Market Feasibility of High Performance Small Office Buildings

11th Annual North American Passive House Conference

September 24, 2016
Scott Kelly  
AIA, LEED Fellow, CPHC  

Drew Lavine  
RA, LEED AP, CPHD  

Re:Vision Architecture  

Sustainable Energy Fund  
• Client  

In:Posse  
• Systems Engineering  
• Energy Modeling  

CVM  
• Cost Estimating
1. Introduction
2. Case Studies
3. Our NZE Study
   a. Baseline
   b. Net-Zero Ready
   c. Energy/Cost Analysis
4. Conclusion
Energy Generated ≥ Energy Used

Net-zero energy? I’ve got this!

Energy Generated?
On-site? Site/source?
Energy Used?
Predicted? Renewable?
One approach is to put PV wherever you can.
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One approach is to put PV wherever you can.
Definitions of NZEBs

“a classification system for NZEBs based on the renewable energy sources used by a building”

Because people cheat!

“Design to be NZE?”
Definitions of NZEBs

NZEB:A  Renewable Energy (RE) sources available within the building’s footprint

NZEB:B  NZEB:A + RE sources outside the footprint but within the building site

NZEB:C  NZEB:A + NZEB:B + off-site RE sources used on-site

NZEB:D  NZEB:A + NZEB:B + NZEB:C  + purchased off-site RE
LA JOLLA COMMONS, LPL FINANCIAL BUILDING
San Diego, California

"The Largest Net-Zero Building in the US"
-April, 2014

"[Bloom Box] fuel cells convert methane into electricity in a non-combustion process. Sufficient methane for the system will be acquired from carbon-neutral sources such as landfills and wastewater plants and placed into the natural gas pipeline system."
There is a better way.
Camden Friends Social Hall: Camden, DE 2006
LEED Platinum

- After first year of operation, the building was producing 150% of the energy it consumed. (verified by NESEA and NREL)

12kW PV array
Generated: 17,994 kWh
Used: 11,691 kWh
Back to Grid: 6,303 kWh
Net Zero Energy Success Stories
NREL RESEARCH SUPPORT FACILITY
Golden, Colorado
RNL Design with Stantec
Haselden Construction

222,000 ft²
35 kBtu/ft²/yr
$57.4m
$260/ft²
2011 NZE
BULLIT CENTER
Seattle, Washington
Miller Hull Partnership

50,000 ft²
16 kBtu/ft²/yr
$18.5m
$370/ft²
2015
NZE
A typical building of this size has an Energy Use Intensity of 72 kBtu/ft²/year. A PV array with an area of 63,348 ft² is required to meet its energy needs.

$6 M

PV OFFSET - AVERAGE SEATTLE OFFICE

© 2014 International Living Future Institute
A building of this size meeting Seattle energy code has an **Energy Use Intensity** of 51 kBtu/ft²/year.

A PV array with an area of **44,752 ft²** is required to meet its energy needs.

**PV OFFSET - NEW SEATTLE OFFICE**

**BUILT TO CODE**

© 2014 International Living Future Institute
A LEED Platinum certified building of this size has an **Energy Use Intensity of 32 kBtu/ft²/year**.

A PV array with an area of **28,599 ft²** is required to meet its energy needs.

**PV OFFSET – NEW SEATTLE OFFICE**

**LEED PLATINUM, ALL ENERGY POINTS**
The proposed building, meeting the Living Building Challenge has an **Energy Use Intensity of 16 kBTU/ft²/year**. A PV array with an area of **14,303 ft²** is required to meet its energy needs.

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**PV OFFSET – BULLITT CENTER AS BUILT FOR NET ZERO ENERGY**

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But what about small office buildings?

Nearly 1/3 of all US office space is in buildings less than 25,000 ft\(^2\).
This study focuses on a specific kind of small office building – multi-tenant with owner occupancy – and the market feasibility of achieving NZE within this typology.
So, what are the barriers?

