A Zero Net Energy Definition for Residential and Commercial Buildings

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Introduction

In 2008, the California Public Utilities Commission (CPUC) developed a Long Term Energy Efficiency Plan with four "Big Bold Energy Efficiency Strategies" that envisioned major new initiatives for promoting building energy efficiency.[1] These strategies are intended to be a basis for organizing California energy efficiency efforts including Investor Owned Utility (IOU) efficiency programs, energy code development and future energy legislation. Two of these key strategies involve the concept of "Zero Net Energy":

1. *All new residential construction in California will be zero net energy by 2020;*
2. *All new commercial construction in California will be zero net energy by 2030;*

In this document, Zero Net Energy (ZNE) was defined as follows:

- *The amount of energy provided by on-site renewable energy sources is equal to the amount of energy used by the building.*
- *A ZNE building may also consider embodied energy – the quantity of energy required to manufacture and supply to the point of use, the materials utilized for its building.*

This policy and associated concept required some clarification so implementation could be effectively pursued. As a result, this group was formed to develop definitions of ZNE, for consideration by the responsible California agencies. Questions that were identified include:

- How is energy valued for trade-offs between different sources (natural gas, propane and electricity) and trade-offs with on-site renewable generation? Example energy metrics include: site, source, TDV, embedded, transportation energy etc.
- What is on-site renewable energy (PV, hydro, fuel cells, biomass, landfill gas)?
- What is on-site? Building site, development site, utility grid etc?
- How does definition or policy address sites that do not have access to renewable energy?

[1] Section 1, Page 6. (CPUC 2008)

The concept of Zero Net Energy is a powerful one. It has reset expectations of what is possible from a small incremental improvements in efficiency to targets that exceed 50% savings from energy efficiency and with the addition of renewables, net energy autonomy. There are hundreds of examples of zero (or near zero) net energy buildings and homes. Griffith, et al., (2007) have estimated that "Based on a ZEB definition that uses net site energy use of zero or less, the results show that 47% of commercial floor area and 62% of buildings could reach ZEB by using known technologies and practices with projected performance levels for 2025." An even greater fraction of buildings would comply with a source energy or societal cost based definition of ZNE. A desirable outcome is that this definition of zero net energy be technically achievable as a policy, enforceable when adopted into building codes, and be meaningful as metric of exemplary building design.

Policy Goals

There are many California policies, such as California AB 32, that are supported by a ZNE strategy to increase building energy efficiency in a cost-effective manner, together with the use of demand response and an expanded use of on-site renewable energy sources.[2] The policy goals for the CPUC Energy Efficiency Strategic Plan ZNE are:

Original (2008 EE Strategic Plan) Zero Net Energy Goals

1. All new residential construction in California will be zero net energy by 2020;
2. All new commercial construction in California will be zero net energy by 2030;

A strict requirement that <u>every</u> building be zero net energy is not currently feasible and may never be feasible when considering site limitations, high rise buildings, high energy intensity buildings, etc. We are offering an alternative definition to the CPUC and other key stakeholders to consider. This definition would be recasting the bold energy efficiency strategies that keeps the policy goal intact while keeping a strong central concept of ZNE that is easy to understand and easy to market for those buildings that are able to meet the unadulterated ZNE principles. This revised definition is as follows:

Revised Zero Net Energy Goals

1. All new residential construction in California will be zero net energy *or equivalent to zero net energy* by 2020;
2. All new commercial construction in California will be zero net energy *or equivalent to zero net energy* by 2030;

This modified definition is a major step forward by recognizing that not all buildings have to be ZNE but for code purposes could be ZNE "equivalent." This definition builds on the performance approach that we have in Title 24 Part 6 while preserving the common sense intent of what is a ZNE building. This is also in line with Long Term

[2] California Public Utilities Code Section 454.5(b)(9)(C)

Energy Efficiency Plan's subsidiary goal for existing commercial buildings: [3] *"50 percent of existing buildings will be equivalent to zero net energy buildings by 2030 through achievement of deep levels of energy efficiency and clean distributed generation."*(emphasis added).

Audience

The primary audiences for the ZNE definition are California policy makers and policy implementers. We expect that some effort will go into developing user-friendly definitions that will be useful to the general public, code officials, design professionals, building owners, builders and the building industry in general. A secondary audience is other states, federal agencies, and other countries that can help transform the market for building products and building practices.

Proposed Definition of Zero Net Energy

The *societal value of energy* consumed by the building over the course of a typical year is less than or equal to the societal value of the *on-site renewable energy* generated.[4]

Definitions of Terms

1. *Societal value of energy*

Societal value of energy is the long-term projected cost of energy including the cost of serving peak demand and varies from hour-to-hour to account for peak demand and other fluctuating costs including projected costs for carbon emissions, e.g., the time dependent valuation (TDV) of energy.

2. *Building*

The contiguous property "receiving development entitlements and building code permits."[5], e.g., a single building, or set of buildings on one site, such as a housing development, multifamily building, , campus, etc.

