Designing High Performance Sustainable Homes

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HEED Workshops for California, 2010
Funded by the California Energy Commission through the project “Getting to 2020”
PI: Murray Milne
Introduction, loading HEED, objectives  20 minutes
HEED: How does it work?  60 minutes
Hands on worked Example with HEED  100 minutes
Break  10 minutes
Advanced Ideas  10 minutes
Climate Consultant  20 minutes
Comparison of projects  10 minutes
Additional Q & A  10 minutes
To help you to design cost effective, low energy, carbon neutral buildings.
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 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 introduce other tools
6. To end by showing how well each of your designs compare.
As a result of attending this class, participants will be able to:

1) Use HEED software to generate home design scenarios by modifying building configuration (shape, size, orientation), building components (e.g., windows, lighting, space conditioning equipment) and building assemblies (walls, roof, foundation),

2) Simulate the annual energy consumption, energy cost, and greenhouse gas emissions of any home design in any climate,

3) Readily compare these factors for multiple home design scenarios, and

4) Fine-tune designs to optimize the energy performance of net zero energy homes.

AIA learning objectives
Why is using HEED important?

1. To improve building performance
2. To reduce energy costs for the homeowner
3. To reduce building effects on climate change
Low energy buildings can help you achieve these goals.
HEED can help you design low energy buildings.

HEED is about Design
It analyzes buildings to determine their performance.
HEED, Home Energy Efficient Design, is an energy analysis tool that calculates a building’s performance.

When HEED is first launched it asks four questions about the project (building type, square footage, number of stories, and climate location) and with this information it creates Scheme 1, a building that meets the California Energy Code. It then designs a second Scheme that is usually about 30% better. Next it suggests other strategies that designers can test using the remaining seven schemes.

HEED makes it very easy for users to change any aspect of the building’s design and after each design change HEED shows how the building’s performance compares with the initial schemes.
HEED California Workshops 2010

How to use it
When you install the HEED disk on your laptop it will automatically begin loading...
Whenever you are in doubt about what to do next...Click "next" to continue

Next it will show you the tutorial
The GOAL is to help you understand how Your Home uses energy.

My 1stDesign

TOTAL YEARLY COST

($)
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.
HEED
Navigating...
You can use the **BASIC Design** options to do work quickly...

............. but .............

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

or **HEED's Advanced EVALUATION Graphic Output** options...
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.
HEED: Home Energy Efficient Design

To show ratepayers a picture of the possible savings in energy costs resulting from various changes in the design or operation of their home:

This Program creates a series of designs based on 4 questions you answer about your home:

1. First, it automatically creates a reference home that Meets the California Energy Code.
2. Using this same data, it also creates a More Energy Efficient version of your home.
3. Next, it asks you to describe in more detail the design of your Current Floorplan.
4. Now Copy your current design (click Library above), and try different energy features.
5. Using the Copy function, create more new designs to further reduce your energy costs.

Energy Cost bar charts show you the improvement in each design (click Basic icon above).
Help with technical terms and Advice on how to save energy are also available.
Advanced users might like to try the Advanced Design and Evaluation Graphics (icons).
HEED is regularly revised and expanded so please always download the latest version from www.energy-design-tools.ucla.edu/heed.

To proceed click the Next button below....

This program was developed at the UCLA Department of Architecture and Urban Design, by the Energy Design Tools with funds from California utility ratepayers administered by the California Energy Commission. The photovoltaic calculation algorithms were developed by the Solar Energy Laboratory at the University of Wisconsin and TESS Inc.

Estimates Only: The Regents of the University of California, the California Energy Commission, the California Public Utilities Commission, Southern California Edison, Southern California Gas, Dan Diego Gas and Electric, Pacific Gas and Electric, CTG Energetics, the University of Wisconsin, and TESS Inc make no warranty, expressed or implied, included but not limited to any warranty of merchantability or fitness for any particular use or application.
On Initial Design Screen, Answer These Questions

- What would you like to do?
  - Construct a brand new home
  - Remodel within your Home's Existing Walls
  - Add on outside your existing floor plan

- What kind of home will it be?
  - Single Family House
  - Town House, attached to others
  - Apartment or Condo unit (entry from interior hallway)
  - Apartment or Condo unit (entry directly from outdoors)

- How many stories does your home have? 1

- How big will your home be? 2,000 Square Feet for Example...

