Continuing Chapter 7
High Energy Efficient Design

Lecture #16
HNRS 228
Energy and the Environment
Adapted from Murray Milne Lecture
UCLA and HEED office
Overview of Chapter 7

- Energy Conservation
  - Space Heating
  - Thermal Insulation
  - Air Infiltration
  - Lighting
  - Appliances
  - Some considerations of agriculture and industry
Designing High Performance Sustainable Buildings

My Objectives are:

1. To show you how to use HEED to design a Basic Residential Building
2. To show you how HEED reports Site Energy Use and CO2 Production with each design change you make.
3. To show you six concepts of Energy Efficient Buildings using HEED’s Advanced Graphic Evaluation tools
4. To give EACH of you a chance to use HEED on your own.
5. To end by showing how well each of your designs compare.
What is the 2010 Imperative

Ed Mazria, the AIA, the USGBC and others have jointly issued the 2030 Challenge, that asks architects to create buildings that are carbon-neutral by 2030.

As a first step they also ask that the fossil fuel reduction of all new buildings be reduced by 50% between now and 2010.

This target is readily achievable, but to do it Mazria says we need a little “performance box” in our design tools to show how close each design change gets us toward that goal.

HEED now has such a little “performance box”.
When you install the HEED disk on your laptop it will automatically begin loading...
Next it will show you the Tutorial

Whenever you are in doubt about what to do next...Click “next” to continue
The GOAL is to help you understand how Your Home uses energy.
The GOAL is to help you understand how your Home uses energy, compared to a home of the same size that just barely meets the Energy Code ①, and one that is More Energy Efficient ②.
The GOAL is to help you understand how Your Home uses energy, compared to a home of the same size that just barely Meets the Energy Code 1, and one that is More Energy Efficient 2.

Try out various remodeling changes 4 5 to see if you can make it better.
The GOAL is to help you understand how Your Home uses energy, compared to a home of the same size that just barely Meets the Energy Code 1, and one that is More Energy Efficient 2.

Try out various remodeling changes 4 5 to see if you can make it better.

Different kinds of design and remodeling changes you might like to test are listed under 6 Basic Design.

Use Library L to Copy your best scheme at each step.
To define any term on your current screen Click on HELP
Using HEED to Design a Basic Residential Building

1. Start in the 'Initial Design' screen by giving Four Facts about your home:
   - Building Type
   - Square Footage
   - Number of Stories
   - Zipcode or Location.

2. Using this data, HEED will automatically design two basecase buildings:
   Scheme 1 that meets the Energy Code
   Scheme 2 that is more Energy Efficient.

3. It will COPY Scheme 2 and ask you to revise it to create your own design.

4. Every few minutes COPY your Scheme and keep on improving your design.

5. Try to make its Energy Costs less than the basecase designs.
On Initial Design Screen, Answer These Questions

To proceed click the Next Button Below...
From this, HEED Automatically Creates Two Buildings

Energy Costs
Scheme 2: More Energy Efficient

Project: Home for Mr/Ms Ratepayer
Building Type: SINGLE FAMILY RESIDENCE
City Location: Los Angeles (Westwood-1)

1. Meets Energy Code
2. More Energy Efficient
1. Meets Energy Code

Dollars Energy Cost per year

The Height of the bars shows either:
1. Dollars Per Year,
2. Percent compared to Scheme 1, or
3. Dollars per square foot of floor per year.

