremely unhealthy for both IAQ and urban air quality. Wood stoves should be prohibited state wide.
2) If gas appliances are to be allowed, they should at very least be the highest efficiency sealed combustion types (95% to 98% efficiency).
3) The 2016 Compliance Manual mentions avoiding "backdrafting" but does not explicitly address the most common scenarios: 1) naturally drafted water heaters in laundry rooms where the 150cfm dryer can easily backdraft the DHW when the door is closed. The example calculation for this includes the area of the entire house rather than the area of the laundry room (when the door is closed). This seems like a considerable oversight. This is the most typical backdrafting scenario which as a BPI GC I have found in countless older homes and should be clearly spelled out in the code.
4) All gas fireplaces should be sealed combustion type with dedicated combustion air intakes or direct vents and a minimum AFUE of .90.
5) Because home owners have a visceral and instinctive attraction to fireplaces, I think it is important to allow electric fireplaces in all-electric ZNE homes that have high efficiency heat pumps or mini-splits, provided that there is a sign on the side of the electric fireplace reading that it is not to be used for primary heat, but primarily for "decorative purposes only". Alternatively, the state should encourage electric fireplace manufacturers to either build in 30-minute timers that turn the heat off but leave the flame on, or include a feature that would allow the installer to flip a switch that is not normally accessible to the occupant that turns the heating function of the fireplace off but leaves the decorative flame on. (Please forgive me for being a product designer, but I feel this is actually important to satisfy the need for decorative fire effects in non-combustion appliances).

NOTE: SUGGESTIONS FOR HVAC SECTION ARE FORTHCOMING –Thank you for taking the time to read this document and consider its content and suggestions. Please contact me if you want specific research or cost analysis referred to in this document. Sincerely, Bruce Severance: BPI Energy Analyst, General Contractor, Zero Energy Consultant: 805-268-4444, zeroenergyexperts@gmail.com