Defining Zero Net Energy: One Utility's Approach

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ABSTRACT

As the definitional debate over zero net energy (ZNE) continues in many academic and political circles, Southern California Edison (SCE) has conducted research to determine the appropriate definition for ZNE buildings within this utility territory. SCE's approach included an assessment of the range of existing ZNE definitions; a review of the pros and cons of each definition; and policy considerations in adoption of various ZNE goals and definitions, especially as related to the utility business model. Based on this research, we propose a flexible definition of ZNE depending on application of the definition for public education, market transformation, or code compliance. Further, to have the greatest impact, a ZNE performance metric is recommended with that metric being an asset-based scale ranging from 0 to 100. This research serves as an important step for SCE toward meeting California's state-wide ZNE goals and adapting to the future of electricity transmission, distribution and use.

Introduction: California Energy Efficiency Strategic Plan

California utilities, including Southern California Edison (SCE), have been tasked with re-aligning their energy efficiency programs to help meet statewide sustainability goals under California's Long Term Energy Efficiency Strategic Plan (the Strategic Plan) with four Big Bold Energy Efficiency Strategies (CPUC 2008, 6). Two of these strategies are directly related to Zero Net Energy (ZNE):

- *All new residential construction in California will be zero net energy by 2020*
- *All new commercial construction and 50% of existing commercial buildings in California will be zero net energy by 2030*

The Strategic Plan is a statement of intent, accompanied by legally-enforceable CPUC directives. In this case, the Strategic Plan references CPUC directive 07.10.032. This directive defines ZNE as follows:

> *Zero Net Energy is herein defined as the implementation of a combination of building energy efficiency design features and on-site* ***clean distributed generation*** *that result in no net purchases from the electricity or gas grid, at the level of a single "project" seeking development entitlements and building code permits. Definition of zero net energy at this scale enables a wider range of technologies to be considered and deployed, including district heating and cooling systems and/or small-scale renewable energy projects that serve more than one home or business (CPUC 2010 Section 4).*

This CPUC directive leaves the definition of ZNE open to interpretation for specific utility projects and programs, allowing a project to be considered ZNE at many scales and with any renewable energy systems. It does not suggest clear, consistent metrics for measuring success in meeting zero net energy. While the flexibility inherent in this definition is welcome at the state level, it is critical for individual utility companies to more specifically define zero net energy in order to ensure consistency across projects for measurement and reporting to the California Public Utilities Commission. SCE set to the task of crafting a definition for ZNE that could be applied across all of its diverse programs. SCE programs specifically related to ZNE include:

- **Benchmarking**. SCE must officially benchmark 50,000 ZNE buildings by 2030.
- **Savings by Design**. This program offers design assistance and financial incentives to nonresidential building projects that pursue high levels of energy efficiency, with some projects approaching ZNE.
- **The Sustainable Communities Program**. This program provides design/technical assistance, training, and other professional resources to new construction projects that incorporate sustainable/green building practices on large-scale master planned projects and unique, smaller scale, ZNE projects.

In the process of defining ZNE for these programs, SCE addressed several key questions:

- Where is energy measured and by what metric?
- What is the project boundary, and how does the ZNE definition apply to different project types and sizes?
- What forms of renewable energy can be accounted for in achieving ZNE? How does ZNE apply to constrained sites?

Where is Zero Net Energy Measured and by What Metric?

There are a number of ways to measure zero net energy, and there are pros and cons to each measurement alternative. First, one must decide what type of energy use to count in the measurement of ZNE. In the CPUC's Strategic Plan, only electric demand is expressly noted as part of ZNE, but the CPUC Decision 07-10-032 requires no net purchases from both the electric or gas grids. Since on-site generation of natural gas is impractical for most building types outside of the agricultural and industrial sectors, this would seem to imply some form of energy equivalency. This raises a number of questions, including:

- How is "energy" defined, i.e., how are trade-offs made between natural gas and electricity (BTU equivalency, useful work performed)? What of non-grid-purchased energy, such as wood, propane, biomass, heating oil, etc.?

