



THE ENERGY BALANCE INDEX

Extending the 2030 Targets to plus-energy buildings

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This paper is about a new and simple index for comparing building energy performance that allows us to expand the familiar 2030 Targets from carbon neutral into the unfamiliar territory of net-zero and plus-energy buildings. The idea is to unpack the 2030 Targets and uncover the important but invisible value of design intelligence.



But before getting into the charts and graphs, I want to remind us all of two things:

1. The technical agenda of this work—and indeed all of PLEA—is really in service to the shared value of solving the climate crisis.
2. AND we are solving the climate crisis—not for ourselves but for the Future generations of all species

PROJECT GOALS

1. Performance goals after 2030
carbon-neutral?
2. Simple index for 2030 Targets
and plus-energy buildings?

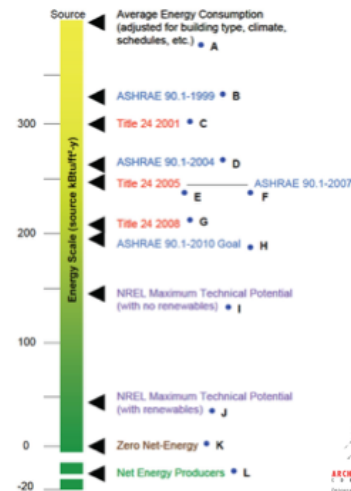


The project has some simple goals. We wanted to know:

1. What performance goals come after the 2030 target of “carbon-neutral”?
2. Can we use a simple index that covers both the 2030 Targets and plus-energy buildings?

CHANGING STANDARDS

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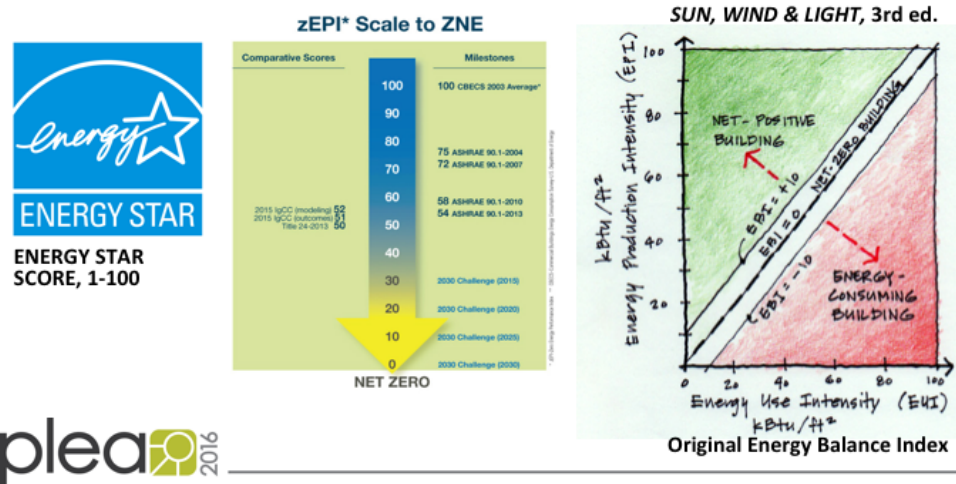


- Green standards based on % less than code
- Codes keep changing
- Comparing buildings becomes difficult



There are lots of energy standards and energy codes out there. They are changing all the time. It is very hard to compare the performance of one building to another using the same yardstick because it is hard to find the yardstick.

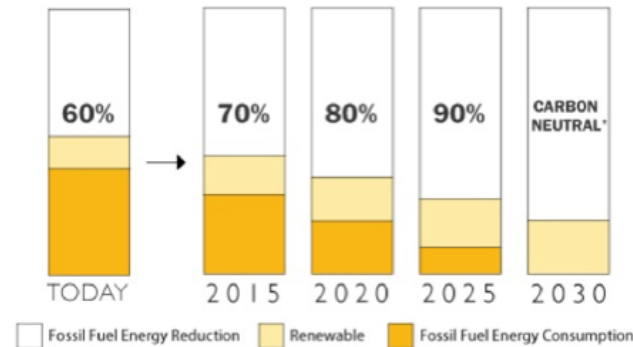
PERFORMANCE INDICES



AND There are also lots of scales and indices out there, including

- the *Energy Star* score found in the US EPA's Target Finder
- the *Zero Energy Performance Index* or zEPI
- and even our first attempt at an *Energy Balance Index* in *Sun, Wind & Light*, 3rd edition

Unfortunately none of these work effectively for extending the 2030 Targets



The 2030 Challenge

Source: ©2010 2030, Inc. / Architecture 2030. All Rights Reserved.
*Using no fossil fuel GHG-emitting energy to operate.