1. Meets Energy Code

- Air Conditioner
- Fans and HVAC Blowers
- Lights
- Equipment and Appliances
- GAS

Move your cursor onto the bars, then you can see the exact amount of each bar.
Scheme 1:

**CODE MINIMUM DESIGN**

- Square floor plan
- Equal area of glass on each wall
- Windows tinted as required by code
- No window shading
- Stud and Stucco walls
- Raised wood floor
- Code required air change infiltration
- Lights are mostly incandescent

Scheme 2:

**ENERGY EFFICIENT DESIGN**

- Rectangular floor plan facing South
- Most glass on South, min. on E & W
- Often clear glass on South and North
- Overhangs shading South Windows
- High mass walls, exterior insulation
- Slab on grade floor, carpet or tile
- Whole-house Fan, 10 air changes/hr
- Lights are mostly fluorescent

**Both Schemes have the same:**

Floor area, Window area, Climate, Occupancy Schedules
Then it asks you to Copy and Re-Name Scheme 2

Click Next
Now begin changing your new Scheme 3 to your own design
Click on the 'Basic' icon to see Basic Design Options
Draw in your own Floorplan by Filling-the-Squares
Click and Rotate your House to its correct Orientation
Drag and Drop Windows/Doors to Exact Location
Checklists let you Describe your Home's Construction

Walls

Scheme 3 : Copy 2: My First Design

- Stucco or Brick on 2x4 Wood Studs at 16" with Plaster Board Interior
- Wood or Vinyl Siding on 2x4 Wood Studs at 16", Plaster Board Interior
- Stucco or Brick on 2x6 Wood Studs at 24", with Plaster Board Interior
- Wood or Vinyl Siding on 2x6 Wood Studs at 24", Plaster Board Interior
- Stucco, Vinyl, or Wood, 1"+Polystyrene, Plywood, 2x4 Wood Studs at 16", Plaster Board
- Stucco, Vinyl, or Wood, 1"+Polystyrene, Plywood, 2x6 Wood Studs at 24", Plaster Board
- Stucco on 4-1/2" SIPS Panels (OSB, 3-5/8"+Polystyrene, OSB), Plaster Board
- Stucco on 8"Concrete Block, +Insulation, 2x4 Stud Wall, Plaster Board (acts like low mass)
- Stucco on 8"Concrete Block, Insulation filled cores, Exposed or Plastered
- Wood or Vinyl Siding, Foil, Air Space, 8"Concrete Block, Exposed or Plastered
- Stucco, 2"+Polystyrene on 8" Hollow Concrete Block, Exposed or Plaster Board
- Stucco, 2"+Polystyrene on 5" Solid Concrete or Block, Exposed or Plaster Board
- Stucco, 9"Insulated Concrete Form Wall, Plaster Board Interior
- Solid 8"Masonry Wall, uninsulated, Exposed Inside and Out (does not meet code)

Note: "+" means thickness can increase if required by the Insulation screen or to meet Local Energy Code
There are over a dozen BASIC Checklists to choose from.
Finally, the Energy Cost bar charts show how each of your Schemes Compare with Schemes 1 and 2.
This same Bar Chart can be plotted in terms of Site Energy or CO2 Production, in Pounds or in Pounds per Square foot.
Almost everything you touch in HEED either gives you more data or moves to show more information.
The 'Energy Efficient Design' screen shows the number of hours the building runs Passively (green) and also give the top ten Design Guidelines for this climate.
The 'Economics' screen will Calculate the Payback of Each Scheme

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Annual Energy Cost vs. Scheme 3</th>
<th>Estimated Cost of Improvements</th>
<th>Years to Pay Back Annual Energy Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. As Built in 1960</td>
<td>$ 4066</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4. Weather-Stripping</td>
<td>$ 3950</td>
<td>$ 116</td>
<td>$ 200</td>
</tr>
<tr>
<td>5. Hi Efficiency A/C</td>
<td>$ 3601</td>
<td>$ 465</td>
<td>$ 2500</td>
</tr>
<tr>
<td>6. Double Pane Tinted</td>
<td>$ 3377</td>
<td>$ 689</td>
<td>-</td>
</tr>
<tr>
<td>7. Shade Patio Sliders</td>
<td>$ 3233</td>
<td>$ 833</td>
<td>$ 800</td>
</tr>
<tr>
<td>8. Attic Insulation</td>
<td>$ 2977</td>
<td>$ 1089</td>
<td>$ 1000</td>
</tr>
<tr>
<td>9. Combine 4+5+7+8</td>
<td>$ 2244</td>
<td>$ 1811</td>
<td>$ 4500</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
These were the kinds of thing you can do using only the BASIC Design options...
These were the kinds of thing you can do using only the BASIC Design options...