A related issue concerns which end-uses to include in ZNE accounting. Should this accounting only address building systems covered by the State Energy Code (building envelope, HVAC, domestic hot water, and lighting)? Or should ZNE comprehensively account for non-regulated loads such as plug-in, behavioral, appliance and process loads? Regulated building loads shrink in comparison to non-regulated loads. What about transportation energy for larger-scale projects? Unfortunately, the tools currently available for predicting non-regulated energy loads are lacking in general acceptance and accuracy. Furthermore, these loads are much more dependent upon occupant behavior, time of use, and, in certain building types such as manufacturing facilities, quantity of output. A final determination as to how to each of these issues are to be addressed in SCE's ZNE definition has yet to be made.

After considering what fuel types and end-uses to include in ZNE measurements, SCE reviewed ZNE definitions from a menu of choices that range in difficulty in terms of both measurement and achievement.

Net Zero Site Energy

The most common definition for ZNE is "net zero site energy," meaning that a building produces at least as much energy as it uses annually, accounted for at the site (or within the project boundaries). The CPUC Strategic Plan utilizes a site-based definition for ZNE. Other organizations that have adopted site-based definitions include ASHRAE, the US Military, the Federal R&D Agenda for Net-Zero Energy High Performance Buildings, the International Living Future Institute, the National Defense Center for Environmental Excellence, the US Department of Energy Building Technologies Program, and the International Energy Agency (US Army Corps of Engineers, 1). These organizations stress achieving net zero by reducing energy needs 60-70% through energy efficiency and intensively using renewable energy to meet the remainder of project energy needs.

The advantage of this definition is that it is easy to implement because it is the most universally understood metric and can be verified by on-site measurement data (Torcellini, Pless & Deru 2006, 5). The disadvantage is that this definition does not consider energy and on-energy differences between fuel types, usually leading to an undercounting of environmental impact since electricity is typically produced off-site at roughly three times the energy factor as natural gas. Despite acknowledging this disadvantage, organizations like ASHRAE and CPUC still choose to use a "site" definition because this definition has a high potential to yield consistent, reliable measurements (ASHRAE 2008, 4).

Net Zero Source Energy

A more accurate way to define ZNE is "net zero source energy," meaning that a building produces at least as much energy as it uses annually, accounted for at the source. A calculation of source energy is comprised of energy used to generate and deliver energy to the site, including utility conversion efficiencies and even mining energy use when a thorough accounting is performed. Unlike the "site" definition, the "source" ZNE definition is able to equate energy value or fuel types used at the source. Since two-thirds of the energy used to create electricity is lost during the generation and transmission process, "source" accounting yields electricity and natural gas site-to-source energy factors of 3.37 and 1.12. This accounting method encourages the use of gas in as many end uses as possible; the higher the percentage of gas used on site, the smaller the required PV system to achieve ZNE (Torcellini, Pless & Deru 2006, 7).

There are a few arguments against the use of the "source" definition. First, calculation of source energy requires access to local power generation and transmission factors, which may not be readily available. Also, source calculations do not account for regional/daily variations in electricity generation rates. Electricity demanded on a midsummer's day has a greater amount of stress on infrastructure than is reflected in either the amount or the cost of the commodity purchased or produced. To account for this latter difference, a site-to-source conversion factor must be developed which requires collecting more information from the various generation sources. These factors change annually, monthly, and even hourly. Finally, the "source" definition does consider non-energy differences between fuel types. For example, electricity from nuclear fuel and electricity from natural gas are treated in the same way ignoring the difference in source energy in terms of effects on the global environment from carbon dioxide and other greenhouse gas (GHG) emissions.

Due the aforementioned challenges, the "source" definition has not been widely applied. However, the European Union *has* adopted this definition as part of its updated "Energy Performance of Buildings Directive" (EPBD) (ECEEE 2010, 6). Interestingly, although the EU officially defines a ZNE building using the "source" definition, the EPBD does not require buildings to meet this definition of ZNE. Instead, all new buildings must be "nearly zero energy" by 2020, meaning building must "have a very high energy performance…the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby" (ECEEE 2010, 2). In other words, the EU building industry is more stringent in their definition of ZNE, but their actual energy target is less stringent than the site-based ZNE requirement laid out in California's Strategic Plan. The European Energy Commission decided to "soften" energy targets after conducting an impact assessment where they found that requiring ZNE buildings would have overburdened the construction industry and would have resulted in home price increases of 7 to 15%.

