ZEB’s: Lessons Learned & Next Steps

Getting To Zero Forum
October 10, 2019

Scott Shell, FAIA

Early EHDD Zero Energy Buildings

IDeAs Z² Office, 2006
Packard Foundation, 2010
Audubon Center, 2001
Exploratorium, 2011
Mark Day School
15,000 SF
ILFI NZE certification pending
EUI: 29, all electric
PV cost
$165,000
1.7% of construction cost
PPA is lower cost than Utility

Include PV in project!
Let your team do the work!
It's just part of MEP system
Lick Wilmerding High School
55,000 SF
ILFI NZE certification pending
EUI: 21, all electric
Replace Existing Gas Boilers with Heat Pumps

Plan future electrification & Campus PV location
Boulder Commons
100,000 SF mixed-use office
ILFI NZE certification pending
EUI: 24 kBTU, all electric
What does a Developer Want? What’s in it for them……?

• Lease Rates/Sales Price that create a return on invested capital (8-10%)

• Predictability with regard to operating costs and tenants

• Long-term operating costs lower than competitors

• Long-term Value (high occupancy, appreciation, etc.)
Creating a Market Rate Return on Solar

- Total Solar Cost including attachment $2.3M
- Market Rate for Energy (low end) $1.90/foot/year
  $190,000 per year before depreciation/credits
- 8.3% Cash on Cash Return before financing

Plug Load Budget – 7 kBtu/SF/YR

- Printer/copier energy save mode
- Laptops
- Energy star appliances
- 1 monitor/person
- Monitoring, continuous reporting
- Power strips w/ timer or occupancy sensors
- Monitor big loads independently
Nonprofit Insurance Alliance of California
26,500 SF
ILFI NZE certification pending
EUI: 27, all electric
Marin Country Day School
12,000 SF
ILFI NZE certification pending
EUI: 27, all electric

Passive House

1. Excellent insulation
2. Reduce thermal bridges
3. Air-tight Enclosure
4. High Performance windows
5. Heat Recovery Ventilation
Thermal Bridging

Air-sealing diagram

1. Seal all top, bottom, and side of all electrical, mechanical, and utility penetrations before drywall or wall coverings are installed.
2. Seal all top, bottom, and side of all electrical, mechanical, and utility penetrations before drywall or wall coverings are installed.
3. Use a non-sagging, non-flammable sealant that is suitable for the application.
4. Ensure that all penetrations are sealed before drywall or wall coverings are installed.
5. Use a non-sagging, non-flammable sealant that is suitable for the application.
6. Ensure that all penetrations are sealed before drywall or wall coverings are installed.
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8. Ensure that all penetrations are sealed before drywall or wall coverings are installed.
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10. Ensure that all penetrations are sealed before drywall or wall coverings are installed.
Energy Recovery Ventilator

- 65% reduction in heating load (ventilation)
- We can use smaller heat pumps
  - *Used on all my projects in past 3 years*
- 1-2 code cycles until they are mandatory

**Energy Recovery Ventilator**

**Standard & Bypass Economizer**

**SPECIFICATIONS**

| Ventilation Type: Static plate, heat and humidity transfer |
| Typical Airflow Range: 250-925 CFM |
| AHRI 1060 Certified Core: One L125-05 |
| Standard Features: Non-fused disconnect, 24VAC transformers/hospital package |
| Filters: Total qty. 2: MERV 9, 20” x 20” x 2” |
| Unit Dimensions & Weight: 54 3/4” L x 23 3/4” W x 35 3/4” H (264-275 lbs., varies by model) |
| Max. Shipping Dimensions & Weight (on pallet): 63” L x 30” W x 56” H (325 lbs.) |
| Accessories box shipped loose on top of unit. |
| Motor(s): Qty. 2, 0.75 HP ea., Direct drive blower/standard |

Download specification at: renewaire.com/specifications

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**Thin Triple Glazing**

**Lawrence Berkeley Labs Andersen Windows**

- **Drop-in** replacement
- High **performance**
- **Minimal** weight
- **Single** spacer
- Same **width** as double
- Low entry **cost**

Thick-glass triple IGU

NOT Zero Energy Buildings...
Is NZE getting us there fast enough?
Renewable & Clean Energy Standards

