Definition of Zero Net Energy (ZNE) for California State Agency Compliance with Executive Order B-18-12

May 19, 2016

Executive Summary

With the issuance of Executive Order B-18-12, mandating zero net energy (ZNE) for new and existing state buildings, it has become necessary for the state of California to determine how it will define ZNE for compliance with state targets, and what strategies or prioritization it will encourage.

A focus group of 20 energy professionals representing state agencies, utilities, federal and private sectors, recommended the acceptance of one definition, which was accepted by the governor's office as the primary definition for use by state agencies in achieving and reporting on ZNE status for new and existing state buildings, and to be consistent with federally adopted definition as follows:

> ***ZNE Source*** *– Produces as much energy as it consumes over the course of a year, when accounted for at the energy generation source.*

By adopting this definition, the state of California will require 39 percent less renewable energy generation capacity, and save the state over $1.9 billion over the next nine years while still achieving the requirements of the executive order, as compared with the "ZNE site" definition, which only accounts for energy within the site. "ZNE source" can effectively be measured for existing as well as new buildings, whereas the California Energy Commission's "ZNE Time-Dependent Valuation (ZNE TDV)" is a code definition for modeling energy based on the utility cost value of energy, and it cannot currently be used to measure existing building compliance.

In order to enable attainment of ZNE on site-constrained or challenging state sites, additional variations of ZNE source are acceptable to allow various boundaries for defining ZNE for buildings, campuses, portfolios and communities, to accommodate the wide variety of state facilities and locations and to provide a more feasible path to achieve ZNE at new and existing state buildings. The focus group also emphasized energy efficiency, energy storage, renewable orientation and other important strategies to reduce long-term operating costs to the state, and reduce impacts to the energy grid.

Background

Zero Net Energy was introduced into state policies as a strategy to reduce greenhouse gas emissions, conserve state energy resources, and lead the state by example.

I. AB 32 Scoping Plan
AB 32 was signed into law in 2006, with a Scoping Plan and

Background (Cont.)

Appendices issued in 2008. Among recommended actions for greening new and existing state buildings, it states:

a. "Beginning in 2025, all new buildings would be ZNE (five years earlier than the statewide mandate for commercial buildings)."[1]

II. Executive Order B-18-12 & Green Building Action Plan

Issued April 25, 2012, EO B-18-12 established targets for achieving Zero Net Energy (ZNE) on new and existing state buildings as follows:

a. "All new state buildings and major renovations beginning design after 2025 shall be constructed as Zero Net Energy facilities with an interim target for 50 percent of new facilities beginning design after 2020 to be Zero Net Energy. State agencies shall also take measures toward achieving Zero Net Energy for 50 percent of the square footage of existing state-owned building area by 2025."

Scope of State Facilities Affected

The state of California is a large real estate holder and a major consumer of energy within the state. California state government has a large task required to meet state-mandated ZNE targets.

I. State building area affected

a. State building area[2] totals approximately 112 million square feet.
b. 50 percent of state building area would equal approximately 56 million square feet.

II. State facility energy use

a. 2015 grid purchases of energy are approximately 9.9 billion kBtu[3].

III. Current on-site renewable energy generation at state facilities

a. 2015 on-site renewable energy generation was approximately 78.41 million kWh (267.4 million kBtu).
b. Equivalent to approximately 3 percent of total state building energy use.

[1] AB 32 Scoping Plan Appendices – Volume I, Page C-143
[2] Includes building area of executive branch state facilities.
[3] kBtu is a common unit of energy measurement meaning thousand British thermal units

Progress to Date

Following the issuance of EO B-18-12, state agencies have taken measures toward achieving ZNE targets for new and existing state buildings, and many efforts are underway.

I. Identification of State ZNE Pilot Projects

a. Eight potential ZNE pilot projects were identified in 2014 report to governor's office including new construction, a major renovation, and existing buildings.
b. Most projects were not funded, but two of the original projects are still pursuing measures to achieve ZNE:
    1. Caltrans warehouse facility, Oakland
        - Completing construction summer 2016.
    2. CDPH Richmond Building P
        - Implemented some measures, installing on-site renewables through PPA.