Zero Net Energy Equivalent

After the Strategic Plan was first presented in 2008, industry stakeholders complained that the ZNE definition was confusing and difficult to implement.

A group of ZNE experts met in 2011 to "clarify ambiguities and suggest ways to recast ZNE goals in terms that are easy to understand and market to the building and property industries" (CPUC 2011, 9). This group concluded that the strict site-based definition was ineffective because it excluded buildings that did not have the space or funding to produce all net energy on site. The group agreed to revise statewide zero net energy goals as follows in order to effectively encourage all buildings to target zero net energy:

- *All new residential construction in California will be zero net energy or* ***equivalent to zero net energy*** *by 2020;*
- *All new commercial construction in California will be zero net energy or* ***equivalent to zero net energy*** *by 2030;*
- *50% 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.***

The inclusion of "ZNE equivalent" in this CPUC definition not only made ZNE an accessible goal for all buildings, but also brought this definition more in line with the Strategic Plan "resource loading order" of energy efficiency first, renewable energy second (CPUC 2008, 1). The ZNE expert group also provided more precise definitions for "on site" ("on the contiguous property receiving development entitlements and building permits") and "renewable resources" (PV, solar-thermal, micro-hydro, and wind-generated electricity") (Diamond & Hopewell, 4). Additionally, it is understood that a "ZNE equivalent" building might use off-site renewable energy in addition to on-site renewables in order to meet the goal of zero net energy.

As part of the “ZNE Equivalent” measurement method, the group redefined “ZNE” itself as: “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,” where “societal value of energy” referred to the time dependent valuation (TDV) of energy (weighting of energy use based on time of use). This TDV calculation method is attractive because it essentially eliminates the site versus source energy debate because TDV multiplies vary for each hour of the year and for each energy type (electricity, natural gas, propane) (Diamond & Hopewell 2011, 5). This calculation method is also attractive to the California building industry because this is the same method that is already used to model compliance with the California Energy Code, Title-24, Part 6 and the HERS Index.

One concern with adopting an equivalency definition is that some aspects of the TDV of energy may require complicated calculations, and the accuracy of the data used to calculate TDV has been questioned. Also, in order to take advantage of the time-variation aspect of TDV, buildings must be equipped with real-time energy meters that charge based on energy use. Additionally, it may be difficult to convey the concept of TDV-based ZNE calculations to the general public. Finally, it may be difficult to report and compare California ZNE equivalent buildings to ZNE buildings in other states that use the straightforward site-based definition rather than the TDV-based definition.

Net Zero Energy Costs

Another definition of zero net energy looks at building energy use from a purely economic perspective. ZNE can be defined as a condition in which the money that a utility pays or credits a building owner for energy exported to grid is at least as much as money paid by the building owner to utility for energy imported from the grid to meet its demand. This balancing account is typically settled on an annual basis. This economic “leveling” is achieved easily through measurement of utility billing, but it assumes or requires the existence of net-metering agreements, and the impacts on infrastructure and the environment are only as good as the rate structures agreed upon. Under standard rate structures, volatile real energy production costs can make for large differences in this balance, making it difficult to track over time, and yielding unrealistic accounting of either energy or environmental impacts.

The National Renewable Energy Laboratory (NREL) has adopted a cost-based definition of ZNE. Using their BOpt modeling software, NREL assumes that at a “zero savings point, the building occupant pays all utility bill costs. As energy-efficient features are added, savings on the bill outweigh the cost of energy-savings features, until a neutral cost point is reached where utility bill savings equal the cost of energy-savings features. Beyond this point, which NREL calculates as about 60% savings, it is cheaper to install photovoltaics than energy-efficient features. For a typical American Midwestern home, NREL found that a an additional 20% energy cost savings can be achieved with PV, for a total of 80% savings. Beyond 80%, there simply is not roof area for PV panels, so to achieve additional energy cost savings, technologies must be improved and made more affordable in order to move the “neutral cost point” up and to the right (NREL 2006,1). In other words, net zero cost energy is easy to measure but nearly impossible to achieve today.