• Wildly variant load profiles by use and location
• Client, Design and Construction sophistication
• Higher envelope to volume ratio than larger buildings
  • Economics of scale
To isolate variables and provide a true apples-to-apples comparison, a “baseline” and “NZE Ready” version of the same office building program were studied.
Baseline Definition

15,000 ft², owner occupied, multi-tenant office building in the Lehigh Valley
Baseline Definition

15,000 ft², owner occupied, multi-tenant office building in the Lehigh Valley
Single story, “sliced loaf of bread”

As much glass as possible

Granular mechanical systems

Rentable area = useable area

Individual suite entrances

Individual suite kitchens and bathrooms
baseline design

15,000 ft², owner occupied, multi-tenant office building in the Lehigh Valley

1. Flexible Plan
2. Maximum Glazing
3. Granular Mechanical Systems
4. Rentable = Useable
5. Individual Entrances
6. Individual Bathrooms & Kitchens
1. Flexible Plan
2. Maximum Glazing
3. Granular Mechanical Systems
4. Rentable = Useable
5. Individual Entrances
6. Individual Bathrooms & Kitchens

Constant volume packaged rooftop air-to-air heat pumps:
- For each 3,000 sf tenant (2) 4-ton units for south and core zones, (1) 3 ton unit for north zone
- 55 tons total
BUILDING ENVELOPE
Code compliant and nothing more

Walls: Brick veneer w/ 1½” continuous exterior XPS R-7.5, metal studs w/ R-13 fiberglass batt insulation*

Kawneer thermally broken storefront with 1” Low-E insulated glass

R-38 fiberglass attic insulation*
$3,273,900
$218.26/ft²

47.2 - 52 kBtu/ft²/yr*

*will vary with tenant density

Net-Zero Energy

Baseline design
15,000 ft², owner occupied, multi-tenant office building in the Lehigh Valley
net-zero ready design
15,000 ft
2 owner occupied, multi-tenant office building in the Lehigh Valley

1. Flexible Plan
2. Optimized Glazing
3. Granular Mechanical Systems
4. Rentable = Useable
5. Individual Entrances
6. Individual Bathrooms & Kitchens
1. Flexible Plan
2. Maximum Glazing
3. **Granular Mechanical Systems**
4. Rentable = Useable
5. Individual Entrances
6. Individual Bathrooms & Kitchens

**VRF (Variable Refrigerant Flow) with Heat Recovery:**
- Twinned 10+8 ton units located on grade
- Individual tenant ERV’s
Walls: 3” Metal SIPs (polyurethane) R-24

Underslab: 2” XPS insul (R-10) 6’ from perimeter

Roofs: 8¼” Wood SIPs (EPS) R-29

Windows: fiberglass frames w/triple pane glass ~R-5

BUILDING ENVELOPE
Good, Better and Best?
SPACE CONDITIONING
VRF (Variable Refrigerant Flow) with Heat Recovery

Natural ventilation!
DAYLIGHTING + VENTILATION

Energy reduction and improved workspace

Natural ventilation!

1.36 EUI savings (6%!) *
Continuous insulation
Thermal bridge free
Extremely airtight construction
Use High-performance windows and doors
Balanced heat and moisture recovery ventilation
Utilized and manage solar energy in appropriate seasons
| Baseline | Optimized | ECM #1 | ECM #2 | ECM #3 | ECM #4 | ECM #5 | ECM #6 | ECM #7 | ECM #8 | ECM #9 Proposed Geometry, Extreme Plug Load Run "Less Good" Walls - SIP R-15 | ECM #10 | ECM #11 | ECM #12 |
|----------|-----------|--------|--------|--------|--------|--------|--------|--------|--------|"Proposed Geometry, HVAC ONLY" Interior Loads ONLY LPD @ 0.45|        |        |
| Energy Consumption (kWh) | 233,327 | 103,081 | 99,028 | 98,204 | 235,885 | 230,846 | 226,602 | 221,838 | 159,039 | 224,962 | 208,428 | 104,792 | 200,542 | 184,272 |
| Cost | $22,679 | $10,019 | $9,626 | $9,545 | $22,928 | $22,438 | $22,026 | $21,563 | $15,459 | $21,866 | $20,259 | $10,186 | $19,493 | $17,911 |
| EUI | 51.0 | 22.4 | 21.5 | 21.3 | 51.6 | 50.5 | 49.5 | 48.5 | 34.5 | 49.2 | 45.6 | 22.8 | 43.8 | 40.3 |