but

at any point you can switch to HEED's ADVANCED Design Data Input Options

or HEED's Advanced EVALUATION Graphic Output options...
There are more than a dozen different Advanced Design Data Input Options.
and over three dozen different Advanced Evaluation Graphic Output options
3D Graphic Plots can show the comparison of any pair of components within a Scheme.
... or click on the menu and 'Capture a Snapshot' to compare with any component in any other Scheme
... here for Scheme 9 the **Air Conditioner** has been 'Captured' and is compared to the **Outdoor Temperature**
The **Hourly Bar Chart** shows which components need your design attention and which do not.
The BEPS screen shows quantitative data for various measures of Building Energy Performance.
Fuel and Electric Charges are available for 5 California Utilities, or you can input your own utility rates.

**ELECTRIC CHARGES**

Scheme 3: Copy 2: My First Design

**Project:**
- Building Type: SINGLE FAMILY RESIDENCE
- City Location: Los Angeles (Westwood)

**Winter Season Charges** for months October to May:
- Basic charge for meter hookup: 243 Days x $0.02900 per day = $7.05
- Baseline, charge for energy used: 2,454 kWh x $0.11808 per kWh = $289.80
- Over Baseline (100-130%): 700 kWh x $0.13741 per kWh = $96.14
- Tier III (130-200% of Baseline): 36 kWh x $0.15369 per kWh = $5.53
- Tier IV (200-300% of Baseline): 0 kWh x $0.17126 per kWh = $0.00
- Tier V (Over 300% of Baseline): 0 kWh x $0.17126 per kWh = $0.00

**Summer Season Charges** for months June to September:
- Basic charge for meter hookup: 122 Days x $0.02900 per day = $3.54
- Baseline, charge for energy used: 1,244 kWh x $0.11808 per kWh = $146.94
- Over Baseline (100-130%): 373 kWh x $0.13741 per kWh = $51.30
- Tier III (130-200% of Baseline): 103 kWh x $0.15369 per kWh = $15.87
- Tier IV (200-300% of Baseline): 0 kWh x $0.17126 per kWh = $0.00
- Tier V (Over 300% of Baseline): 0 kWh x $0.17126 per kWh = $0.00

**TOTAL COST (not including taxes) = $616.41**
This **Comparison** screen shows how **Site Energy** and **CO2 Production** compare for all nine schemes...
Click 'Next' and it will give **Site Energy** in kBTU/sq.ft. and **CO2 Production** in Lbs/sq.ft. for all nine schemes.
This is the data you need for the 2010 Challenge