Net Zero Energy Emissions (zero carbon)

The most ambitious definition of ZNE is "net zero emissions," which means that on-site (and sometimes off-site) renewable energy generation offsets the total carbon emissions generated through on-site energy consumption. This calculation typically includes not only emissions associated with building operation, but also carbon emissions generated during the construction of the building, and even the embodied energy of the materials used in building construction. In some cases, the carbon emissions associated with commuting to and from the site are also considered as part of this ZNE calculation. Emissions may include other gases beyond carbon dioxide, such as nitrogen oxides and sulfur oxides.

The advantage of an emissions-based ZNE definition is that it accounts for non-energy differences between fuel types and their impact on greenhouse gases. The disadvantage is that in order to accurately assess ZNE under this definition, appropriate emission factors from all source types must be determined and all sources used to generate electricity throughout the day must be metered and accounted for hourly. Emissions-based ZNE definitions are more common outside the US and Canada, but this definition is usually considered more aspirational than practical. In one recent application of the emissions-based ZNE definition, an integrated design team led by HoK designed a hypothetical zero-emissions market-rate office building in Saint Louis, Missouri called Net Zero Co2urt. In an integrated research and design process lasting over a year, this team was able to design a zero-emissions building at a competitive price of only $233 per foot and a payback period of 12 years for carbon neutrality (Net Zero Co2urt, 2010). This project represents an impressive first step and a prototype for carbon neutral buildings. However, the major design and research tasks associated with this effort make the emissions-based ZNE definition impractical for utilities and other public entities.

What is the project boundary?

Defining "Site" versus "Source"

For those using the popular site-based ZNE definition, it is critical to determine where the line is drawn between "site" and "source," in order to ensure consistent and accurate reporting to show that any given "site" is truly NZE. Two key steps in determining how much energy needs to be generated for each site are: first, whether or not the "source" (energy generation supply chain) should be included; and second, if not, where measurements should be taken to maximize accuracy.

As is evident in the differences between ZNE definitions, the scope of the definition is a key parameter to measuring and claiming ZNE achievement. The recent passage of the virtual net metering legislation in California simplifies the process of sharing on-site renewable energy systems in a multi-tenant environment and across property lines. However, due to the complexities of the new property owner agreements, SCE has opted to not allow energy balancing unless a legal entity, such as a homeowners association, acts as the administrator of the agreement. In general, district- or community-scale solutions (e.g. eco-industrial systems, shared on-site generation, etc) are encouraged where feasible to level load profiles and improve affordability and cost-effectiveness; however, current requirements may impose some challenges to this strategy.

What forms of renewable energy can be accounted for in achieving ZNE?

On-site Renewable Energy

All of the aforementioned ZNE definitions emphasize that ZNE homes and buildings must achieve a high degree of energy efficiency and strive to meet any remaining energy requirements through the use of clean renewable energy resources. ZNE-Site, ZNE-Source, ZNE-Equivalent, ZNE-Cost, and ZNE-Emissions are all variations on this theme. But what is "clean renewable energy" as defined by the CPUC: does it only include photovoltaic electricity, small hydro, wind and biomass, as noted in the Strategic Plan? What about other renewable sources such as fuel cells, landfill gas, large hydro, grid-scale renewables, geothermal heating and cooling[1], or micro-hydro systems? Is any system that requires fuel to be transported to the building site to produce electricity or heat, automatically not a "renewable" resource? A cogeneration system that requires fuel to be transported to the building site to produce electricity and heat simultaneously (e.g. fuel cells and micro-turbines), while encouraged for efficiency gains, as defined in the CPUC's Long Term Energy Efficiency Plan would not contribute toward ZNE achievement.