**Enduses**

- **Lights**: 49,346, 18,799, 18,911, 18,911, 49,346, 49,346, 49,346, 49,346, 18,799, 22,206, 22,206
- **Task Lights**: 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
- **Misc Equip**: 60,324, 48,145
- **Space Heating**: 14,727, 9,012, 4,743, 3,981, 18,108, 16,461, 12,418, 10,643, 15,950, 19,608, 21,956, 10,408, 22,963, 25,521
- **Space Cooling**: 23,887, 10,459, 11,153, 11,234, 20,923, 19,974, 22,634, 21,738, 13,714, 19,877, 18,314, 10,345, 17,659, 16,134
- **Heat Reject**: 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
- **Pumps & Aux**: 2,301, 0, 0, 0, 2,169, 2,252, 2,399, 2,475, 0, 2,118, 2,035, 0, 2,002, 1,916
- **Refrig Display**: 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
- **HT Pump Supplenment**: 6,309, 637, 355, 296, 6,321, 5,672, 4,561, 3,793, 1,121, 6,727, 7,336, 779, 7,554, 8,109
- **DHW**: 5,175, 5,176, 5,173, 5,173, 5,178, 5,178, 5,175, 5,175, 5,178, 5,179, 5,180, 5,178, 5,180, 5,181
- **Ext Usage**: 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

**Total** | 233,327 | 103,081 | 99,028 | 98,204 | 235,885 | 230,846 | 226,602 | 221,838 | 159,039 | 224,962 | 208,428 | 104,792 | 200,542 | 184,272

- % savings over Optimized: 3.9% 4.7%
- % Savings over Baseline: 55.8% 57.6% 57.9% -1.1% 1.1% 2.9% 4.9% 31.8% 3.6% 10.7% 55.1% 14.1% 21.0%
$3,322,800
$221.52/ft²
+1.5%

17.6 – 21.2 kBtu/ft²/yr *
-61%

Net-Zero Energy Ready!

*will vary with tenant density

net-zero ready design
15,000 ft², owner occupied, multi-tenant office building in the Lehigh Valley
Space condition 51% 118,997 kwh!!

End-use Comparison

233,327 kWh

75% reduction!

20% reduction!

97,444 kWh
<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>$551,000</td>
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<tr>
<td>Structure</td>
<td>$468,000</td>
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<tr>
<td>Roof</td>
<td>$193,000</td>
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<tr>
<td>Walls + Windows</td>
<td>$357,000</td>
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<tr>
<td>Interior</td>
<td>$387,000</td>
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<tr>
<td>HVAC</td>
<td>$190,000</td>
</tr>
<tr>
<td>Electric</td>
<td>$290,000</td>
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<tr>
<td>Plumbing</td>
<td>$113,000</td>
</tr>
<tr>
<td>Fire Protect.</td>
<td>$70,000</td>
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<tr>
<td>Const Fees*</td>
<td>$655,800</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$3,273,900</strong></td>
</tr>
</tbody>
</table>

- $218.26/sf

$553,000  
$470,000  
$245,000  
$270,000  
$316,000  
$293,000  
$320,000  
$113,000  
$78,000  
$664,800  
**$3,322,800**  
+$48,900

- $221.52/sf
<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>$3,273,900</td>
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<tr>
<td>Scope Conting.</td>
<td>$130,950</td>
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<tr>
<td>Design</td>
<td>$240,960</td>
</tr>
<tr>
<td>Commissioning</td>
<td>$0</td>
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<tr>
<td>Precon Svcs</td>
<td>$0</td>
</tr>
<tr>
<td>Owner Soft $</td>
<td>$50,000</td>
</tr>
<tr>
<td><strong>Project Total</strong></td>
<td><strong>$3,695,810</strong></td>
</tr>
<tr>
<td><strong>Delta</strong></td>
<td><strong>$293,440</strong></td>
</tr>
</tbody>
</table>
Energy cost escalation over time is a complex equation which values the generation of energy and its transmission differently. Currently, generation is the majority of overall energy cost; however, within the project time horizon, transmission is expected to become the larger cost factor as our energy infrastructure degrades.