II. Completion of state buildings attempting to achieve ZNE

a. To date, two state facilities have been completed that are intending to achieve ZNE after verification period:
    1. Department of Motor Vehicles (DMV) Fresno Field Office, Fresno
    2. CA Lottery Office, Santa Fe Springs

III. Buildings pursuing ZNE in design or construction

a. Four DMV projects are under design, pursuing ZNE.
b. Two additional projects are seeking funding to pursue ZNE, including projects from California's Air Resources Board (ARB) and California Conservation Corps (CCC).
c. CA Lottery has one additional new project under construction pursuing ZNE, and five more following.
d. One California Department of Corrections and Rehabilitation (CDCR) project under design is pursuing ZNE.

IV. Commitments of state agencies toward ZNE

a. DMV, Department of General Services (DGS), CA Lottery, CDCR and CCC are committed to building every new facility to ZNE.
b. ARB is committed to achieving ZNE at the Southern California Consolidation Project, a laboratory and emissions testing facility.

Defining ZNE

Several ZNE definitions were analyzed for their potential use for designing and verifying ZNE for state new and existing buildings:

I. ZNE source

a. Produces as much energy as it consumes over the course of a year, when accounted for at the energy generation source.
b. Includes site energy plus energy consumed in extraction, processing and transport of primary fuels such as coal, oil and natural gas; energy losses in thermal combustion in power generation plants; and energy losses in transmission and distribution to the building site.
c. Used by U.S. Department of Energy (DOE), federal agencies, and endorsed by the American Institute of Architects (AIA) and American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE). In September 2015, the DOE published *A Common Definition for Zero Energy Buildings,*[4] which identified source energy as the primary basis for calculating zero energy buildings. This paper developed a common definition for ZNE intended for use by government, utilities and private entities.
d. Advantages include nationally accepted definitions, allowing comparison with ZNE buildings outside California. ZNE source can be easily calculated for newly constructed as well as existing buildings. Typically, the renewable energy requirement is smaller than for the *ZNE site* definition, whenever buildings use natural gas or other energy types (see Table 1).
e. Disadvantages include the possibility of a slightly larger renewable energy requirement or greater overgeneration of electricity during parts of the day than a ZNE TDV building, unless this is addressed through other strategies such as energy storage, because source energy fails to address timing of generation.
f. Measurement of energy converts all energy sources into common units of kBtu using different factors for each energy source. The DOE definition uses national average conversion factors, which is recommended both for consistency and because 26 percent of California energy is purchased from outside the state.

[4] A Common Definition for Zero Energy Buildings, September 2015, U.S. Department of Energy

Defining ZNE (Cont.)

II. ZNE site

a. Produces as much energy as it consumes over the course of a year, when accounted for within the building site boundary.
b. This excludes the energy losses that occur off-site, including generation, transmission and distribution systems losses (total system efficiency is approximately 30 percent) to get the energy to the building; as a result, this metric is dramatically inconsistent with building energy bills.
c. Widely used by many design professionals as an early ZNE calculation method because of its simplicity.
d. Advantages include its simplicity and straightforward conversion of all forms of energy into common units (kBtu). The calculation simply measures total energy used within the site boundaries and compares with total energy generated within site boundaries.
e. A disadvantage is that the required on-site renewable generation is the largest of the three definitions evaluated. The exception is with all-electric buildings where on-site energy consumption and on-site renewable energy generation result in identical renewable requirements. ZNE site energy fails to address timing of generation, and like ZNE source energy, would need to address this through other strategies.
f. Measurement is made by converting all energy to common units of kBtu. Annual total energy generated is greater than or equal to annual energy used within site.
g. Favors electric resistance heating over natural gas heating because the losses of grid-supplied electricity and benefits of on-site combustion are not addressed in the energy calculations.

III. ZNE TDV: Time-Dependent Valuation (TDV)

a. ZNE TDV is a California Energy Commission (CEC) developed and promulgated definition for the "utility cost" value of energy whereby the energy consumed by the building over the course of a typical year is less than or equal to the utility cost value of the on-site renewable energy generated.
b. Currently only used within California in current energy codes (California Code of Regulations Title 24, Part 6). TDV will likely be used to provide a code definition for new buildings and major renovations in future code

Defining ZNE (Cont.)

developments targeting ZNE for residential by 2020, and nonresidential by 2030.

c. Advantages of TDV include addressing timing of renewable energy generation and that it would encourage the use of energy storage systems to more closely align the time of energy production with peak energy demand on the grid to better manage overgeneration. ZNE TDV may result in renewable generation requirements slightly smaller than *source*, and definitely smaller than *ZNE site* definitions.
d. Disadvantages of using TDV to define ZNE are that it is intended for design of new construction and not currently for measuring performance on existing buildings. Software is under development for new construction. No existing meters or programs currently exist to calculate TDV values based on existing building energy use.
e. In order to measure and verify existing buildings for achievement of ZNE, hourly energy use data is needed for every hour of the year, and a program would need to be created to apply hourly energy data to hourly TDV values assigned.