Off-site Renewable Energy

"Off-site renewable energy systems" refer to utility-scale renewable energy generation systems wherein the building owner enters into a multi-year contract with the utility to purchase renewable energy for their building. These green power or green energy contracts are limited in California except in cases where large entities with existing direct access accounts are permitted to add load. Commissions are considering relaxing these regulations, and we may yet see rules that allow large, multi-meter customers to consolidate and contract for power from off-site renewable sources. Other specialty tariffs such as the CREST tariff and Virtual Net Metering (VNM) for multi-family housing may also provide a way for solar and other renewable generation to be added onto the meter. Recently the CPUC ruled that VNM be made available to all multi-family buildings and that all units of the building behind a single service delivery point can take credit for the electricity produced by a single photovoltaic system.

Off-site renewable energy also provides a potential opportunity for SCE to combine two goals: ZNE and Renewable Portfolio Standards. The California Public Utilities Commission's Renewable Portfolio Standards require electrical utilities to provide 33% of their power mix from renewable sources by 2020. SCE plans to meet this goal partially through large building projects that feed excess renewable electricity into the grid. Assumedly, excess renewable energy from these projects could be allocated to site-constrained buildings through green power contracts. In this analysis, utilizing SCE chose not to include forecasted changes to the utility's renewable portfolio as a method for achieving ZNE, but this is a possibility for future ZNE calculations.

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[1] Geothermal Exchange Systems (i.e. ground source heat pumps): Based on the coefficient of performance, only that portion of the energy supplied by the earth to heat or cool (kBTU) can be claimed as renewable. The electricity to operate the motors, compressors, fans etc. is not to be considered in the renewable resource calculation.

Renewable Energy Credits

Renewable Energy Credits (RECs) are tradable, non-tangible energy commodities that represent proof that one unit (generally a megawatt-hour, or MWh) of electricity was generated from an eligible renewable energy resource (renewable electricity). The market for RECs is still in its infancy in California but holds promise as an encouragement for off-site renewable energy development, and as a tradable commodity for "gap" filling when a building is unable to achieve on-site ZNE.

If renewable energy generation cannot cost-effectively be installed within the building footprint, then could generation in close-proximity to or other off-site resources be considered as an alternate path to ZNE? There is a growing consensus that some form of "ZNE equivalent" status be created for those projects that achieve large reductions in energy consumption but whose site does not permit on-site generation. "Off-site renewable energy" is far more likely than RECs to be included in this revised "ZNE Equivalent" generation.

Constrained Sites

There are many building projects, especially in an infill environment, that have limited access to on-site generation capabilities. Site constraints can be due to dense building configuration, shading from adjacent vegetation, topography or structures, or building uses with extremely high energy use intensity (data centers, for instance). As generation technology becomes increasingly efficient and therefore requires less space for the respective output, this problem may be alleviated in some, but not all, cases. This potential limitation played a major role in the ZNE definition decision for SCE as it led to consideration of additional community-scale accounting methodologies and ultimately a strong rationale for time-dependent valuation and ZNE Equivalency.

Other Utility-Specific Policy Considerations

From a utility business model and policy perspective, there are several additional issues that required consideration when selecting a ZNE definition. Following is a discussion of these issues, as well as a brief summary of the considerations for addressing such issues from the utility's perspective.

Electricity Pricing

The regulatory structure in place drives the current pricing scheme that (largely) embeds fixed infrastructure costs in volumetric pricing per unit of energy. As volumetric net purchases are reduced through deeper penetration of ZNE buildings, the same fixed costs must be covered by fewer ratepayers and lower volumetric sales. This raises rates on those ratepayers who remain on the system, prompting more to seek relief through ZNE retrofits. This initiates a vicious revenue-loss cycle for the IOUs. There should be consideration given to an approach that emphasizes zero-peak energy buildings either as a milestone towards the Strategic Plan ZNE goals or as an alternative.