- What is your Zipcode or location? 90024 contains Los Angeles (Westwood) City

- What is the name of this project? Home for Ms/Mr Ratepayer

To proceed click the Next Button Below...
... HINT: Start with 2 or 3 stories because it is easier to remove stories than add them
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 to select the EPW option.
Does your house have an attached enclosed garage?

- No attached garage or else it is not fully enclosed (i.e. it is a car-port)
- Garage is attached on the front
- Garage is attached on the left
- Garage is attached on the rear
- Garage is attached on the right
With the initial data HEED automatically creates two buildings
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
You create your first design

You now have the option to add PV systems
HEED gives some advice for low energy design

CLIMATE ZONE 6: Energy Efficient Design Strategies
Warm Dry Summers, Morning Fog, Clear Winter (like Santa Monica)

1. Air Conditioning can be eliminated in this climate if the building design strategy prevents overheating in summer and takes advantage of winter solar gain.
2. Long extended floorplan facing south and/or the prevailing breezes, flat or low pitched roof with large overhangs (to maximize natural ventilation and winter passive solar gain).
3. Slab on grade should provide enough thermal mass to help reduce day-to-night temperature swings and store solar gain, but (if air conditioning is still needed test high-mass walls).
4. Maximize the glass on the South and South East, (for passive solar gain) shade in summer to prevent overheating, North glass will balance daylighting and provide cross ventilation.
5. Test if high performance glazing is cost effective in these mild outdoor temperatures, if windows are carefully shaded.
6. Maximize the option of natural cross ventilation with large sliding glass doors and operable windows.
7. A light colored (cool) roof with extra insulation should be cost effective, but standard insulation will help retain internal gains.
8. A large whole-house fan can provide enough economizer cooling if there is adequate interior mass (to eliminate A/C).
9. Minimize or eliminate west-facing glass and locate storage areas and attached garages on westerly side to help insulate.
10. Keep floorplan small and efficient, big buildings waste energy, and provide sheltered outdoor patios to extend living spaces.
Now begin changing your new Scheme 3 to your own design
HEED gives you much useful information in this first screen.
Draw in your own Floorplan by Filling-the-Squares
Click and Rotate your House to its correct Orientation
Then you can add or modify windows…

To add new Windows or doors

To Change dimensions

Click and drag to change sizes
Drag and Drop Windows/Doors to Exact Location
Define the glass types

- Aluminum without a thermal break, Operable Window
- Wood or Vinyl Operable Window

Glass with Wood or Vinyl Frame Operable Windows:
- Energy Code Minimum Hypothetical for Climate Zone 9 (U=.40 SHGC=.40 Tvis=.63)
- Clear Single Pane 1/8" glass in wood/vinyl frame (U=.89 SHGC=.64 Tvis=.66)
- Clear Double Pane in wood/vinyl frame (U=.51 SHGC=.52 Tvis=.57)
- Clear Double Pane Low-E in wood/vinyl frame (U=.40 SHGC=.40 Tvis=.63)
- Clear Double Pane Low-E squared in wood/vinyl frame (U=.39 SHGC=.28 Tvis=.61)
- Clear Argon filled Double Pane Low-E squared wood/vinyl (U=.36 SHGC=.28 Tvis=.64)
- Tinted Double Pane in wood/vinyl frame (U=.51 SHGC=.38 Tvis=.49)
- Tinted Double Pane Low-E in wood/vinyl frame (U=.40 SHGC=.30 Tvis=.45)
- Tinted Double Pane Low-E squared in wood/vinyl frame (U=.39 SHGC=.21 Tvis=.33)
- Tinted Double Pane Reflective (SS) in wood/vinyl frame (U=.51 SHGC=.13 Tvis=.08)
- Clear Triple Pane in wood/vinyl frame (U=.39 SHGC=.46 Tvis=.51)

Note: You can load in values for any other manufactured window assemblies on the Advanced Windows screen. Values from ASHRAE 2007 Ch.31; double and Triple glazing has 1/4" glass with a 1/2" air space. Tinted Double glazing has blue/green on the exterior with clear on interior, SS is Stainless Steel.
Define the insulation levels