IV. Zero Emissions Building

a. Produces or purchases enough emissions-free renewable energy to offset emissions from all energy used in the building over the course of a year.
b. Measures in mass of carbon-equivalent CO2 greenhouse gas (GHG) emissions related to energy use in the building, including Scope 1 and Scope 2 emissions.
c. Not a stated target yet for state buildings and difficult to achieve given that most existing state buildings include combustion equipment that use natural gas or other fuels to generate heat for water and/or air.
d. This option was not explored nor discussed at any depth by the ZNE focus group.

Selected Definition: ZNE Source & Prioritized Approaches

ZNE source is the selected definition for state agency implementation of Executive Order B-18-12. The following variations of the *ZNE source* definition are needed to accommodate the variety of state buildings, campuses and portfolios. To the extent possible, the following ZNE definition variations should be sought in the order listed below:

I. **ZNE building** – An energy-efficient building where, on a source energy basis, the actual annual consumed energy is less than or equal to the on-site renewable generated energy.
   a. The building footprint (i.e., rooftop), or around the building site (i.e., parking lot, adjacent land) can be utilized for on-site renewable generation.
   b. The Renewable Energy Credits (RECs) must be retired (not sold) for all on-site renewable energy systems. This will prevent double-counting of the systems' environmental benefits.
   c. Achievement of this definition is based upon 12 consecutive months of actual energy performance data.

II. **ZNE campus** – An energy-efficient campus where, on a source energy basis, the actual annual consumed energy is less than or equal to the on-site renewable generated energy.
   a. A multiple building campus can be utilized as a boundary for on-site renewable generation to offset energy use of all or a portion of the campus buildings.
   b. This approach would allow ZNE to be achieved for energy-efficient buildings within the campus where the individual building capacity for on-site renewable energy is very restricted.
   c. This would also provide an outlet for on-site energy use for periods of the day when overgeneration of electricity is likely, to avoid financial losses from selling back excess energy wholesale to utilities.
   d. The RECs must be retired (not sold) for all renewable energy systems within the campus boundary.

III. **ZNE portfolio** – An energy-efficient portfolio in which, on a source energy basis, the actual annual consumed energy is less than or equal to the on-site renewable generated energy.
   a. Multiple building sites by the same owner could be used and aggregated so that the combined on-site renewable energy could offset the combined building energy from

Selected Definition: ZNE Source & Prioritized Approaches (Cont.)

the aggregated project sites. This could apply to the entire portfolio, or portions of the portfolio.

b. This approach would allow ZNE to be achieved for energy-efficient buildings within the portfolio where the capacity for on-site renewable energy is very restricted.
c. This would also provide an outlet for excess renewable energy production during periods of the day when overgeneration of electricity is likely, to avoid financial losses from selling back excess energy wholesale to utilities.

IV. ZNE community – An energy-efficient community where, on a source energy basis, the actual annual consumed energy is less than or equal to the on-site renewable generated energy.

a. This could be applied to allow long-term purchase agreements of locally generated, renewable energy, dedicated to providing energy for the building(s). Agreements should extend a minimum of 20 years.
b. Purchased Renewable Energy Certificates (RECs) are typically short-term and not necessarily locally based within the community. While they are an effective strategy to reduce GHG emissions, they would not be allowed to be counted toward achievement of ZNE.
c. The RECs must be retired (not sold) for all renewable energy systems within the community.

Strategies for all ZNE Applications

Beyond defining ZNE, a number of strategies should be considered and employed in ZNE facilities whenever possible to ensure the highest output and efficiency possible, reduce long-term operating budgets and avoid overgeneration.

I. Energy efficiency – Ultra-low energy use through energy conservation, passive systems and whole-building integrated energy efficiency measures should always be the initial focus for each building pursuing ZNE.

II. Share excess generation – Whenever possible, excess generation should be utilized on-site through energy storage, with other buildings on campus, or through utility agreements with other buildings in portfolio.