What is most illuminating about the energy cost analysis is that while costs rise exponentially for both the baseline and NZE-ready designs, the baseline escalates more significantly. This is due to the anticipated transmission charges on an increased load size.

**Note:**
Energy costs were calculated using the following criteria:
- PPL G3-3 service
- Fixed monthly fee of $40
- Distribution charge: $4.192 per kW, 0.6% annual escalation
- Generation & Transmission: $0.09148 per kWh, 7.6% annual escalation

**BASELINE 30 YEAR ENERGY COST**
$1,333,870

**NZE READY 30 YEAR ENERGY COST**
$500,827
As annual energy use is compounded upon the initial project cost, the overall building expense for the baseline and optimized designs equals out around 15 years. This is the simple payback period.

For simplicity and isolation of variables, the NZE payback period focuses only on project first costs and 30 year energy use. There are, however, many other costs which factor into the overall life-cycle cost analysis including but not limited to operations and maintenance fees, system and/or equipment replacement, tenant renovations, tenant vacancies, rental value increases, property taxes, insurance premiums, etc. If these are factored in to the overall financial equation, it is anticipated that the net effect will be of further benefit to the NZE Ready building.
PV Analysis for Net-Zero Energy

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>ARRAY SIZE</td>
<td>105 kW</td>
</tr>
<tr>
<td>PANEL SIZE</td>
<td>0.31 kW</td>
</tr>
<tr>
<td>TOTAL PANELS</td>
<td>339</td>
</tr>
<tr>
<td>INSTALLED COST/W</td>
<td>$ 2.50</td>
</tr>
<tr>
<td>TOTAL INSTALLED COST</td>
<td>$ 262,725</td>
</tr>
<tr>
<td>ANNUAL GENERATION</td>
<td>120,768 kW</td>
</tr>
<tr>
<td>FEDERAL CORPORATE TAX CREDIT</td>
<td>$ 78,817.50</td>
</tr>
<tr>
<td>DEGRADATION RATE</td>
<td>0.50%</td>
</tr>
<tr>
<td>ANNUAL MAINTENANCE COST</td>
<td>$300</td>
</tr>
</tbody>
</table>
net-zero design

15,000 ft², owner occupied, multi-tenant office building in the Lehigh Valley

105 kW PV array
60% of south facing roof!
In order to get to NZE a building needs to offset its energy demand with renewable energy generation. The NZE Ready design, through energy demand reduction, is able to comfortably fit the required PV array within it’s building footprint.

0.31 kW/panel
37.8' x 77.5'
$2.50/watt installed before standard tax credits
(based on pricing at the time of the study)

Average Existing Comp
75 kBu/ft²/yr
350,000 kWh/yr
377 kW array for NZE
24,025 sf
$943,175*

NZE Ready Building
21 kBu/ft²/yr
97,444 kWh/yr
105 kW array for NZE
$262,726

Baseline
52 kBu/ft²/yr
238,287 kWh/yr
251 kW array
16,487 sf
$527,750*

* - The most cost effective way to install a PV array is on a building. Site mounted arrays cost more due to required structural mounting systems, earthwork, connection distance and access to electrical service and stormwater management. These costs would be incurred on the baseline and existing comp but are not accounted for in these estimated PV array costs.
As annual energy use is compounded upon the initial project cost, the overall building expense for the baseline and optimized designs equals out around 15 years. This is the simple payback period.

For simplicity and isolation of variables, the NZE payback period focuses only on project first costs and 30 year energy use. There are, however, many other costs which factor in to the overall life-cycle cost analysis including but not limited to operations and maintenance fees, system and/or equipment replacement, tenant renovations, tenant vacancies, rental value increases, property taxes, insurance premiums, etc. If these are factored in to the overall financial equation, it is anticipated that the net effect will be of further benefit to the NZE Ready building.
In order to comfortably “guarantee” NZE, the renewable energy system was designed with a healthy contingency of 20%. This means that assuming typical conditions from Day One, the total project cost starts to decrease as excess energy is produced and sold back to the grid.