Unintended Consequences for Urban Form

While the intent of ZNE building projects is to limit and ultimately eliminate the long term impacts of the construction industry, a building-by-building application of ZNE may actually encourage sprawl. The higher embodied energy from new construction instead of reuse, in combination with the transportation impacts of sprawl, likely has a net negative impact on GHG reduction. SCE attempts to address this challenge by encouraging local government partnerships and regional implementation efforts, but these unintended consequences were ignored for the purposes of defining ZNE.

Developing a Customer-Friendly ZNE Benchmarking System

The aforementioned ZNE definitions serve to identify verifiable "points" at which the design of a structure or community has achieved the established target of ZNE. However, these definitions do not address two key measurement criteria that will be integral to public education about ZNE. First, the achievement of a measurement "point" alone does not give any information about a given home or building's impact relative to other homes or buildings (except that one building achieved ZNE and one did not). Second, the achievement of ZNE by any of these definitions does not explain whether a ZNE building completed in 2015, is any better than a ZNE building completed in 2020. Also not addressed is the question of how many years into the future a ZNE building completed today may still be considered "ZNE."

One proposed solution to these issues is the development of a uniform ZNE scale or metric, akin to the HERS rating system for building energy use. There is a need for a consistent long-term metric that goes beyond EPA's Energy Star Performance, since that tool measures a building's performance relative to other buildings rather than a fixed metric. The ASHRAE Building EQ tool does have a technical scale with zero-energy as the zero-value, but that tool requires a costly energy audit to determine the building rating. ASTM International's Building Energy Performance Assessment (BEPA) will apply to the reporting process but will not include benchmarks (Zero Energy Commercial Buildings Consortium 2011, 19).

One proposed scale is a "Zero Energy Performance Index" (zEPI), based on a scale in which zero is the established absolute ZNE goal (based on site, source, equivalency, cost, or emissions), and 100 is average energy consumption based on the 2003 Commercial Building Energy Consumption Survey (CBECS) data (L., Mark, 2003). This metric meets the criteria of setting two points upon which to properly measure relative positioning (much as the Celsius temperature scale defines two arbitrary but useful reference points of 0°C and 100°C for the freezing and boiling of water respectively), and gives a temporal benchmark for comparing building energy.

While such a definition is extremely useful, it is not without its complications. First, CBECS data does not cover residential buildings – a similarly robust residential benchmark needs to be prescribed for both multifamily and residential buildings. Also, it is not clear whether one should benchmark commercial buildings by type or climate – CBECS data is able to differentiate between approximately a dozen building types and several regional climatic and utility subdivisions of data, allowing for meaningful relative measurement but complicating the actual measurement itself and demanding a greater understanding of the tool on the part of the reader. A reference can lose its meaning and usefulness once the yardstick used is allowed to stretch and bend. Further, CBECS is a limited and dated dataset and the disaggregated data may violate data sharing and confidentiality (small sample set) limits, and is criticized as too small a database with too small a sampling to offer the best source for establishing benchmarks.

Alternatively, using the HERS Index for residential buildings and a similar commercial building index based on Title-24 and TDV energy values may be an option that alleviates the concerns associated with basing a scale on CBECS data while communicating the same message. As with zEPI, it is recommended that a single code iteration be used as a constant baseline (e.g. Title 24, Part 6, of the California Code of Regulations 2005 Standards) for the scale. This way, as codes and building design improves over time; the improvements will be reflected on the scale. Another option would be to simply rate buildings on an absolute scale based on their Energy Use Intensity (EUI). Massachusetts is currently engaged in a state-wide pilot program that ranks buildings on a simple letter scale based on overall EUI, with the highest grade given to zero net energy buildings (Massachusetts Department of Energy Resources 2010, 7).

Conclusion

There are several aspects of the broad ZNE definitions that must be clarified in order to provide a clear, concise standard by which all types of new construction buildings can be measured. This includes the actual energy metrics by which ZNE is measured, the project boundary, and what is considered on-site renewable energy. Additionally, understanding that not all buildings can achieve ZNE purely based on using currently available technologies for energy efficiency and on-site renewable production, we must choose a definition that can account for grid-scale renewable energy resources. Further, consideration must be given to the investor owned utility business model and impacts ZNE may have on electricity pricing.

