

## 2015 Definition for Zero Energy Building (ZEB)

### Overview

Based on the Executive Order 13514, all new federal buildings that enter planning process in 2020 or thereafter shall be designed to achieve zero-net-energy by 2030. To achieve this goal and provide design consistency among different parties (designers and owners), a commonly accepted definition of Zero Energy Building is necessary. During the last decade, several definitions of Zero Energy Buildings or Net Zero Energy Buildings have emerged. This bulletin will focus on the latest definition published by the Department of Energy (DOE) in 2015.

### Previous Definitions

National Renewable Energy Laboratory (NREL) in 2006 published several definitions for Net Zero Energy Buildings. Four main definitions are: **Net Zero Site Energy**, **Net Zero Source Energy**, **Net Zero Energy Costs** and **Net Zero Energy Emissions**. These definitions allow designers and owners to select the metrics depending on the goal of the project. For example Department of Energy (DOE) may strive to reduce energy at the source whereas private owner of a building may put higher emphasis on energy cost. One of the main problem with these definitions is the intrinsic non-uniformity as it pertains to a fair comparison between two similar projects. As an example, two similar size/type buildings, fed from two different utility companies, constructed to achieve Net Zero Energy Cost may not be fairly compared as utility energy cost differs. Similar unfair comparison scenarios exist for buildings implemented to achieve Net Zero Source and Net Zero Emission.

### Zero Energy Buildings (2015 Common Definition)

Four types of ZEB, as defined by DOE in 2015, are as follows:

- **Zero Energy Building (ZEB):** An energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.
- **Zero Energy Campus:** An energy-efficient campus where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.
- **Zero Energy Portfolio:** An energy-efficient portfolio where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.
- **Zero Energy Community:** An energy-efficient community where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.

Table-1 (national average source energy conversion factor)

Energy Form	Source Energy Conversion Factor ( $\tau$ )
Imported Electricity	3.15
Exported Renewable Electricity	3.15
Natural Gas	1.09
Fuel Oil (1,2,4,5,6,Diesel, Kerosene)	1.19
Propane & Liquid Propane	1.15
Steam	1.45
Hot Water	1.35
Chilled Water	1.04
Coal or Other	1.05

### Converting Delivered/Exported Energy to Source Energy

To fairly compare different ZEBs and based upon DOE definitions above, all delivered/exported energy needs to be converted to source energy using the national average ratios as tabulated in Table-1. This ensures that no building will be credited or penalized because of the efficiency of energy provider (i.e. coal, hydro, cogeneration, and nuclear power plants have different efficiencies). In addition, no building will be credited or penalized by energy cost differences that exist among different energy providers as energy cost is removed from the ZEB definition.

### Source Energy Formula

A building (campus, portfolio or community) is called ZEB if source energy balance  $E_{source} \leq 0$ . The formula to calculate source energy balance is as follows:

$$E_{source} = \sum_i (E_{del,i} \tau_{del,i}) - \sum_i (E_{exp,i} \tau_{exp,i})$$

Where  
 $E_{del,i}$  is the delivered energy for energy type  $i$ ;  
 $E_{exp,i}$  is the exported on-site renewable energy for energy type  $i$ ;  
 $\tau_{del,i}$  is the source energy conversion factor for the delivered energy type  $i$ ;  
 $\tau_{exp,i}$  is the source energy conversion factor for the exported energy type  $i$ ;

ZEB calculation requires proper identification of clearly defined site boundary, usually property boundary. Renewable energy produced and used inside the boundary is not part of the source energy calculation. Meaningful site boundary shall also include the points of utility interface.

### Example

A building has the following actual annual energy delivered: 87,921 Kwh electricity (equivalent to 300,000 KBtu), 49 cubic feet of gas (equivalent to 50,000 KBtu) and 40,000 KBtu chilled water. The onsite annual exported renewable energy from photovoltaic is 102,574 Kwh electricity (equivalent to 350,000 KBtu). Source energy calculation using the formula shown above is as follows:

$$E_{source} = 300,000 \times 3.15 + 50,000 \times 1.09 + 40,000 \times 1.04 - 350,000 \times 3.15$$

$$E_{source} = -61,400 \text{ kBtu}$$

$E_{source} \leq 0$ , so this building is a Zero Energy Building (ZEB).

### Laboratory Buildings

As laboratory buildings consumes a large amount of energy (due to 100% outdoor air required for safety), achieving ZEB becomes very challenging. On-site renewable energy generation (solar, wind, biomass etc.) required to supply building energy, needs a large foot print and substantial capital investment. Alternatively, purchase of Renewable Energy Certificate (REC) can offset required on-site renewable energy generation. REC-ZEB designation allows high energy consuming buildings such as laboratory buildings meet the executive order mandates. Buildings, however, shall have demonstrated energy consumption less than or equal to on-site renewable exported energy plus (REC) to meet the REC-ZEB designation requirements.

### References and Further Reading

1. A common definition for Zero Energy Buildings, September 2015 (U.S department of Energy).
2. Zero energy Buildings: A critical Look at the Definition, National Renewable Energy Laboratory (NREL). <http://www.nrel.gov/docs/fy06osti/39833.pdf>
3. ASHRAE Journal September 2009, Getting to Net Zero. <http://www.nrel.gov/docs/fy09osti/46382.pdf>