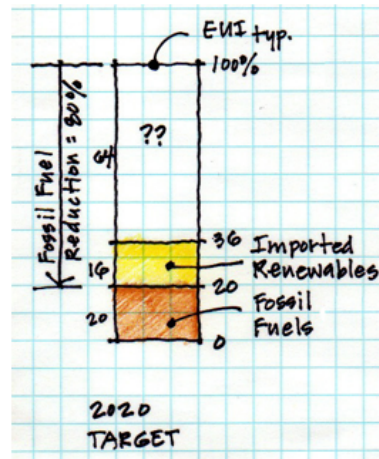


Probably the most effective and influential metric we have in North America is the 2030 Targets from the Architecture 2030 organization. These targets are simple and easy to understand. They focus us all on the big issue of carbon by reducing fossil fuels.

This graphic is actually a little out of date, because today, are operating under the 2015 target. The idea is to benchmark energy use, in the form of an *energy use intensity* (EUI) for a building type and climate, based on building energy use data

from a large survey. Then, to set as a target for new buildings and major renovations to reduce the fossil fuels used by, today, 70% —then to increase that reduction target incrementally by another 10% every five years to a target of “carbon neutral” by 2030. Carbon-Neutral in this sense means no fossil fuels are used in the building’s operation. Note that the area on the graphs marked “renewable” actually means renewable energy imported from off-site.

But there is more behind the scenes.
So let’s take the 2020 Target as an example.



2030 TARGETS EXPLAINED

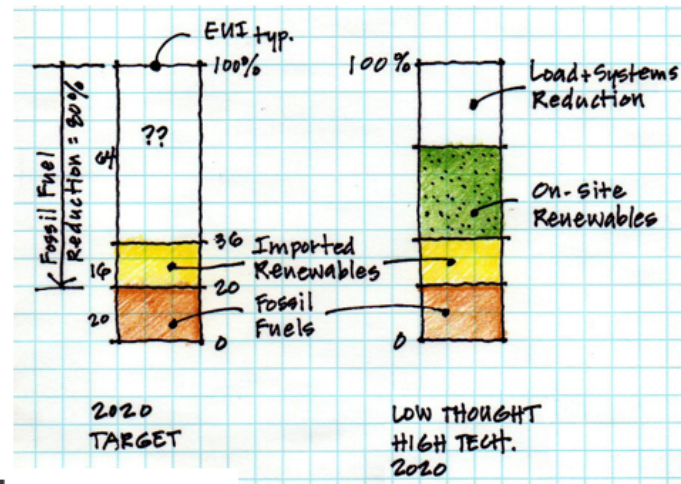
2030 Target = Fossil Fuel Reduction %, relative to benchmark

Imported Renewable Energy Maximum
= Fossil Fuel Reduction % × 20%

For 2020, Imported Renewables = 16% max.

All the 2030 Targets refer to a Fossil Fuel Reduction % relative to a benchmark building.

- The **imported renewables** allowed are set at 20% of the Reduction %
- In our 2020 example, the Reduction Target is 80% and the Imported Renewables are capped at 20% of 80 — or 16% of the original 100% (benchmark EUI)
- But what is in the white part of the graph?
- What is the 64%?