29 States + DC have a Renewable Portfolio Standard, 3 states have a Clean Energy Standard (8 states have renewable portfolio goals, 2 states have clean energy goals)

Ready for 100 Campaign
Cities Committed to 100% Clean Energy

1 in 4 people in America now live in a community committed to a transition to 100% clean, renewable energy.
204 companies have committed to 100% renewables

Utilities with Clean Energy Targets

<table>
<thead>
<tr>
<th>Utility Name</th>
<th>Goal Type</th>
<th>Target</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEP Ohio</td>
<td>Emission Reduction</td>
<td>2050</td>
<td>80% emissions reduction below 2000 levels by 2050 (2018)</td>
</tr>
<tr>
<td>AES Corporation</td>
<td>Carbon Reduction</td>
<td>2030</td>
<td>70% carbon reduction through 2030 (revised prior goal of 50% reduction from a 2016 baseline) (2019)</td>
</tr>
<tr>
<td>Alliant Energy</td>
<td>Emission Reduction/Renewable Energy</td>
<td>2050</td>
<td>40% below 2005 levels by 2030 and 80% of total emissions by 2050 (also eliminating all coal by 2050) - 30% renewable energy by 2024 (2017)</td>
</tr>
<tr>
<td>Ameren</td>
<td>Emission Reduction</td>
<td>2050</td>
<td>80% emissions reduction by 2050 compared to 2005 levels (2017)</td>
</tr>
<tr>
<td>APS</td>
<td>Carbon Reduction</td>
<td>2032</td>
<td>Reduce CO2 emissions rate to &lt;600lbs/MW/h by 2032 (48% reduction from 2005 levels) (2017)</td>
</tr>
<tr>
<td>Austin Energy</td>
<td>Renewable Energy/Zero Carbon/Emission Reduction</td>
<td>2027 2050</td>
<td>65% renewable energy by 2027, zero carbon energy target by 2050 (2018) Reduce carbon dioxide (CO2 power plant emissions) 20% below 2005 levels by 2020 (2018) Meet 55% of all energy needs through renewable resources by 2025, including 950 MW of solar power, 200 MW of which will be local solar (2018)</td>
</tr>
<tr>
<td>Avangrid</td>
<td>Carbon Reduction</td>
<td>2035</td>
<td>Carbon-neutral by 2035</td>
</tr>
<tr>
<td>Avista</td>
<td>Emission Reduction</td>
<td>2027 2045</td>
<td>100% carbon neutral by 2027 and carbon-free by 2045</td>
</tr>
</tbody>
</table>
### Green Power Partnership

<table>
<thead>
<tr>
<th>Partner Name</th>
<th>Annual Green Power Usage (kWh)</th>
<th>GP % of Total Electricity Use*</th>
<th>Green Power Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. University of California</td>
<td>273,347,223</td>
<td>95%</td>
<td>Various</td>
</tr>
<tr>
<td>2. University at Buffalo - the State University of New York</td>
<td>224,325,000</td>
<td>100%</td>
<td>Biomass, Solar</td>
</tr>
<tr>
<td>3. University of Pennsylvania</td>
<td>200,609,000</td>
<td>71%</td>
<td>Wind</td>
</tr>
<tr>
<td>4. Stanford University</td>
<td>159,626,907</td>
<td>57%</td>
<td>Solar</td>
</tr>
<tr>
<td>5. Georgetown University</td>
<td>159,499,000</td>
<td>133%</td>
<td>Wind</td>
</tr>
<tr>
<td>6. University of Tennessee, Knoxville</td>
<td>158,644,000</td>
<td>67%</td>
<td>Solar, Wind</td>
</tr>
<tr>
<td>7. University of Maryland</td>
<td>146,567,825</td>
<td>53%</td>
<td>Various</td>
</tr>
<tr>
<td>8. University of Oklahoma</td>
<td>135,602,000</td>
<td>70%</td>
<td>Wind</td>
</tr>
<tr>
<td>9. Carnegie Mellon University</td>
<td>132,398,967</td>
<td>100%</td>
<td>Solar, Wind</td>
</tr>
<tr>
<td>10. University of North Texas</td>
<td>107,250,000</td>
<td>100%</td>
<td>Solar, Wind</td>
</tr>
<tr>
<td>11. Arizona State University</td>
<td>105,600,000</td>
<td>80%</td>
<td>Solar, Wind</td>
</tr>
<tr>
<td>12. University of Missouri</td>
<td>104,601,209</td>
<td>42%</td>
<td>Biomass, Solar, Wind</td>
</tr>
<tr>
<td>13. Northwestern University</td>
<td>100,370,800</td>
<td>39%</td>
<td>Solar, Wind</td>
</tr>
<tr>
<td>14. Oklahoma State University</td>
<td>93,821,563</td>
<td>67%</td>
<td>Wind</td>
</tr>
<tr>
<td>15. Drake University</td>
<td>87,766,000</td>
<td>104%</td>
<td>Solar, Wind</td>
</tr>
<tr>
<td>16. The Ohio State University</td>
<td>85,965,075</td>
<td>14%</td>
<td>Wind</td>
</tr>
</tbody>
</table>