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Scheme 1</th>
<th>Scheme 2</th>
<th>Scheme 3</th>
<th>Scheme 4</th>
<th>Scheme 5</th>
<th>Scheme 6</th>
<th>Scheme 7</th>
<th>Scheme 8</th>
<th>Scheme 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passive Hours (no heat or cool)…%</td>
<td>44.81</td>
<td>67.17</td>
<td>69.36</td>
<td>69.36</td>
<td>72.58</td>
<td>75.64</td>
<td>76.93</td>
<td>80.83</td>
<td>80.63</td>
</tr>
<tr>
<td>Total Floor Area ……. sq.ft.</td>
<td>2000.00</td>
<td>2000.00</td>
<td>2000.00</td>
<td>2000.00</td>
<td>2000.00</td>
<td>2000.00</td>
<td>2000.00</td>
<td>2000.00</td>
<td>2000.00</td>
</tr>
<tr>
<td>Total Fuel consumed..... kBTU/sf</td>
<td>38.91</td>
<td>35.66</td>
<td>36.41</td>
<td>34.82</td>
<td>29.20</td>
<td>29.23</td>
<td>24.96</td>
<td>23.91</td>
<td>23.41</td>
</tr>
<tr>
<td>Total Electricity consumed kWhr/sf</td>
<td>2.46</td>
<td>1.77</td>
<td>2.03</td>
<td>2.00</td>
<td>1.88</td>
<td>1.65</td>
<td>1.57</td>
<td>1.41</td>
<td>1.20</td>
</tr>
<tr>
<td>Electricity Equivalent…in kBTU/sf</td>
<td>8.41</td>
<td>6.04</td>
<td>6.91</td>
<td>6.83</td>
<td>6.42</td>
<td>5.64</td>
<td>5.35</td>
<td>4.81</td>
<td>4.10</td>
</tr>
<tr>
<td>Site Energy Use Total…….kBTU/sf</td>
<td>47.32</td>
<td>41.70</td>
<td>45.32</td>
<td>41.65</td>
<td>35.62</td>
<td>34.88</td>
<td>30.31</td>
<td>28.71</td>
<td>27.51</td>
</tr>
<tr>
<td>Site Energy Use, …..% of Scheme 1</td>
<td>100.00</td>
<td>88.12</td>
<td>95.79</td>
<td>88.02</td>
<td>75.23</td>
<td>73.71</td>
<td>64.05</td>
<td>60.68</td>
<td>58.13</td>
</tr>
<tr>
<td>CO2 Carbon Dioxide……….lbs/sf.</td>
<td>11.87</td>
<td>10.31</td>
<td>11.14</td>
<td>11.11</td>
<td>9.07</td>
<td>8.88</td>
<td>7.32</td>
<td>6.83</td>
<td>6.43</td>
</tr>
<tr>
<td>CO2………………….% of Scheme 1</td>
<td>100.00</td>
<td>86.88</td>
<td>93.81</td>
<td>93.64</td>
<td>76.40</td>
<td>74.81</td>
<td>61.70</td>
<td>57.53</td>
<td>54.14</td>
</tr>
</tbody>
</table>

This example shows that compared to the Scheme 1 Basecase, Scheme 9 uses only 58.13% of the Site Energy and produced only 54.14% of the CO2... (so it is almost there)
PLEASE every few minutes click on Library...

...and make a copy of your current scheme in order to create a new scheme... and try out new design options that you think will improve its performance...

Each time check back on 'Energy Costs' under the 'Basic' icon to see how well you newest scheme is doing
Part 2: How HEED’s advanced evaluation options can help you visualize graphically...

**Six Concepts of High Performance Buildings**

1. Good Passive Buildings have **Saddle Shaped** Plots
2. Bad Passive Buildings have lots of **Heat Mountains**
3. High Mass Walls cause **Time Lags** in Heat Gain/Loss
4. **Economizer Bowl** shows the Free Cooling with Outdoor Air
5. **Daylight Canyon** shows the Electric Lighting displaced by Good Design
6. **Powerful Tools** help you create High Performance Buildings
South Window
Scheme 1: Meets Energy Code

South Window
Scheme 2: More Energy Efficient

KiloBTU/Hr
5.10 ~ 6.57
3.63 ~ 5.10
2.16 ~ 3.63
.68 ~ 2.16
-.79 ~ .68

KiloBTU/Hr
15.73 ~ 20.08
11.38 ~ 15.73
7.03 ~ 11.38
2.68 ~ 7.03
-1.67 ~ 2.68
Scheme 1: Meets Energy Code

Max: 7.36

Min: -0.79

DEC  SEP  JUN  MAR  6am  midnight

KiloBTU/Hr:
-5.73 ~ 7.36
-4.10 ~ 5.73
-2.47 ~ 4.10
-0.84 ~ 2.47
-0.79 ~ 0.84

Scheme 2: More Energy Efficient

Max: 7.2

Min: -0.15

DEC  SEP  JUN  MAR  6am  midnight

KiloBTU/Hr:
-0.54 ~ 0.72
-0.37 ~ 0.54
-0.20 ~ 0.37
-0.02 ~ 0.20
-0.15 ~ 0.02

Heat Gain/Loss through all West Facing Windows
Air Changes

Scheme 1: Meets Energy Code

Project: SCG Workshop
Building Type: SINGLE FAMILY RESIDENCE
City Location: Downey