2030
TARGETS:
Where does
the reduction
come from?

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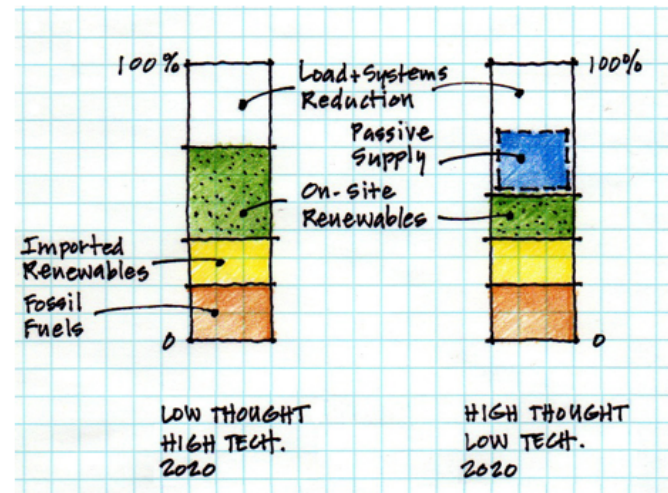
The undefined white space is composed of some combination of

- 1) Load reductions,
- 2) Systems efficiency, and
- 3) On-site renewables.

With little design thought, one could have large loads and a large PV system to compensate.

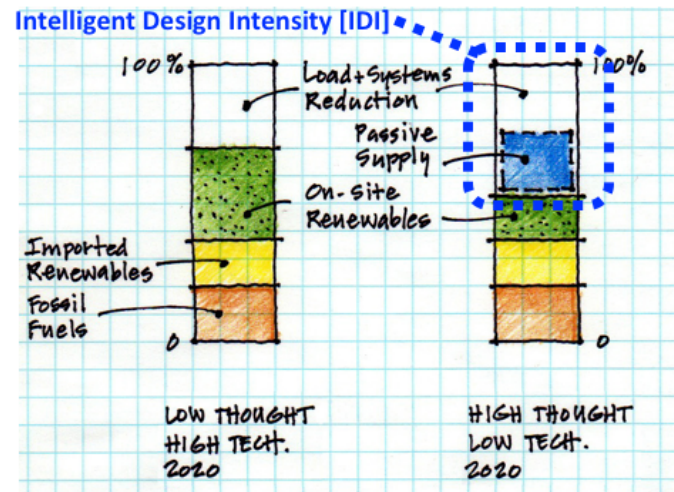
I call that “Low Thought–High Tech”

2030
TARGETS:
The Value of
Design



Or one can have High Thought—Low Tech, which means employing more **passive design**, not just high tech envelopes and high efficiency systems, but heating with the sun, cooling with the wind, and lighting with the sky. Note the difference in these examples of the area for on-site renewables.

2030 TARGETS: The Value of Design

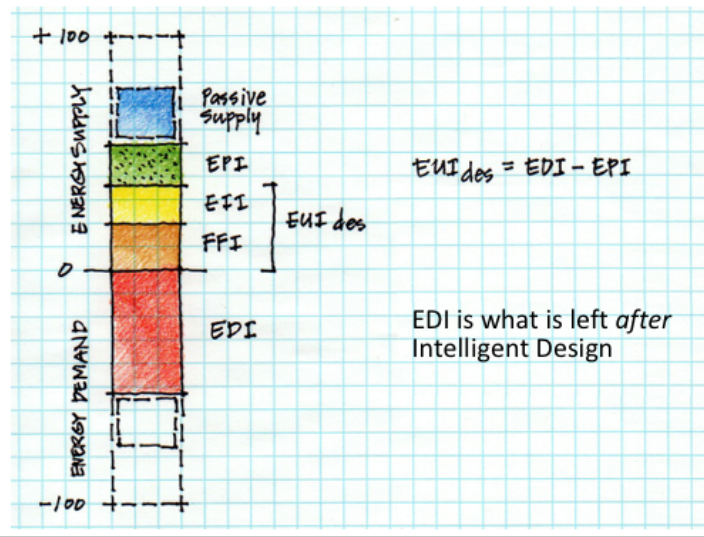


Minimizing loads first, then using passive natural energies, and finally having a small PV system to supply the remaining needs is what I call “Intelligent Design Intensity” (IDI) as the driver of Energy Use Intensity (EUI). So the total energy picture is composed of some combination of these five elements.