3. *On-site*

On-site is defined for new construction as located on the property for the "project receiving development entitlements and building code permits."[6] For existing buildings we define on-site as "located on the contiguous property under control of the building owner."

[3] Section 3 – Page 31, (CPUC 2008)

[4] For a home or low-rise dwelling unit, ZNE is achieved by demonstrating a California Whole-House Home Energy Rating of zero or less.

[5] Section 2 – Page 13. (CPUC 2008).

[6] ibid

4. *Renewable resources*

Photovoltaic-generated electricity, solar-thermal generated electricity, micro-hydro generated electricity and wind-generated electricity.

5. *Zero net energy equivalent*

A property that achieves the societal value of energy (TDV energy) equivalent of ZNE with consideration of off-site renewable resources, or other factors to be determined by California policy makers.

Notes

1. Policy Goal. The ZNE goal helps support the AB 32 carbon reduction goal, it also provides substantial other benefits that are compatible and synergistic with AB 32. For example reductions in energy consumption and definitions of on-site renewable energy that do not involve local emissions help address California's serious ground level ozone problems.

A major step forward was the recognition that not all buildings had to be ZNE but for code purposes could be "equivalent." This definition builds on the performance approach that we currently have in Title 24 Part 6, while preserving the popular understanding of a ZNE building or community.

This policy goal primarily defines the desired outcome (ZNE buildings) and does not directly address the loading order (efficiency and demand response before renewables). However this set of priorities is captured in Title 24 Part 6 rule sets for renewables and energy efficiency that are under development as well as in the California Public Utilities Code.[7]

We also anticipate that policy makers will need to address additional energy costs such as the energy use of transportation to the building site, the embodied costs of energy in the building materials, the energy costs of water use at the building, and other factors that reflect the larger societal energy costs of the building, but we are not currently including these concepts in the definition of ZNE. State policymakers can add these concepts at the appropriate time. We note them here because we believe they are important considerations and want to contribute to the discussion of their implementation (see also the notes under "societal value of energy" below).

2. Proposed Audience. The purpose of this exercise is to refine the definitions of ZNE for policymakers so progress can be made on a number of fronts. However we recognize that ZNE is a powerful concept that has sparked the imaginations of people all over the world and that there are a growing number of builders and designers who are marketing ZNE buildings.

[7] California PUC §454.5(b)(9)(C): "The electrical corporation will first meet its unmet resource needs through all available energy efficiency and demand reduction resources that are cost effective, reliable, and feasible"

3. Societal Value of Energy. The energy definition is based on societal value of energy as contained in time dependent valuation (TDV) of energy. TDV is really the only metric that addresses peak demand well and has embedded within it a number of previous policy decisions. TDV is also the basis of Title 24 Part 6, the California Home Energy Rating System Program and even the evaluation of utility programs.[8] TDV is the only one of the metrics considered that differentiates between natural gas and propane as their long term costs are significantly different. TDV provides the correct policy signals that would be missing with a flat (non-time dependent) evaluation of energy that does not include a value for peak demand. TDV could be considered more complex because the relative value of different sources changes on an hour by hour basis. However TDV occurs "under the hood" of the performance method calculations and the California Whole-House Home Energy Rating calculations and what he consumer sees is a "percent better than Title 24" or a HERS score.. If TDV is hard to understand, it is only because we have not spent enough time providing a simpler "close enough" description of what TDV is – perhaps just "societal value of energy."

Source energy, also considered as a metric for this definition, is not truly universal since different regions use different source energy multipliers, thus one could consider TDV an improved version of source energy. The basis of these source energy multipliers can also be very complex if an accurate source multiplier is developed that includes the average heat rate of generation and the mix of sources providing electricity for a given area.

Site energy was also considered as it is clearly defined. However, electricity and natural gas are sold in different energy units and these energy sources have different source energy content, environmental impacts and costs. The thermodynamic quality of electricity is higher than natural gas, unit for unit electricity can heat more, (including combustion losses) light more, and create more motive power. A ZNE definition based on site energy sets the bar significantly higher for homes with gas heating and water heating (90% of our building stock). For a home that was able to reduce Title 24 Part 6 loads by 15% each code cycle, the costs of a photovoltaic (PV) system sized on site energy definition of ZNE would be 60% greater than a PV system sized to meet a source or TDV energy definition of ZNE.