Although the initial project cost is higher when PV is factored in, the decrease over time actually slides the payback point of the NZE design versus the baseline back even further. The cost and energy modeling performed suggest that this payback period is occurring in the 10th year of operation.

For the PV system cost analysis, federal and state incentives were not included. Incentives such as grants or tax credits will reduce the NZE design first cost further pushing the simple payback point back further.
And now, the autopsy
nothing like second guessing your own work…
1 | ENERGY MODELLING
ENERGY MODELLING
a crowded and complicated industry
1 | ENERGY MODELLING

a crowded and complicated industry
1 | ENERGY MODELLING
a crowded and complicated industry
1 | ENERGY MODELLING
a crowded and complicated industry

WUFI
PASSIVE

REVIT CONCEPTUAL ANALYSIS

PHPP

REVIT/GREEN BUILDING STUDIO
BUILDING ENVELOPE: Better

Wall: R-40 (R-28)
SHGC: 0.27 (Unchanged)
0.05 cfm/ft² (0.15 ACH nat)

Roof: R-29 (R-29)
SHGC: 0.5 (0.27)

23% (25%) Window – Wall Ratio
R-30 Continuous (R-10 @ 6' Perimeter)

50% (40%) Window – Wall Ratio
BUILDING ENVELOPE: Better

Data state/results: Now warning

- Heating demand: 1.35 kBtu/ft²yr
- Cooling demand: 2.99 kBtu/ft²yr
- Heating load: 4.36 Btu/ft²h
- Cooling load: 4.26 Btu/ft²h
- Primary energy: 36.87 kBtu/ft²yr
- Site energy: 11.67 kBtu/ft²yr

All energy values are within acceptable limits.
1 | ENERGY MODELLING
a crowded and complicated industry
a crowded and complicated industry
MARKET FEASIBILITY
## 1 | MARKET FEASIBILITY

### the cost of reducing EUI

<table>
<thead>
<tr>
<th>Energy Consumption (kWh)</th>
<th>Baseline</th>
<th>Optimized</th>
<th>ECM #1</th>
<th>ECM #2</th>
<th>ECM #3</th>
<th>ECM #4</th>
<th>ECM #5</th>
<th>ECM #6</th>
<th>ECM #7</th>
<th>ECM #8</th>
<th>ECM #9</th>
<th>ECM #10</th>
<th>ECM #11</th>
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<tbody>
<tr>
<td></td>
<td>233,327</td>
<td>103,818</td>
<td>99,028</td>
<td>98,204</td>
<td>235,885</td>
<td>230,846</td>
<td>226,602</td>
<td>221,838</td>
<td>159,039</td>
<td>224,962</td>
<td>208,428</td>
<td>104,792</td>
<td>200,542</td>
</tr>
<tr>
<td>Cost</td>
<td>$22,679</td>
<td>$10,019</td>
<td>$9,626</td>
<td>$9,545</td>
<td>$22,928</td>
<td>$22,438</td>
<td>$22,026</td>
<td>$21,563</td>
<td>$15,459</td>
<td>$21,866</td>
<td>$20,259</td>
<td>$10,186</td>
<td>$19,493</td>
</tr>
<tr>
<td>EUI</td>
<td>51.0</td>
<td>22.4</td>
<td>21.5</td>
<td>21.3</td>
<td>51.6</td>
<td>50.5</td>
<td>49.5</td>
<td>48.5</td>
<td>34.5</td>
<td>49.2</td>
<td>45.6</td>
<td>22.8</td>
<td>43.8</td>
</tr>
</tbody>
</table>