2030
TARGETS:
Demand vs.
Energy Supply

2020 Target
Graph

plea 2016



Here we have the same graph, but displayed to show energy *demand* below the zero line and all energy supplies above the zero line. Energy Demand always has to be met by Energy Supply.

First note that EDI, the *Energy Demand Intensity* is equal to the sum of Fossil Fuels + Energy Imported + On-site Energy Produced.

So EDI is the energy needed by the building after all *Intelligent*

Design Intensity has been applied.

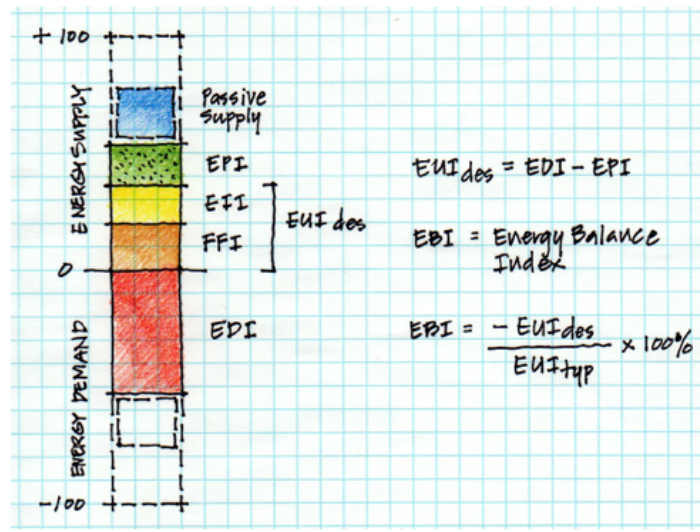


Now a reminder. With climate change, Seals are hard to catch. But what are dolphins doing in the Norwegian Arctic in winter? Once again, its important to *remember the why* of our technical agenda.

2030
TARGETS:
Energy
Demand vs.
Energy Supply

2020 Target
Graph

plea 2016



OK, back to work.

Next, let us define the *Energy Use Intensity* EUI of the designed building as equal to the *Energy Demand Intensity* (the building's need for energy) minus *Energy Production Intensity* (the energy produced on-site).

And now we can finally define the *Energy Balance Index* (EBI) as simply

the inverse of the *EUI design* divided by the *EUI of the typical building* (our 100 value),

expressed as a percentage

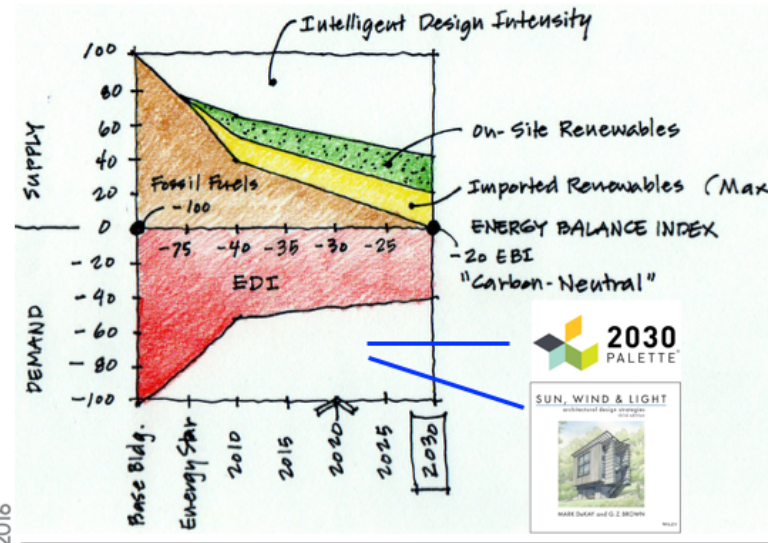
So EBI is an index relative to a benchmark for a building class and climate.

This graph is for the year 2020 Target.

If we put all of the 2030 Targets together...

ENERGY BALANCE INDEX: The 2030 Targets

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It looks like this. We begin on the left side with the base building's energy use, set at -100 . Its EBI is also -100 . Notice that energy Demand is below the zero line and energy Supplies are above the zero axis.