Air Changes per Hour, either from Natural Ventilation or Whole House Fan, showing impact of Economizer Cooling

Max 9.95
Min .50

AirChanges per Hour
0.00 Min .40
DEC SEP JUN MAR 6am noon midnight 6pm

AirChanges per Hour
8.04 – 9.95
6.13 – 8.04
4.22 – 6.13
2.31 – 4.22
.40 – 2.31
KWHR Lights
Scheme 1: Meets Energy Code

Max: 1.20
0.00 Min: 0.00
DEC SEP JUN MAR 6am noon 6pm midnight

Kilowatts/Hr
96 - 1.20
72 - 0.96
48 - 0.72
24 - 0.48
00 - 0.24

KWHR Lights
Scheme 2: More Energy Efficient

Max: 0.80
0.00 Min: 0.00
DEC SEP JUN MAR 6am noon 5pm midnight

Kilowatts/Hr
.64 - .80
.48 - .64
.32 - .48
.16 - .32
.00 - .16

Project: SCG Workshop
Building Type: SINGLE FAMILY RESIDENCE
City Location: Downey
Finally it is your turn to create your own design:

1. Answer the questions on **Initial Design**, under Basic Design

2. When in doubt, click 'Next'

3. Regularly Click on **Library** and 'Copy' to create new designs

4. To see how your designs Perform, Click on **Energy Costs**

5. To Start with a **new Project**, click on Library, then Projects
For Other Climates...

To load in climate data for any station outside California, click on Help at the Climate screen or see the READ-USA.TXT file in the c:\heed...docs folder.

It explains how HEED can directly read EnergyPlus Weather for over 1000 stations around the world.

From the HEED web site, click on the EnergyPlus site, then select the city you wish. Click on the EPW format option then Save This Page into the c:\heed...solar5...tmy folder.

Now go back to HEED's 'Initial Design' screen and click the down arrow on the Location line.
For 12-Day Plots....

To look at any individual hour of the year, you can “zoom in” on any 12-day segment you choose from the Climate Data screen.

Start with July 4
For 12- Day Plots....

In this case the Outdoor Temperature reached 92° on July 9... But on most nights the Whole House Fans tried to cool down the interior.
Validation:

- HEED calculates an Hourly Heat-Balance for all 8760 hours of the year (similar to the method used in DOE’s new EnergyPlus)
- HEED has been validated against DOE-2 and others programs, using BESTEST (the ASHRAE Standard 140-2001). Results are posted on web site.
- HEED accommodates single zone buildings up to 4,600 s.f. per floor
- HEED accommodates energy-efficient design strategies such as: natural ventilation, daylighting, external shading, smart HVAC controls, thermal mass, passive solar heating, night flushing, economizer cycles
- HEED uses electric rate structures for the four major utilities, but you can input electric, gas, oil, or propane rates for your own utility
- HEED has a huge Help system to answer your questions (click the Help icon), Advice, Getting Started Tutorial, an on-line Demo, and a basic Users Manual.
Some of Our Other Energy Design Tools You Might Find Helpful...
Climate Consultant
Total R Value: 12.05
Total U Value: 0.08
Time Lag: -2.21
Decrement Factor: 0.94

Material Name: Thickness: R Value:
Inside Air Film: 0.01 0.61
Gypsum Board: 0.50 0.13
Wood Studs: 3.50 3.99
Fibreglass Insulation: 3.15 11.03
Plywood Sheathing: 0.50 0.63
Siding (Wood): 0.44 0.55
Outside Air Film: 0.01 0.17
HEED (and a copy of this Power Point) can be downloaded at no cost from:

www.aud.ucla.edu/heed

Our other Design Tools can be downloaded from

www.aud.ucla.edu/energy-design-tools

Contact Murray Milne at:

milne@ucla.edu

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