III. Install energy storage – Utilize on-site energy storage (batteries, thermal, etc.) to shift energy use for peak load reduction, limit overgeneration sent back to the grid, reduce

Strategies for all ZNE Applications (Cont.)

demand charges, reduce energy costs by taking advantage of time-of-use (TOU) rates, and provide cloud cover and outage protection for the facility.

IV. **PV array orientation –** To the extent possible, consistent with California Solar Initiative's Flexible Installation (CFI) option, orient the PV arrays between 150 and 270 degrees from true north to delay the maximum generation to later in the day to better coincide with the CAL-ISO grid's high peak periods. This approach should be reviewed and adjusted over time to provide alignment with the needs of the utility grid.

V. **Use overgenerated energy for EVSE charging** – Electric vehicle service equipment (EVSE) can utilize excess energy generated to charge electric vehicles. This will help reduce or avoid export of overgenerated electricity, and help agencies meet zero-emission vehicle charging infrastructure goals. Energy used for electric vehicle charging does not count toward building energy use, nor does it need to be included in ZNE building calculations. Energy generated through on-site renewables used for EVSE charging can be included in the annual calculation of ZNE using the same source energy factor as overgenerated energy delivered to the utility grid.

Next Steps

I. **Review and approval of concept at agency and governor's offices –** ZNE white paper definitions and strategies approved by the Government Operations Agency and by the governor's office May 19, 2016.

II. **Draft new management memo defining ZNE and outlining strategies**
   - **a.** Develop and issue new policy through management memo into the State Administrative Manual (SAM) to define ZNE and strategies to be used by state agencies in pursuit of their achievement of ZNE for meeting EO B-18-12 objectives.
   - **b.** Edit and refine any existing management memos referencing ZNE to accurately reflect and/or reference definition and strategies.

Table 1: Sample building scenarios showing renewable energy generation requirements using different ZNE definitions

	ZNE source PVs required (kW)[5]	ZNE site PVs required (kW)	ZNE TDV PVs required (kW)[6]
1. Capitola DMV 10,619 sq. ft. 206,070 kWh 2,999 therms	158	196	148
% PV to offset gas	12%	30%	unknown
2. All electric DMV 11,436 sq. ft. 364,794 kWh 0 therms	243	243	254
% PV to offset gas	0%	0%	unknown
3. Large office bldg. DOT District 11 San Diego 292,148 sq. ft. 3,655,259 kWh 23,736 therms	2,597	2,901	2,590
% PV to offset gas	6%	16%	unknown
4. **50% of total state energy use** 586,062,738 kWh 29,505,725 therms	590,199	967,217	unknown

Summary By utilizing the *ZNE source* definition for attainment of ZNE targets for state facilities, the state will align with federal government ZNE definitions. State efforts to achieve ZNE on 50 percent of state facility building area will require approximately 377 MW[7] (approximately 39 percent) less renewable energy installations using the *ZNE source* definition than the *ZNE site* definition, saving the state approximately $1.9 billion over the next nine years.

[5] Source and site PV calculations & percentages provided by Kent Peterson, P2S Engineering.

[6] TDV calculations provided by Maziar Harakh, California Energy Commission.

[7] Estimate based on 2015 California executive branch total energy use. Further energy efficiency improvements through 2015 will further reduce the renewable generation requirements.

State of California ZNE Definitions Focus Group

DGS formed and led a group of state and national energy professionals to review ZNE definitions and discuss the practicality and feasibility of each definition for measuring and determining achievement of ZNE on both new and existing state facilities.

I. California Department of General Services
- Dan Burgoyne – group chair
- Joe Flores
- Paul Wilburn
- Brian Ferguson
- Glenn Connor
- Diane Elliott

II. California Government Operations Agency
- Matt Henigan

III. California Energy Commission
- Bill Pennington
- Maziar Sharakh
- Gabriel Taylor

IV. California Department of Corrections and Rehabilitation
- Jeff Henninger

V. California Public Utilities Commission
- Mindy Craig – Consultant (Bluepoint)

VI. Pacific Gas & Electric
- Peter Turnbull
- Can Anbarlilar

VII. Sacramento Municipal Utility District
- Michele Friedrich

VIII. National Renewable Energy Laboratory
- Paul Torcellini
- Shanti Pless

IX. New Buildings Institute
- Ralph DiNola
- Jim Edelson

X. P2S Engineering
- Kent Peterson