The Base Building uses 100% fossil fuels. As we move right on the graph, the building design gets more efficient and its demand for energy, the EDI magnitude decreases, moving toward zero. The level of fossil fuel use decreases. Again, what is interesting is the white area. The demand reductions are achieved by intelligent design strategies, such as those found in

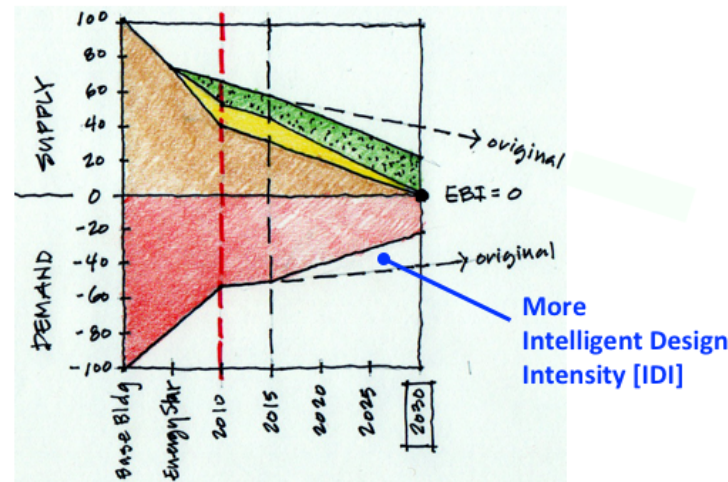
Sun, Wind & Light, 3rd edition (DeKay and Brown, 2014) and in the online 2030 Palette from Architecture 2030. So the biggest zone on the Supply side is actually the *Intelligent Design Intensity* (IDI)!

At 2010, we begin the “2030 Targets.” In this example, we have the Imported Renewables set at the maximum allowed by Architecture 2030, with is 20% of the target fossil fuel reduction. That zone you can see increasing in magnitude toward 2030. We have also set the On-Site Renewables equal to the Imported Renewables. This is a choice and assumption not specified in the 2030 Targets protocol. So, On-Site Renewables also increases toward 2030.

The 2030 target is called “Carbon-Neutral,” and as you can see, the fossil fuel curve has decreased to zero. The EBI scale can be read on the horizontal axis. EBI is a site-based index, and because of the 20 units of imported renewables, the Carbon-Neutral target has an Energy Balance Index (EBI) of –20. So Carbon-Neutral and site Net-Zero are *not*

ENERGY
BALANCE
INDEX:
The 2030
Targets,
quick path to
net-zero

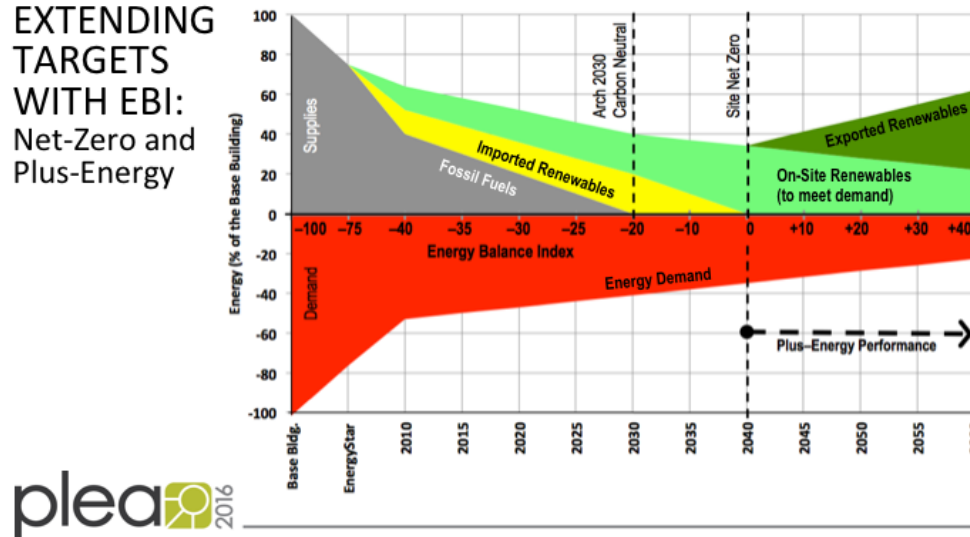
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- Here's what the short-cut path to Net-Zero in 2030 looks like:
- Off-site Imported Renewables have to go to 0.
 - In this graph, demand has to decrease to offset the supply loss.
 - That means *more* IDI, more *Intelligent Design Intensity*.
 - You could also increase On-Site Renewables, but for a long time, more efficient design is less expensive than a bigger PV system.