**Level of Insulation:**
- No Insulation: House Built pre-Sixties (Wall R=0, Ceiling R=0, Floor R=0)
- Insulated Attic Only (Wall R=0, Ceiling R=18, Floor R=0)
- Insulated Attic and Raised Floor (Wall R=0, Ceiling R=15, Floor R=13)
- Little Insulation: Built before Energy Code in 1978 (Wall R=7, Ceiling R=11, Floor R=0)
- Early Energy Code (Wall R=11, Ceiling R=19, Floor R=11)
- Current Energy Code (2008) for Climate Zone 9 (Wall R=13, Ceiling R=30, Floor R=19)
- Insulation Upgrade to 1.5 times Current Code
- Super Insulation to 2 times Current Code
- Current Energy Code with Heavy Mass Walls (Wall R=2.44, Ceiling R=30, Floor R=0)

**Reflective Foil Radiant Barriers (in Attics only)**
- Radiant Barrier installed in Attic (shiny surface facing into vented attic above insulation in ceiling)
  or in Flat Roof (shiny surface facing into a vented air space above insulation)
- No Radiant Barrier in Attic or Flat Roof (or upstairs is an occupied unit; see roof screen)

R-Values in Current Energy Code are for insulation installed between wood framing members (Total assembly R-values will be less)

Note: In this Climate Zone 9, the Code Package C and D requires a Radiant Barrier in Attics
Checklists let you Describe your Home’s Construction
Define the Roof Insulation

Roof Construction:
- No Heat Loss through ceiling because upstairs is another heated unit
- Cool Roof Flat or Low Sloped (less than 9.5 degrees)
- Cool Roof Sloped, Naturally Ventilated Attic, Light Weight Shingles (less than 5 lb/sf)
- Cool Roof Sloped, Fan Vented Attic, Light Weight Shingles (less than 5 lb/sf)
- Cool Roof Sloped, Naturally Vented Attic, Heavy Weight Tiles (5 lb/sf or more)
- Cool Roof Sloped, Fan Vented Attic, Heavy Weight Tiles (5 lb/sf or more)
- Default Flat or Low Sloped Roof, (less than 9.5 degrees)
- Default: Sloped Roof, Naturally Ventilated Attic, Light Weight Shingles (less than 5 lb/sf)
- Default: Sloped Roof, Fan Vented Attic, Light Weight Shingles (less than 5 lb/sf)
- Default: Sloped Roof, Naturally Vented Attic, Heavy Weight Tiles (5 lb/sf or more)
- Default: Sloped Roof, Fan Vented Attic, Heavy Weight Tiles (5 lb/sf or more)

Cool Roofs have higher reflectance which means they absorb less solar radiation, and slightly higher thermal emittance which means they re-radiate heat to the sky during both day and night. In this climate zone, attics must have a Reflective Foil Radiant Barrier on the underside of the roof exposed to attic air, to meet the Energy Code’s Prescriptive Package C and D (see Basic Insulation screen). All Roofs have Plaster Board Ceilings and Wood Joists with Insulation between. Attic Fans have a thermostat so only run when needed. Other Assemblies calculated by hand can be loaded on the Surface Area screen (use Time Lag and Decrement from similar roofs here).
Define the Floor Construction

Floor Construction:
- Wood Floors Exposed, above grade
- Wood Floors Carpeted, above grade (if partly covered set % on Thermal Mass Screen)
- Ceramic Tile on Wood Sub-Floor, above grade
- Light Weight Concrete, Carpeted, on Wood Sub-Floor, above grade
- Slab on Grade Exposed or Tiled
  - Slab on Grade Covered by Carpet or Casework (if partly covered set % on Thermal Mass Screen)
- Concrete Structural Floor, Exposed or Tiled, above grade
- Concrete Structural Floor, Carpeted, above grade (if partly covered set % on Thermal Mass Screen)
- Basement, Lowest Floor in an Occupied Conditioned Basement
- Finished Basement, Lowest Floor is an Occupied Conditioned Basement

Under First Floor Condition:
- No heat loss through floor, because there is another heated unit below
- Raised Vented Crawl Space
- Unheated Garage, Carport, or Area Open to Exterior
- Earth (under Slab or Occupied Basement)
Define ventilation and infiltration rates
Define heating and cooling systems
Operable Shading:

- Overhangs* (Default Condition) Are Fixed All Year, or there are No Overhangs, also No Shades or Venetian Blinds
- Overhangs* or Awnings are Retracted/Removed in Winter (October through May)
- Overhangs* or Awnings Retracted All Winter and Any Hour in Summer when Indoor Temperature is Below Comfort Low
- Overhangs* or Awnings Automated Hourly to Minimize Summer Overheating and Optimize Winter Solar Gain
- Light Translucent Interior Shades (25%) Close To Block Sun Any Hour When Indoor Reaches 3°C below Comfort High
- White Opaque Interior Shades (0%) Close To Block Sun Any Hour When Indoor Temperature Reaches 3°C below Comfort High
- Light Translucent Interior Shades (25%) Automated Hourly for Summer Shading or Retract to Maximize Winter Solar Gain
- White Opaque Interior Shades (0%) Automated Hourly for Summer Shading or Retract to Maximize Winter Solar Gain
- Light Venetian Blinds Are Fixed at 45 Degrees All Year Long, They Are Never Retracted
- Light Venetian Blinds at 45 Degrees or Closed Tight Hourly When Indoor Temperature Reaches 3°C below Comfort High
- Light Venetian Blinds Close if Sun is on Window and Indoors is Above Comfort Low, or 3°C below Comfort High in Winter
- Exterior Light Slatted Blinds Automated the Same as Above either Closed Tight or Drawn Fully Open

* Overhangs (such as awnings) must be added or removed on either the Basic or Advanced Windows Design screens
Operable Sun Controls apply to all windows unless deleted individually on Advanced Windows/Sunshade screen
Moveable Drapes for night window insulation are controlled separately on Advanced Windows/Sunshade screen

Define operable shading systems
### APPLIANCES: Annual Energy Consumed

**Scheme 3 : santa monica 3**

<table>
<thead>
<tr>
<th>COOKING: RANGE</th>
<th>and OVEN: ELECTRIC*</th>
<th>CLOTHES DRYING: ELECTRIC*</th>
<th>APPLIANCES ELECTRIC*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GAS</strong> Therms/year</td>
<td><strong>0.000</strong> kWh/year</td>
<td><strong>37.200</strong> Therms/year</td>
<td><strong>0.000</strong> kWh/year</td>
</tr>
<tr>
<td>Cooking (Basecase default)*</td>
<td>29.100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clothes Drying (Basecase default)*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Electrical (Basecase default)</td>
<td></td>
<td></td>
<td>1233.158</td>
</tr>
<tr>
<td>(name of appliances to be added, removed)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL Annual Energy:**

29.100 kWh/year | 0.000 kWh/year | 37.200 kWh/year | 0.000 kWh/year | 1233.158 kWh/year

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Note: Furnaces, Air Conditioners, Lights, and Water Heaters are defined on other screens (explained in Help above).

* FUEL TYPE can be changed on the Advanced Fuel Rates screen. (Dryers add 10% of their heat to space, the rest add 100%)

ADD new appliance Annual Energy Consumption here, but be sure to SUBTRACT the energy used by the old appliance.

These annual energy estimates are on the Energy Star labels of new appliances, or in California's DEER data base.

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You can change default appliances
### Summary Table

Project: Los Angeles House  
A 2,000 Square Foot SINGLE FAMILY RESIDENCE in LOS ANGELES CENTER  C208

<table>
<thead>
<tr>
<th>Scheme Name</th>
<th>Energy Costs</th>
<th>Savings Compared to Scheme 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Electricity</td>
<td>Gas</td>
</tr>
<tr>
<td>1. Meets Energy Code</td>
<td>$1,180.17</td>
<td>$380.43</td>
</tr>
<tr>
<td>2. More Energy Efficient</td>
<td>$371.84</td>
<td>$332.68</td>
</tr>
<tr>
<td>3. Copy 2: My First Design</td>
<td>$372.06</td>
<td>$332.31</td>
</tr>
<tr>
<td>4. more south windows</td>
<td>$498.20</td>
<td>$309.49</td>
</tr>
<tr>
<td>5. more windows everywhere</td>
<td>$966.82</td>
<td>$327.29</td>
</tr>
<tr>
<td>6. better insulation</td>
<td>$941.72</td>
<td>$298.70</td>
</tr>
<tr>
<td>7. minimum windows</td>
<td>$369.54</td>
<td>$324.11</td>
</tr>
<tr>
<td>8. north windows</td>
<td>$341.96</td>
<td>$336.31</td>
</tr>
<tr>
<td>9. west windows</td>
<td>$391.78</td>
<td>$304.98</td>
</tr>
</tbody>
</table>

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If you encounter problems or have comments please email to: energy.design.tools@ucla.edu
HEED provides many graphical analysis tools
HEED has over three dozen different Advanced Evaluation Graphic Output options in several formats
The ‘Energy Efficient Design’ screen shows the number of hours the building runs Passively (green) and also gives the top ten Design Guidelines for this climate.
Traditional bar charts show how each scheme compares with schemes 1 and 2. This same bar chart can be plotted in terms of site energy or CO2 production, in pounds or in lbs/sqft.
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**.