Given that the state mandate is to achieve major building-related energy use reductions through market adoption of ZNE, it is important to gain traction by; (1) clarifying the definition of ZNE and (2) making ZNE achievable across many sectors. With these two objectives in mind, SCE makes the following recommendations:

- “Site” energy is the most universally understood metric and should be used to help in the understanding of this initiative. Utility programs targeted at end-users, such as SCE’s Savings by Design, have led to significant energy savings; maintaining customers’ understanding of ZNE is key for the success of these programs. This indicates that a site-based ZNE definition is best in the context of utility programs. However, a more sophisticated modeling approach, based on TDV and source energy, will likely still be needed for code compliance.
- An emphasis on maximizing cost-effective demand side management, namely energy efficiency and demand response, should be apparent (per the CPUC loading order of energy efficiency first, renewables second). If a building is able to achieve significant energy reductions, but unable to purchase renewable energy system(s) to cover energy consumption, that building should not necessarily be considered a failure. Similarly, buildings cannot by law, and should not by policy, be required to incorporate measures which are not in themselves cost effective. Such an approach would create success milestones for building types for which it may be technically impossible to achieve ZNE. In other words, recognition of maximum economically feasible ZNE should be applied based on building type, along with maximum technologically feasible ZNE.

- The Strategic Plan should emphasize zero peak energy buildings both as a milestone on the way to ZNE, and barring significant regulatory reform, as a preferred alternative to them. Otherwise, utilities will lose revenue as more buildings target ZNE, creating perverse incentives.
- If renewable energy generation cannot be cost-effectively installed within the building or site footprint, then consideration should be given to generation in close proximity and under the same ownership. There is growing consensus that some form of "ZNE Equivalent" or "ZNE Capable" status should be created to capture projects that achieve deep energy reductions but whose site does not permit adequate on-site generation.
- Consider the utilities' generation mix in the netting out of site usage. This will provide two avenues for renewables; directly at the site or indirectly through utility scale renewable portfolio acquisition. This rewards utility efforts to improve their overall generation mix with clean generation sources and lowers costs to individual buildings through bulk IOU purchase and centralizing system operations and control.[2]
- Embodied energy of water and materials, as well as transportation should not be considered in the initial definition. Inclusion of each of these complicates the accounting, and makes achievement of ZNE orders of magnitude more difficult

In addition, it is recommended that the following other related definitions be adopted:

- **On-site** – Includes all contiguous land under the control of the building owner or developer that is associated with and supports normal building operations for the ZNE building, including all land that was is disturbed for the purpose of undertaking the project.
- **Renewable resources** – Solar, wind, geothermal (deep earth water or steam), geo-exchange systems, low-impact hydro, biomass and biogas energy producing strategies. These systems shall produce electric power or thermal energy for use on-site.
- **Societal Value of Energy** – the long-term projected cost of energy on an hourly basis which includes the cost to provide energy during peak demand as well as other fluctuating costs (e.g. cost for carbon emissions). Also known as the Time Dependent Valuation (TDV) of energy.

Further, to have the greatest impact, a ZNE performance metric is recommended with that metric being an asset based scale ranging from 0 to 100 with 0 being a ZNE or ZNE Equivalent building and 100 being the reference code. In the calculation of design-case energy use, for residential projects the rated TDV value of the home and the TDV of the on-site renewable generation will be determined as it is in the Home Energy Rating System Index (HERS Technical Manual 2008). A similar approach is recommended for commercial facilities.

Lastly, we must keep in mind the purpose of the ZNE goals that the State has established. Were the goals established to ultimately help achieve Zero Net Carbon in the State? If so, this may affect the solutions to many of the questions above. The CPUC metric explicitly focuses on energy; however, the ultimate goal from a climate change perspective would seem to be carbon neutrality.

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[2] If the definition is "clean" energy rather than "renewable" energy on the supply side, then it must be determined whether large Hydro is clean enough to count toward ZNE even though it does not count toward RPS.

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