### Enduses

| Task Lights              | 0        | 0         | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Misc Equip               | 60,324   | 48,145    | 48,145 | 48,145 | 60,324 | 60,324 | 60,324 | 60,324 | 60,324 | 60,324 | 48,145 | 29,582  | 48,145  | 48,145  |
| Space Heating            | 14,727   | 9,012     | 4,743  | 3,981  | 18,108 | 16,461 | 12,418 | 10,643 | 15,950 | 19,608 | 21,956 | 10,408  | 22,963  | 25,521  |
| Space Cooling            | 23,887   | 10,459    | 11,153 | 11,234 | 20,923 | 19,974 | 22,634 | 21,738 | 13,714 | 19,877 | 18,314 | 10,345  | 17,659  | 16,134  |
| Heat Reject              | 0        | 0         | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| Pumps & Aux              | 2,301    | 0         | 0       | 0       | 2,169  | 2,252  | 2,399  | 2,475  | 0       | 2,118  | 2,035  | 0       | 2,002   | 1,916   |
| Vent Fans                | 71,258   | 10,853    | 10,548 | 10,464 | 73,516 | 71,639 | 69,745 | 68,344 | 13,406 | 73,962 | 74,679 | 11,138  | 74,833  | 75,623  |
| HT Pump Supplem          | 6,309    | 637       | 355    | 296    | 6,321  | 5,672  | 4,561  | 3,793  | 1,121  | 6,727  | 7,336  | 779     | 7,554   | 8,109   |
| DHW                      | 5,175    | 5,176     | 5,173  | 5,173  | 5,178  | 5,178  | 5,178  | 5,178  | 5,178  | 5,178  | 5,178  | 5,178   | 5,180   | 5,181   |
| Ext Usage                | 0        | 0         | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       | 0       |
| **Total**                | 233,327  | 103,818   | 99,028 | 98,204 | 235,885| 230,846| 226,602| 221,838| 159,039| 224,962| 208,428| 104,792 | 200,542 | 184,272 |

% savings over Optimized | 3.9%     | 4.7%      | 4.7%   | 4.7%   | 4.7%   | 4.7%   | 4.7%   | 4.7%   | 4.7%   | 4.7%   | 4.7%   | 4.7%    | 4.7%    | 4.7%    |

% Savings over Baseline   | 55.8%    | 57.6%     | 57.9%  | -1.1%  | 1.1%   | 2.9%   | 4.9%   | 31.8%  | 3.6%   | 10.7%  | 55.1%  | 14.1%   | 21.0%   |
## MARKET FEASIBILITY
the cost of reducing EUI

<table>
<thead>
<tr>
<th>ECM</th>
<th>EUI REDUCTION</th>
<th>2016</th>
<th>1ST COST ADD</th>
<th>$/EUI</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Good” Envelope Package</td>
<td>1.5</td>
<td>$37,500</td>
<td>$25,000</td>
<td></td>
</tr>
<tr>
<td>“Better” Envelope Package</td>
<td>2.2</td>
<td>$105,000</td>
<td>$47,727</td>
<td></td>
</tr>
<tr>
<td>Improved Glazing</td>
<td>1.1</td>
<td>$71,000</td>
<td>$64,545</td>
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<tr>
<td>HVAC System</td>
<td>16.5</td>
<td>$103,000</td>
<td>$6,242</td>
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<tr>
<td>LED Lighting Package</td>
<td>5.4</td>
<td>$30,000</td>
<td>$5,555</td>
<td></td>
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<tr>
<td>PV Array</td>
<td>25.4</td>
<td>$262,725</td>
<td>$10,343</td>
<td></td>
</tr>
</tbody>
</table>

- **1st** cost add for HVAC system: $103,000, $6,242 if necessary
- **2nd** cost add for LED Lighting Package: $30,000, unlikely
- **3rd** cost add for PV Array: $262,725, thermal comfort
3 | PV FORECAST
PV FORECAST
how will the cost equation change?

Swanson's Law

Module Cost / Watt


Cumulative Module Shipments (MWp)
the price of solar photovoltaic modules tends to drop 20% for every doubling of cumulative shipped volume.

At present rates, costs halve about every 10 years.
2 | PV FORECAST
how will the cost equation change?
“The behavior from here seems clear: the solar industry will expand. Retaliatory steps from distribution utilities will increase the market for cost-effective battery storage. This becomes – initially – a secondary market for battery technologies being developed”

-AllianceBernstein's Michael Parker and Flora Chang
## 2 | PV FORECAST

How will the cost equation change?