### Electric Charges

**For Southern California Edison, Rates Effective 2003 for Rate Zone 10**

#### Winter Season Charges (for months October to May)
- **Basic charge for meter hookup**: 243 Days × $0.02900 per day = $7.05
- **Baseline charge for energy used**: 2,654 kWh × $0.11808 per kWh = $309.80
- **Over Baseline (100-130%)**: 700 kWh × $0.13741 per kWh = $96.14
- **Tier III (130-200% of Baseline)**: 36 kWh × $0.15369 per kWh = $5.53
- **Tier IV (200-300% of Baseline)**: 0 kWh × $0.17126 per kWh = $0.00
- **Tier V (Over 300% of Baseline)**: 0 kWh × $0.17126 per kWh = $0.00

#### Summer Season Charges (for months June to September)
- **Basic charge for meter hookup**: 122 Days × $0.02900 per day = $3.54
- **Baseline charge for energy used**: 1,244 kWh × $0.11808 per kWh = $140.94
- **Over Baseline (100-130%)**: 373 kWh × $0.13741 per kWh = $51.30
- **Tier III (130-200% of Baseline)**: 103 kWh × $0.15369 per kWh = $15.67
- **Tier IV (200-300% of Baseline)**: 0 kWh × $0.17126 per kWh = $0.00
- **Tier V (Over 300% of Baseline)**: 0 kWh × $0.17126 per kWh = $0.00

**Total Cost (not including taxes) = $306.41**

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**Fuel and Electric Charges are available for 5 California Utilities, or you can input your own utility rates**

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HEED California Workshops 2010
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/ft$^2$ for all nine schemes.
There are more than a dozen different Advanced Design Data Input Options.

The advanced menus permit to modify the information that was introduced in the basic screens. You can modify information related to climate, windows, walls, thermal mass, HVAC system, pollution, etc..

The following screens show some examples of these options.
The advanced climate option permits you to zoom in the performance of 12 days instead of 12 months.
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.

For Example

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.
Envelope permits changes to roof properties
### Surface Area Design Summary

#### Scheme 3: Santa Monica 3

<table>
<thead>
<tr>
<th></th>
<th>Area sq.ft.</th>
<th>% of Max Surface</th>
<th>Transmissivity or Absorbivity</th>
<th>Average U Factor</th>
<th>Time Lag</th>
<th>Decrement Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Windows + Doors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South</td>
<td>164.01</td>
<td>16.873</td>
<td>0.63</td>
<td>0.400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>West</td>
<td>144.00</td>
<td>36.364</td>
<td>0.53</td>
<td>0.415</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North</td>
<td>164.01</td>
<td>18.983</td>
<td>0.63</td>
<td>0.400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>East</td>
<td>144.00</td>
<td>22.222</td>
<td>0.54</td>
<td>0.414</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skylight</td>
<td>0.00</td>
<td>0.000</td>
<td>0.00</td>
<td>0.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>WALL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South</td>
<td>878.09</td>
<td>116.149</td>
<td>0.50</td>
<td>0.090</td>
<td>3</td>
<td>0.68</td>
</tr>
<tr>
<td>West</td>
<td>427.79</td>
<td>44.011</td>
<td>0.50</td>
<td>0.090</td>
<td>3</td>
<td>0.88</td>
</tr>
<tr>
<td>North</td>
<td>622.66</td>
<td>108.818</td>
<td>0.50</td>
<td>0.090</td>
<td>3</td>
<td>0.88</td>
</tr>
<tr>
<td>East</td>
<td>557.52</td>
<td>57.359</td>
<td>0.50</td>
<td>0.090</td>
<td>3</td>
<td>0.88</td>
</tr>
<tr>
<td><strong>ROOF Opaque</strong></td>
<td>1,192.00</td>
<td>98.413</td>
<td>0.50</td>
<td>0.031</td>
<td>2</td>
<td>0.94</td>
</tr>
<tr>
<td>FLOOR Raised</td>
<td>0.00</td>
<td>0.000</td>
<td>0.300</td>
<td>2</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>SLAB Edge in feet</td>
<td>108.00</td>
<td>84.375</td>
<td>F factor= 0.700</td>
<td>24</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

Surface area permits changes to opaque envelope thermal properties.
This screen permits you to modify some of the characteristics of windows and doors directly.