So what about beyond 2030?

EXTENDING
TARGETS
WITH EBI:
Net-Zero and
Plus-Energy

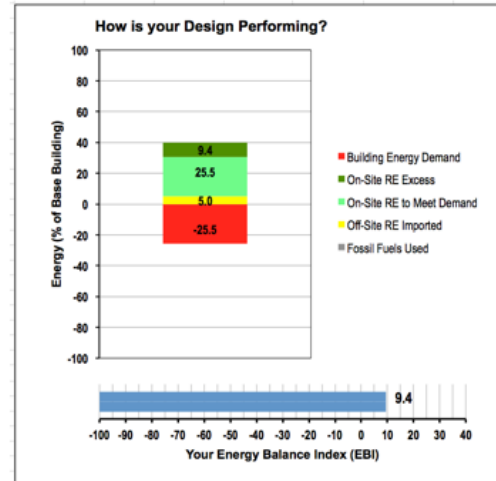


Here's our *complete proposed outlook* for extending the 2030 Targets.

- This idea keeps the Imported Renewables in place up to 2030 and then drops them out by 2040 to reach Net-Zero, where $EBI = 0$.
- Demand continues to fall through better design and engineering, requiring and due to more Intelligent Design and more Passive Design.
- Beyond 2040 we could have *Plus-Energy Targets* where EBI increases, by decreasing Demand and also increasing energy

production on-site.

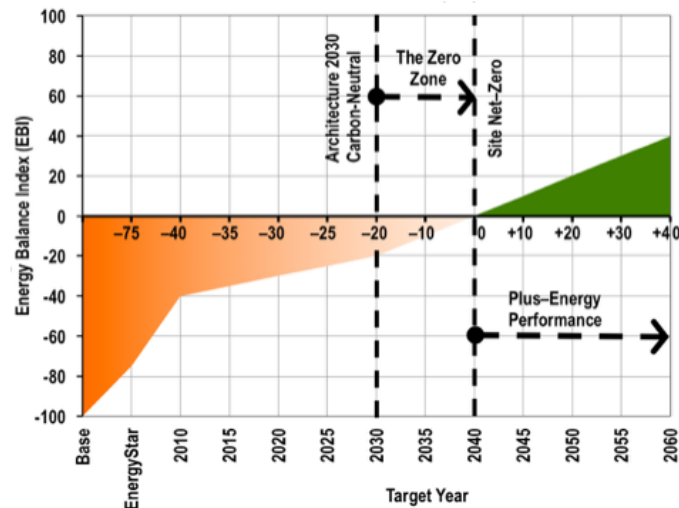
CALCULATING EBI with *SWL Tools*



We have tested the EBI with second-year architecture students. We use the *SWL Tools*, an Microsoft Excel workbook that accompanies *Sun, Wind & Light, 3rd edition*. This is one small graphic excerpt. So one can easily see the factors that produce the EBI and calculate it quickly.

You can download this from my faculty web page at the University of Tennessee for free.

ENERGY BALANCE INDEX TARGETS



Finally, here are the EBI Targets simplified by year. Not every building will get to Carbon-Neutral or Net-Zero or EBI +20, just like every car will not be a Prius or a Tesla Model 3. But it is important to have a measuring stick accurate enough and long enough, and including the important variables, to do the job. Something like EBI is needed to move cultures and building stocks in the right direction as fast as possible.



I hope that you have seen that the *Intelligent Design Intensity* of buildings is the most important driver on the road to Net Zero and that the *Energy Balance Index* will be helpful to you in “solving the climate crisis by design”—and, among other things, helping to save our furry friends from extinction.