ZNE is a transformative concept that is not quite captured by "near ZNE." There have been calls to set the bar even higher for ZNE homes where it is based on a site energy definition or inclusion of other indirect forms of energy consumption associated with buildings. These higher standards for ZNE run the risk of the goal being unattainable and the goal becomes "aspirational" or "advisory" i.e. with no teeth and no hard policy milestones. If the state of California wants to hit the 2020 target for homes we should start with ZNE being based on the energy consumed by use of the home (HVAC, water heating and appliances). Once we have clearly hit this target then it is reasonable to start considering the additional energy consumption due to 1) embodied energy, 2) the energy

[8] TDV represents the societal costs born by all Californians for energy. TDV includes the avoided wholesale costs of energy including energy, T&D, capacity costs and carbon costs, TDV also includes the "retail rate adder" which includes utility fixed costs and overhead and profit. For evaluation of the cost-effectiveness of utility programs, the CPUC uses the E3 Calculator to calculate the avoided wholesale costs of energy in essentially the same manner that is used by TDV, however the retail rate adder is not included. It should also be noted that the CPUC sets energy savings targets for the IOUs that are in terms of site energy, but these targets do not allow for trade-offs between different energy sources.

costs of water, 3) transportation, and 4) other services. However even in the short term, these important other forms of energy consumption may be addressed in venues other than ZNE definitions, such as product life cycle assessment and enhanced water conservation in CALGreen,[9] and transportation planning in CEQA.[10]

4. Building. The question was raised of how code could address multiple buildings. The current definition allows for multiple buildings as part of the same development, or under the same building permit. Another solution would be to differentiate "ZNE Building" from "ZNE Community," as has been proposed by others.

5. Asset vs. Operational Ratings. Asset ratings are based on a computer model of energy consumption of buildings. Operational ratings are based on the actual energy consumption of buildings (typically a billing analysis). For new buildings an "asset" is really the only practical rating method as part of a certificate of occupancy. Existing buildings can be rated using either operational or asset ratings. Energy Star is actually a hybrid of asset and operational ratings — it is based on actual usage, but includes normalization for weather, operating schedules, vintage, etc. such that it isn't simply just an asset or an operational rating. The details of these ratings are developed though a public process and reflect trade-offs of accuracy, comparability, simplicity and repeatability. As we approach zero energy, plug loads become increasingly important. Addressing this in asset rating methods will require careful consideration. See COMNET.org for one method of how plug loads are addressed.

6. On-Site. The question was raised whether it was acceptable if an owner could purchase Renewable Energy Credits (RECs). The consensus was that this would not be allowable, but that other more dependable offsets would be available (see "equivalency" below). Additional debate is whether it makes sense for some building types, e.g., hospitals, high rises, some locations, e.g., downtown, and specific geographic regions, e.g., coastal fog belt, are appropriate candidates at this time for on-site generation. The concept of equivalence may resolve all of these issues.

7. Renewable Resources. This definition does not include "geothermal" (in the sense of a heat pump) or solar thermal domestic water heating as a renewable resource. Geothermal heat pumps, solar domestic water heating, solar driven absorption cooling etc. all reduce energy consumption on-site and reduce needed imports of energy from off-site. But currently, these sources cannot usefully export energy off-site and are treated as energy efficiency measures.

A ZNE building must export as much societal value of on-site renewable energy as was imported. At this time, the only form of on-site renewable energy we can envision being exported is electricity. and thus on-site renewable energy exports would be in the form of photovoltaic-generated electricity, solar-thermal generated electricity, micro-hydro generated electricity or wind-generated electricity injected back into the grid. Biofuels, fuel cells and landfill gas would not be included as an on-site renewable resource; as this

[9] *California Green Building Standard (CALGreen)* California Code of Regulations Title 24 Part 11. http://www.bsc.ca.gov/CALGreen/default.htm

[10] As required by SB 375 Steinberg. Statutes of 2008, "Transportation planning:" http://www.leginfo.ca.gov/pub/07-08/bill/sen/sb_0351-0400/sb_375_bill_20080930_chaptered.pdf

results in local emissions and is not renewable in the sense of the useful energy transformation of local solar and wind energy.

8. Equivalency. Redefining the 2020 and 2030 goals in terms of ZNE or equivalent helps address all of the concerns about exceptions to the ZNE rule. Not every building can be ZNE but every building can be ZNE equivalent. However, a "ZNE equivalent" building should not have the bragging rights of being called ZNE - that would weaken the brand and value of ZNE for all the people who are making buildings that are truly ZNE.

Our initial thoughts on equivalency is that it would take the form of paying for the installation of a new renewable energy system on another California building[11] (i.e. help support PV on commercial buildings or PV on existing residential buildings.) By making sure the residual energy consumption is served by systems on a building site, we help assure that one of the other objectives of the BBEES is accomplished i.e. the volume of on-site installed renewables systems are large enough to maintain the economies of scale that are driving down system costs.

The conditions that would allow equivalency via off-site renewables and the details of the geographical location, and the timing of construction for qualifying off-site renewables systems and many other issues would have to be carefully considered as the state gets closer to the development and adoption of the 2019 Title 24, part 6 standards. We expect that implementation of many of the intermediate steps towards the realization of ZNE goals will help inform the rules on ZNE equivalency.

[11] TDV allows for accounting of equivalency at any location in California; however, there are likely to be policy reasons for restricting the location of the alternative renewable energy system.

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