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>DIMENSIONS</th>
<th>GLAZING</th>
<th>ORIENTATION</th>
<th>Drape</th>
<th>OVERHANG</th>
<th>LEFT FIN</th>
<th>RIGHT FIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Window</td>
<td>3.00</td>
<td>4.00</td>
<td>0.400</td>
<td>0.63</td>
<td>39.00</td>
<td>90.00</td>
<td>0.00</td>
</tr>
<tr>
<td>West Window</td>
<td>2.00</td>
<td>4.67</td>
<td>0.400</td>
<td>0.63</td>
<td>129.00</td>
<td>90.00</td>
<td>0.00</td>
</tr>
<tr>
<td>West Door</td>
<td>1.00</td>
<td>6.67</td>
<td>0.500</td>
<td>0.00</td>
<td>129.00</td>
<td>90.00</td>
<td>0.00</td>
</tr>
<tr>
<td>North Window</td>
<td>3.00</td>
<td>4.00</td>
<td>0.400</td>
<td>0.63</td>
<td>-141.00</td>
<td>90.00</td>
<td>0.00</td>
</tr>
<tr>
<td>East Window</td>
<td>5.00</td>
<td>4.00</td>
<td>0.400</td>
<td>0.63</td>
<td>-51.00</td>
<td>90.00</td>
<td>0.00</td>
</tr>
<tr>
<td>East Door</td>
<td>1.00</td>
<td>6.67</td>
<td>0.500</td>
<td>0.00</td>
<td>-51.00</td>
<td>90.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

To add new windows or doors, type in: south, west, north, east, south door, west door, north door, east door, or skylight. To delete windows or doors, change the Quantity to 0.

* Facing direction starts clockwise from South (i.e. South Facing = -45 up to 45, West Facing = 45 up to 135)

** This Column adds Operable Sunshades (as defined on the Basic Operable Shading Menu). To add to any window click this box and a Check will appear. To remove from any window, click this check.
New in this version is the design of a PV system.
Design of a solar hot water system

Coming soon......
A project is a distinctive design in a given location. Schemes are different iterations and variations of a project in which you evaluate the performance of different ideas. You can have up to 9 schemes per project of which the first two are automatically generated.

The library pull down menu is where you select schemes or projects to work on.
You can merge schemes from different projects.
You can create new projects from existing projects
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 your newest scheme is doing
Time for some work with HEED
How to do 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
Advanced Ideas
HEED’s advanced evaluation options can help you visualize graphically...

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
1. Good Passive Buildings have *Saddle Shaped* Plots

(South Windows Gain more heat in Winter than in Summer, well shaded windows flatten off summer mid-day gains)
2. Heat Mountains contribute to poor Building Performance
(for example, West Windows Gain most Heat in Mid-Afternoon in Mid-Summer)
3. High Mass Walls create **Time Lags** in Heat Gain/Loss

(Mass in the Envelope can delay afternoon gain until late at night, while Mass in the Interior can help store heat until the next day)
4. **Economizer Bowl** shows the Free Cooling with Outdoor Air (a Smart Thermostat runs a Whole-House Fan to bring in cool night air, interior mass stores “coolth” for the next day: “get a handle on the Bowl”)
5. **Daylight Canyon** shows **Electric Light not used by Good Design** (shallow rooms with tall wide windows will make the canyon deeper and wider)
6. Air Conditioner Energy can be Almost Eliminated (powerful Tools help create High Performance Buildings)
Total Energy Costs are the sum of Electricity (air conditioner, lights, fans, and appliances) and Fuel (heating, cooking, DHW)
Architecture 2030, a non-profit, non-partisan and independent organization, was established in response to the global-warming crisis by architect Edward Mazria in 2002. 2030’s mission is to rapidly transform the US and global Building Sector from the major contributor of greenhouse gas emissions to a central part of the solution to the global-warming crisis.

http://www.architecture2030.org/
The 2030 Challenge

Credible scientists give us 10 years to be well on our way toward global greenhouse gas (GHG) emissions reductions in order to avoid catastrophic climate change. Yet there are hundreds of coal-fired power plants currently on the drawing boards in the US. Seventy-six percent (76%) of the energy produced by these plants will go to operate buildings.