<table>
<thead>
<tr>
<th>ECM</th>
<th>EUI REDUCTION</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1&lt;sup&gt;ST&lt;/sup&gt; COST ADD</td>
</tr>
<tr>
<td>“Good” Envelope Package</td>
<td>1.5</td>
<td>$37,500</td>
</tr>
<tr>
<td>“Better” Envelope Package</td>
<td>2.2</td>
<td>$105,000</td>
</tr>
<tr>
<td>Improved Glazing</td>
<td>1.1</td>
<td>$71,000</td>
</tr>
<tr>
<td>HVAC System</td>
<td>16.5</td>
<td>$103,000</td>
</tr>
<tr>
<td>LED Lighting Package</td>
<td>5.4</td>
<td>$30,000</td>
</tr>
<tr>
<td>PV Array</td>
<td>25.4</td>
<td>$262,725</td>
</tr>
</tbody>
</table>
## PV Forecast

**How will the cost equation change?**

<table>
<thead>
<tr>
<th>ECM</th>
<th>EUI Reduction</th>
<th>2016</th>
<th>2026</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Cost Add</td>
<td>$/EUI</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Cost* Add</td>
</tr>
<tr>
<td><strong>&quot;Good&quot; Envelope Package</strong></td>
<td>1.5</td>
<td>$37,500</td>
<td>$25,000</td>
</tr>
<tr>
<td><strong>&quot;Better&quot; Envelope Package</strong></td>
<td>2.2</td>
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<tr>
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<td>$64,545</td>
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<tr>
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<tr>
<td><strong>LED Lighting Package</strong></td>
<td>5.4</td>
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<td>$5,555</td>
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<tr>
<td><strong>PV Array</strong></td>
<td>25.4</td>
<td>$262,725</td>
<td>$10,343</td>
</tr>
</tbody>
</table>
“a building that integrates and optimizes all major high-performance building attributes, including energy efficiency, durability, life-cycle performance, and occupant productivity.”

-Energy Policy Act of 2005
ECONOMY
What the real estate industry is saying:

• **Reduced operating costs**
• **$3.60/sf higher rental rates***
• **3.7% Reduced Vacancy** *
• **Fewer renovations** for tenant turnover
• **Increased asset value** against market comps

* - research from Jones Lang LaSalle's Philadelphia Green Gauge report

48% of corporate real estate executives would pay up to a 10% premium for sustainable spaces*
A history of the energy code
Think about your real estate value…

- green benchmarking
- energy reporting
- huge code changes
THE TENANT VALUE EQUATION
Let’s not forget who ultimately drives the financial success of a multi-tenant office building…

Base Building Energy $/sf + Tenant Space Lease $/sf + Employee Value $/sf = Investment
Re:Vision Office
Philadelphia, PA

EUI = 22!

$0.50

$20

$500
EQUITY
Health, Happiness, Equity, and Beauty

The problem:
- We spend up to 90% of our workday inside
- Office building related illnesses account for $60 billion of annual productivity losses nationwide
- Air quality inside our office buildings is 2-5 times worse than outside air
- Rise in “presenteeism” – which is quickly being understood to be worse than absenteeism
EQUITY
Health, Happiness, Equity, and Beauty

The solution:
• Daylight & Views
• Occupant Comfort
• Ventilation
• Temperature control
• Reduced toxicity
• Biophilia
• Beauty and quality of space!
SMALL OFFICE BUILDINGS MATTER
The Trim-Tab effect

KNOW YOUR LOAD PROFILE
Understand your energy use before digging in to an iterative and data-driven design process

FOCUS ON THE 300
Energy is only one piece of a holistic sustainability equation
1. What is NZE?

2. Case Studies

3. Our Study
   a. Baseline
   b. Optimized
   c. Energy/Cost Analysis

4. Lessons Learned

www.ReVisionArch.com
Thank you!

Scott Kelly
AIA, LEED Fellow, CPHC
Kelly@ReVisionArch.com
215.482.1133

Drew Lavine
RA, LEED AP, CPHD
lavine@revisionarch.com
215.482.1133

www.revisionarch.com