12 Practices for Achieving Net Zero
12 Practices in Building Design

1. Build and Empower Your Team
2. Engage with a Collaborative Process
3. Embrace a Bold Vision
4. Commit to Metrics
5. Design Living Places
6. Minimize Energy Loads
7. Optimize Systems for Comfort and Efficiency
8. Power with Renewables
9. Detail and Build
10. Learn and Operate
11. Celebrate
12. Realize

ENHANCE (GROW)

ENVISION (NUTURE)

FLOWER (SEED)

ORIENT
• Step 1-Build and Empower Your Team
  1. Creating the Right Team
  2. Challenge and Align your Team
  3. Dialogue for Success
Joint Venture Net Zero Design Team
Design Team With Net Zero Architect Consultant
Step 1 - Build and Empower Your Team

Assemble the Right Client Team

- Director of Development
- Assistant Head of School / CFO
- Plant Manager
- Head of School
- Director of Development
- Board of Directors
- Staff
- Students
Step 1-Build and Empower Your Team

Creating the Right Design Team
• Experience
• Core Mission
• Market Segment

Bill Maclay
Founding Principal

Eileen Hee
Studio Director

Bill Gallup
Senior Associate

Megan Nedzinski
Sr. Project Manager

Tom Bodell
Technical Director

Laura Bailey
Research Director

Kevin Dennis
Designer

Marc Young
Designer, Project Manager

Chris Cook
Designer, Project Manager

Patricia Lorraine
Office Manager
Step 1—Build and Empower Your Team

Selecting the Right Consultant Team
• New vs. Repeat Team
• Team Experience
Step 1-Build and Empower Your Team

Selecting the Right Construction Team
• CM vs. Bid Process
• New vs. Repeat Team
Step 1 - Build and Empower Your Team

Challenge & Align your Team
Dialogue for Success

- Poor Alignment

- Good Alignment
• Step 2 – Engage with a Collaborative Process
  1. Engage all stakeholders
  2. Connect with purpose, cares, and concerns
  3. Collaboration, integration and teamwork
Step 2 – Engage with a Collaborative Process

Engage all stakeholders
Step 2 – Engage with a Collaborative Process

Connect with purpose, cares, and concerns
Step 2 – Engage with a Collaborative Process

Collaboration, Flow & Teamwork
• Step 3- Explore, Understand, and Discover
  1. Living in Worlds / World Views
  2. The Emergence and Evolution of World and Project
Step 3- Explore, Understand, and Discover

Living in Worlds / World Views
Step 3- Explore, Understand, and Discover

The Emergence and Evolution of World and Project
ENVISION

- Step 4 - Embrace a Bold Vision
  1. Opening the Quest with Wonder
  2. Imagine Scenarios
  3. Creating a Vision that Lasts
ENVISION

• Step 5 – Commit to Metrics
  • Purpose/Organizational Mission
  • Environmental Goals
    – Objectives / Metrics
• Space Programming

Documented in Owner’s Project Requirements (OPR)
Define the environmental “goals” for the building

- **Who**: Green Champion, architect, consultants with Owner(s)
- **When**: Pre-Schematic
Define the environmental “goals” for the building

- Organization’s Mission
- Overall Environmental Goals for Project
- Specific Environmental Goals

- Examples, See handouts
  - Shelburne Farms Goals
  - HMC Building Environmental Goals
  - Shelburne Farms Ecogoals#4
Step 5 – Commit to Metrics
Purpose, Goals, Objectives / Metrics

Translate goals into “objectives” or “metrics”
– When you walk into the building, how do you know if you met a goal?
– Who: Green Champion on design team, architect, others on design team with Owner
– When: pre-Schematic
Step 5 – Commit to Metrics
Purpose, Goals, Objectives / Metrics

Clear metrics: Why Bother?

Guidance for design team during
• Visioning
• Designing
• Value engineering
Step 5 – Commit to Metrics
Purpose, Goals, Objectives / Metrics

Translate goals into “objectives” or “metrics”

- How do you know you met a goal when you walk into the building?

• Goal: Daylight all regularly occupied spaces
  - Metric: Daylight sufficient and comfortable in all workspaces without electric light on a clear day
  - minimum 30 fc on work surfaces; max 120 fc
Translate goals into “objectives” or “metrics”

- How do you know you met a goal when you walk into the building?
  - Moving into geek world!
- Net Zero goal is a numerical goal – This is a numbers game!
- ACTIVATE YOUR INNER GEEK! Or go find one!
- Or train one!
Step 5 – Commit to Metrics

Purpose, Goals, Objectives / Metrics

Low “Energy Usage Index”
or
EUI
What’s an EUI??

• Energy Use per Unit Area per year
  – kBtu/sq.ft.-yr
  – kWh/sq.m.-yr

• From all energy sources for the building
Step 5 – Commit to Metrics
Purpose, Goals, Objectives / Metrics

What’s an EUI??

100,000,000 Btu/year
----------------------------------
3,000 sq.ft.

= ~33,333 Btu/sq.ft. - yr
= 33 kBtu/sq.ft. -yr

= ~100 kWh/sq.m-yr

SPECIFY IF THIS IS “SITE” OR “SOURCE” ENERGY
EUI Metrics Calculators

- For **monthly** all electric home
  - *Electric heat normalization worksheet 170302.xlsx*

- For **monthly** data – all fuels
  - *Energy Statistics and EUI for Buildings for monthly data 170302.xlsx*

- For **annual** data – all fuels
  - *EUI calculator with annual data 170302.xlsx*
Delia's House

Electric Use total*

<table>
<thead>
<tr>
<th>Month</th>
<th>kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb 2014</td>
<td>1,420</td>
</tr>
<tr>
<td>Mar</td>
<td>1,790</td>
</tr>
<tr>
<td>Apr</td>
<td>500</td>
</tr>
<tr>
<td>May</td>
<td>300</td>
</tr>
<tr>
<td>Jun</td>
<td>300</td>
</tr>
<tr>
<td>Jul</td>
<td>375</td>
</tr>
<tr>
<td>Aug</td>
<td>375</td>
</tr>
<tr>
<td>Sep</td>
<td>350</td>
</tr>
<tr>
<td>Oct</td>
<td>430</td>
</tr>
<tr>
<td>Nov</td>
<td>1,200</td>
</tr>
<tr>
<td>Dec</td>
<td>1,480</td>
</tr>
<tr>
<td>Jan 2015**</td>
<td>1,700</td>
</tr>
<tr>
<td>Total</td>
<td>10,220</td>
</tr>
</tbody>
</table>

**est. from part month

Annual heat only use

- 6,103 kWh for heating (Annual total - 13* summer baseline)
- 7,700 Normal degree days (65 base)
- 2.4 Btu/sq.ft-dday -- NOT NORMALIZED

Seasonal heating usage

- 8,651 Degree days from period of usage

From wunderground.com

- 2.1 Btu/sq.ft-dday -- NORMALIZED
- 5,432 Normalized heating usage, kWh/yr

For average weather data

Go to http://www.nrcc.cornell.edu/ccd/nrmhdd.html and find the closes weather station.

For weather data for period you have data for

Got to wunderground.com. Use same weather station as you used for normal degree days. Click "more" on black bar, then "history". Enter the first day of your data period in the date and click "submit".

Cost of electricity $0.15 per kWh

EUI - normalized

<table>
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<tr>
<th>EUI - normalized</th>
<th>2014/15</th>
<th>normalized</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 kWh/sq.m-yr</td>
<td>$916</td>
<td>$810</td>
</tr>
<tr>
<td>28 kBTU/sq.ft-yr</td>
<td>$1,533</td>
<td>$1,400</td>
</tr>
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Total Electricity, kWh

- May, June and Sep baseline -- no air conditioning
- Select which baseline months to average

Delia's House

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<td>$1,400</td>
</tr>
</tbody>
</table>
Now open this one

- **EUI calculator with annual data150821.xls**

### Energy Usage Index -- EUI -- Calculator

<table>
<thead>
<tr>
<th>Project name</th>
<th>Building conditioned sq.ft.</th>
<th>Total units/year</th>
<th>MMBtu/unit</th>
<th>MMBtu/yr</th>
<th>Electricity</th>
<th>Natural Gas</th>
<th>Propane</th>
<th>Oil</th>
<th>Other Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3,875</td>
<td>0.003413</td>
<td>0.138</td>
<td>-</td>
<td>0.100</td>
<td>24</td>
<td>0</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>3,875</td>
<td>-</td>
<td>-</td>
<td>2.0</td>
<td>22</td>
</tr>
</tbody>
</table>

**MMBtu/yr total:** 82 MMBtu/yr

<table>
<thead>
<tr>
<th>Energy source</th>
<th>Total units/year</th>
<th>MMBtu/unit</th>
<th>MMBtu/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>3,875</td>
<td>0.003413</td>
<td>13</td>
</tr>
<tr>
<td>Natural Gas</td>
<td></td>
<td>0.100</td>
<td>24</td>
</tr>
<tr>
<td>Propane</td>
<td></td>
<td>0.091</td>
<td>0</td>
</tr>
<tr>
<td>Oil</td>
<td></td>
<td>0.138</td>
<td>2.0</td>
</tr>
<tr>
<td>Other Fuel</td>
<td></td>
<td></td>
<td>44</td>
</tr>
</tbody>
</table>

**kBtu/sq.ft.-yr:** 39

Insert data only in yellow cells

**Number of months**

- Electricity: 12
- Natural Gas: 12
- Propane: 12
- Oil: 12
- Other Fuel: 12

*This is number of months of usage covered by the fuel use

**Fuel Cost Table**

<table>
<thead>
<tr>
<th>Meter read date</th>
<th>kWh</th>
<th>Ccf or therm</th>
<th>Delivery date</th>
<th>Gallons</th>
<th>Delivery date</th>
<th>Gallons</th>
<th>Delivery date</th>
<th>No. of units</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/01/15</td>
<td>350</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>02/01/15</td>
<td>350</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>03/01/15</td>
<td>325</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>04/01/15</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>05/01/15</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>06/01/15</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>07/01/15</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08/01/15</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>09/01/15</td>
<td>300</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/01/15</td>
<td>325</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/01/15</td>
<td>350</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12/01/15</td>
<td>375</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Fuel Cost Table**

<table>
<thead>
<tr>
<th>Fuel (Abbrev.)</th>
<th>Unit</th>
<th>$/Unit</th>
<th>MMBtu/</th>
<th>$/MMBtu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>kWh</td>
<td>$0.15</td>
<td>0.003413</td>
<td>$43.99</td>
</tr>
<tr>
<td>Kerosene</td>
<td>Gal</td>
<td>$3.50</td>
<td>0.137</td>
<td>$25.62</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>ccf</td>
<td>$2.00</td>
<td>0.100</td>
<td>$20.00</td>
</tr>
<tr>
<td>Oil</td>
<td>Gal</td>
<td>$3.00</td>
<td>0.138</td>
<td>$21.43</td>
</tr>
<tr>
<td>Propane</td>
<td>Gal</td>
<td>$3.00</td>
<td>0.138</td>
<td>$21.43</td>
</tr>
<tr>
<td>Wood**</td>
<td>Cord</td>
<td>$220</td>
<td>22</td>
<td>$10.89</td>
</tr>
<tr>
<td>pellets</td>
<td>ton</td>
<td>$229</td>
<td>16</td>
<td>$14.31</td>
</tr>
<tr>
<td>wood chips**</td>
<td>ton</td>
<td>$61</td>
<td>9.0</td>
<td>$6.72</td>
</tr>
</tbody>
</table>

* green wood chips
** dry hardwood
Open this one:
**EUI calculator with annual data150821.xlsx**

### EUI Calculator

**EUI = Energy Usage Index**

1. **How big is the building?**
   - Total fully conditioned sq.ft. 5,000

2. **How much fuel does the building use?**

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Unit</th>
<th>Used per year</th>
<th>MMBtu/Unit</th>
<th>MMBtu/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>kWh</td>
<td>12,100</td>
<td>0.00341</td>
<td>41</td>
</tr>
<tr>
<td>Kerosene</td>
<td>Gal</td>
<td>100</td>
<td>0.137</td>
<td>14</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>ccf</td>
<td>100</td>
<td>0.100</td>
<td>10</td>
</tr>
<tr>
<td>Oil</td>
<td>Gal</td>
<td>100</td>
<td>0.136</td>
<td>14</td>
</tr>
<tr>
<td>Propane</td>
<td>Gal</td>
<td>100</td>
<td>0.094</td>
<td>9</td>
</tr>
<tr>
<td>Cord Wood</td>
<td>Cord</td>
<td>1.0</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Wood pellets</td>
<td>ton</td>
<td>10</td>
<td>16</td>
<td>160</td>
</tr>
<tr>
<td>Wood chips</td>
<td>ton</td>
<td>5.0</td>
<td>9.0</td>
<td>45</td>
</tr>
</tbody>
</table>
   
   TOTAL MMBtu Used per year 313

3. **Normalize heating usage for coldness of period of usage data**
   - Fuel used for space heating only, MMBtu/yr 262
   - Normal Degree Days for your location 7,478
   - Starting date for fuel use data 1/1/2014
   - Ending date for fuel use data 12/31/2014

**Andy Shapiro:**
- Don't include unconditioned spaces or partially conditioned spaces such as unoccupied basements
- Example assumes 10 MMBtu for domestic hot water

A link to find the nearest weather station is provided: [Go to http://www.nrcc.cornell.edu/ccd/nrmhdd.html](http://www.nrcc.cornell.edu/ccd/nrmhdd.html)
c. Example goal and metrics (Shelburne Farms)

A building that connects to the outdoors and adapts to the seasons: Natural light, multiple access points to the outdoors, patios and landscaping will allow full use of both indoor and outdoor spaces for gathering, eating, learning activities and reflection. The building will support activity that expands (is outdoor oriented) in the summer and contracts (is hearth/fire oriented) in the winter.

- Objective/Metric: Daylighting will be used in all spaces.
- Objective/Metric: All spaces will have a view out of a window.
- Objective/Metric: Outdoor learning spaces will have appropriate weather protection and furniture for productive use in all seasons
Step 5 – Commit to Metrics
Purpose, Goals, Objectives / Metrics

Example

– Goal: Air tight building
  • Metric: tested air leakage no more than 0.05 cfm@50 Pa air leakage per square foot of above grade shell area (0.05 cfm50/sq.ft. shell)

– Goal: An energy efficient building
  • Metric: 20 kBtu/sq.ft. year total energy actual usage (site energy) from all sources

– Goal: Net Zero building
  • Metric: Site energy consumption is at least 100% offset by on-site energy production
ENVISION

• Step 6 - Design Living Buildings and Places
  1. Organizational Ecology
  2. Living Systems, Design and Building Formats
  3. Health for Occupants and Environment
Step 6 - Design Living Buildings and Places

Organizational Ecology
Step 6 - Design Living Buildings and Places

Living Systems, Design and Building Formats
Step 6 - Design Living Buildings and Places

Connect Building to Site