Buildings are the major source of demand for energy and materials that produce by-product greenhouse gases (GHG). Slowing the growth rate of GHG emissions and then reversing it over the next ten years is the key to keeping global warming under one degree centigrade (°C) above today’s level. It will require immediate action and a concerted global effort.

To accomplish this, Architecture 2030 has issued The 2030 Challenge asking the global architecture and building community to adopt the following targets:

All new buildings, developments and major renovations shall be designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 50% of the regional (or country) average for that building type.

At a minimum, an equal amount of existing building area shall be renovated annually to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 50% of the regional (or country) average for that building type.

The fossil fuel reduction standard for all new buildings and major renovations shall be increased to:

- 60% in 2010
- 70% in 2015
- 80% in 2020
- 90% in 2025
- Carbon-neutral in 2030 (using no fossil fuel GHG emitting energy to operate).

These targets may be accomplished by implementing innovative sustainable design strategies, generating on-site renewable power and/or purchasing (20% maximum) renewable energy and/or certified renewable energy credits.

This table tells you emissions reduction (%) for 2030 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>41.66</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)
The ‘Economics’ screen will Calculate the Payback of Each Scheme when you input estimated construction costs

<table>
<thead>
<tr>
<th>Scheme</th>
<th>Annual Energy Cost $</th>
<th>Savings vs. Scheme 3 $</th>
<th>Estimated Cost of Improvements DIY $</th>
<th>Estimated Cost of Improvements Contracted $</th>
<th>Years to Pay Back</th>
<th>Annual Energy Savings DIY $</th>
<th>Estimated Cost of Improvements Contracted $</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. As Built in 1960</td>
<td>$ 4066</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4. Weather-Stripping</td>
<td>$ 3950</td>
<td>$ 116</td>
<td>$ 200</td>
<td>$ 500</td>
<td>2</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>5. Hi Efficiency A/C</td>
<td>$ 3601</td>
<td>$ 465</td>
<td>$ 2500</td>
<td>$ 4000</td>
<td>5</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>6. Double Pane Tinted</td>
<td>$ 3377</td>
<td>$ 689</td>
<td>-</td>
<td>$ 8000</td>
<td>-</td>
<td>-</td>
<td>(12)</td>
</tr>
<tr>
<td>7. Shade Patio Sliders</td>
<td>$ 3233</td>
<td>$ 833</td>
<td>$ 800</td>
<td>$ 1600</td>
<td>1</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>8. Attic Insulation</td>
<td>$ 2977</td>
<td>$ 1089</td>
<td>$ 1000</td>
<td>$ 2000</td>
<td>1</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>9. Combine 4+5+7+8</td>
<td>$ 2244</td>
<td>$ 1811</td>
<td>$ 4500</td>
<td>$ 8000</td>
<td>2.5</td>
<td>-</td>
<td>4.5 years</td>
</tr>
</tbody>
</table>
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.
<table>
<thead>
<tr>
<th>Tipo de vidrio</th>
<th>Proyecto:</th>
<th>Tipo de Edificio:</th>
<th>Localización de la Ciudad:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esquema 9 : 34</td>
<td>santa monica 2</td>
<td>SINGLE FAMILY RESIDENCE</td>
<td>Santa Monica</td>
</tr>
</tbody>
</table>

**Tipo de Marco:**
- Aluminio sin barrera térmica, ventana operable
- Ventana operable de madera o vinilo

**Ventana de vidrio con marco de madera o vinilo:**
- Paño simple de vidrio claro 1/8" en marco de madera/vinilo (U=.40 SHGC=.64 Tvis=.66)
- Doble paño vidrio en marco de madera/vinilo (U=.51 SHGC=.52 Tvis=.57)
- Doble paño vidrio claro baja emisividad en marco de madera/vinilo (U=.40 SHGC=.40 Tvis=.64)
- Doble paño vidrio claro baja emisividad encuadrado en marco de madera/vinilo (U=.39 SHGC=.28 Tvis=.61)
- Doble paño de cristal baja emisividad con Argon encuadrado en marco de madera/vinilo (U=.36 SHGC=.28 Tvis=.64)
- Vidrio doble paño oscuro en marco de madera/vinilo (U=.51 SHGC=.36 Tvis=.45)
- Baja emisividad doble paño oscuro en marco de madera/vinilo (U=.40 SHGC=.30 Tvis=.45)
- Baja emisividad doble paño oscuro encuadrado en marco de madera/vinilo (U=.39 SHGC=.21 Tvis=.33)
- Oscuro doble paño reflectivo (SS) en marco de madera/vinilo (U=.51 SHGC=.13 Tvis=.08)
- Triple paño cristal en marco madera/vinilo (U=.39 SHGC=.46 Tvis=.51)