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### Carbon Intensity of US Electrical Generation

![Graph showing the carbon intensity of US electrical generation from 2005 to 2023.](http://dx.doi.org/10.1016/j.tej.2015.09.019)

Keith Dennis in The Electricity Journal [http://dx.doi.org/10.1016/j.tej.2015.09.019]
Building Electrification as Pathway to Zero Carbon

Annual Greenhouse Gas Emissions from Energy Use of Title 24 2019-Compliant Building

Gas-heated building

Electric-heated building

Yearly Per Home Emissions (MT CO2e)

Why All Electric?

Sonoma County, low rise residential. Courtesy Rachel Kuykendall, Sonoma Clean Power
California Universities Are Transitioning to All-Electric Buildings

The University of California system and Stanford University are making all-electric buildings the default in new construction.

“No new UC buildings or major renovations after June 2019, except in special circumstances, will use on-site fossil fuel combustion, such as natural gas, for space and water heating”

https://www.greentechmedia.com/articles/read/california-universities-are-transitioning-to-all-electric-buildings#gs.UUr5W_E
In the UK:

https://utilityweek.co.uk/gas-connections-new-homes-banned-2025/

https://www.ft.com/content/3f50601c-45a5-11e9-b168-96a37d002cd3

The Netherlands
Removing gas from 30,000-50,000 existing homes/year thru 2022
Then 200,000 homes/year
QUESTIONS?
scott.shell@ehdd.com

Induction: SMUD’s cooking now

Customer research
SMUD customer panel: How would you rate your impression of induction cooking before and after trying the induction cooktop?

Before
21%
| Negative | Positive |

After
91%
| Negative | Positive |

Benefits

Boils water 2X FASTER

🌟 TWICE AS EFFICIENT

🔥🔥 Low consistent heat

🔥 Easy to clean

❄️ No open flames

Keeps your home cooler

Fast temperature response

You're in control
Precise, digital controls take the guesswork out of cooking.

12 lbs. Water Temperature Response


2018 – 10 Top Rated Cooktops

<table>
<thead>
<tr>
<th>Score</th>
<th>Cooktop</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Induction - Samsung $2,000</td>
</tr>
<tr>
<td>2.</td>
<td>Induction – Dacor $3,100</td>
</tr>
<tr>
<td>3.</td>
<td>Induction – GE $1,800</td>
</tr>
<tr>
<td>4.</td>
<td>Induction – GE $1,440</td>
</tr>
<tr>
<td>5.</td>
<td>Induction – GE $2,600</td>
</tr>
<tr>
<td>6.</td>
<td>Induction – Kenmore $1,600</td>
</tr>
<tr>
<td>7.</td>
<td>Induction – Bosch $1,700</td>
</tr>
<tr>
<td>8.</td>
<td>Induction – Kenmore $1,200</td>
</tr>
<tr>
<td>9.</td>
<td>Induction – Frigidaire $700</td>
</tr>
<tr>
<td>10.</td>
<td>Induction – Frigidaire $820</td>
</tr>
</tbody>
</table>

... 94  top rated Electric cooktop $900
... 94  top rated Electric cooktop $1,400
... 89  top rated Gas cooktop $1,350