Nota: Estos son únicamente valores para el software. Los valores de ventana se pueden obtener en ASHRAE 2007 Cap. 31; para acristalamiento doble o triple incluye vidrio 1/4" con cámara de aire de 1/2". El vidrio acristalamiento tiene azul-verde en el exterior, claro en el interior, ss es de acero inoxidable.
HEED Contacts for help
HEED can be downloaded at no cost from:

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

Our other Design Tools can be downloaded from

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

Contact Murray Milne at: milne@ucla.edu
Pablo La Roche at: pmlaroche@csupomona.edu
Carlos F. Gomez: cfg83@earthlink.net

The current version of HEED was funded by the California Energy Commission. It was developed by the Energy Design Tools Group at the UCLA Department of Architecture with the cooperation of Bill Beckman at the University of Wisconsin.
Climate Consultant & other tools
Climate Consultant analyzes over 1000 stations worldwide.
Climate Consultant identifies best design strategies

Design Strategies: January through December

1. Comfort (475 hrs)
2. Sun Shading of Windows (1460 hrs)
3. High Thermal Mass (459 hrs)
4. High Thermal Mass Night Flushed (483 hrs)
5. Direct Evaporative Cooling (146 hrs)
6. Two-Stage Evaporative Cooling (229 hrs)
7. Natural Ventilation Cooling (731 hrs)
8. Fan-Forced Ventilation Cooling (722 hrs)
9. Internal Heat Gain (3025 hrs)
11. Passive Solar Direct Gain High Mass (3332 hrs)
12. Wind Protection of Outdoor Spaces (0 hrs)
13. Humidification (4 hrs)
14. Dehumidification (208 hrs)
15. Cooling, add Dehumidification if needed (187 hrs)
16. Heating, add Humidification if needed (1277 hrs)

100.0% Comfortable Hours using Selected Strategies (8760 out of 8760 hrs)
OPAQUE calculates U, R, time lag, and decrement factor.
SOLAR-2 evaluates window and sunshade designs.
Comparison of Results (yearly cost)

- Base Case
- More Energy Efficient
- Energy Use
- Cost of Energy Total (dollars/year)
HEED technical papers

Are available for download:
http://www.energy-design-tools.aud.ucla.edu/papers.html
Informes de la Construccion, January 2010

Solar Today, May 2010
http://www.solartoday-digital.org/solartoday/201005#pg44

Recent papers w HEED

HEED California Workshops 2010
Emissions Sources in Residential Building Design

By Pablo La Roche, Ph.D., LEED AP, Associate AIA
Published: April 26, 2010

To calculate emissions for a model home in the four predominant U.S. climates, we made some assumptions for each of the types of carbon emissions. (See "Design Strategies for Low Building Emissions" in the May 2010 SOLAR TODAY.)

Operation. Emissions from operation include all sources that require energy to keep the building and everything inside it running. They can originate from energy used directly at the site (such as natural gas) or at the power plant (electricity) to run heating and cooling equipment, lighting and appliances. These emissions are calculated by determining the energy consumption and then multiplying by a carbon dioxide conversion factor. Any of several methods can be used to determine this conversion factor, which varies by region, time of day and season. Because different locations use power from different sources at different times, which would further muddle the numbers by introducing another variable, we used the same conversion factors for electricity and gas in all climates: 1.36 lb of CO2 per kilowatt-hour (kWh) electricity (U.S. average, per eGRID2006 Version 2.1 Summary Tables) and 0.42 lb of CO2 per kilowatt hour (11.97 lb CO2e per therm) for natural gas, the value proposed by the UK Department for Environment Food and Rural Affairs.[MEED: or Home Energy Efficient Design] is an energy-analysis tool we used to predict energy use in the four locations, which we then multiplied by this conversion factor to determine GHG emissions.

Construction. Greenhouse gas (GHG) emissions from construction processes are usually generated during the fabrication and transportation of the materials used in the building and during construction of the building. They are challenging to calculate due to the difficulty in determining how much energy is used to fabricate and transport the materials or how much of these materials are used in the building, which must then be multiplied by a multitude of conversion factors to determine total emissions. We calculated emissions for construction using BuildCarbonNeutral.org, a simple calculator that provides

Solar Today: