Teaching Architecture + Energy

Hosted by Washington University in St. Louis

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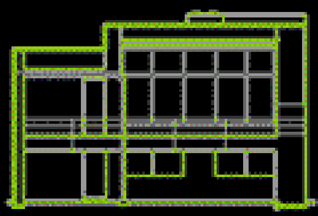
Welcome to the Teaching Architecture + Energy project at Washington University. This site is part of a collaborative network of energy technology teachers in architecture schools, sponsored in part by the U.S. Dept. of Education . Our goal is to make it easier for architecture students to understand energy concepts and to design energy efficient buildings. The curricula developed here and at other universities is centered around Energy Scheming, a energy simulation tool that helps the student think about energy as an integral part of building design.

Climate:
context for design

Exercises:
"recycling with energy scheming"

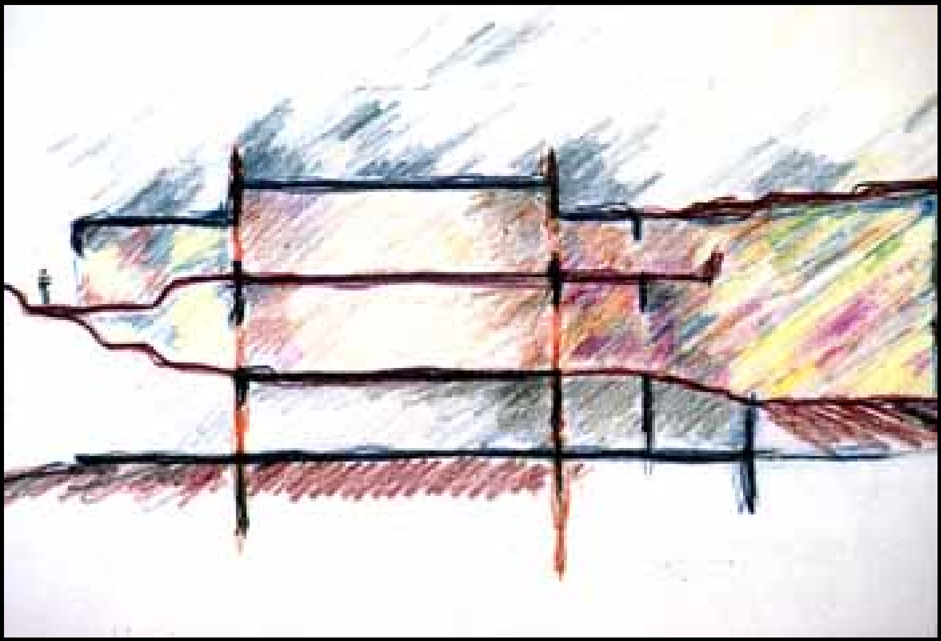


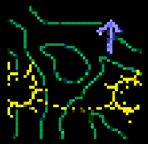
Example:
shanley building

Student Work

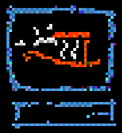
Legal Disclaimer

RECYCLING WITH *ENERGY SCHEMING*: Schematic Design & Performance

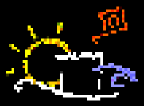




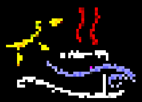
TERRAIN MAP: outline of exercise



A. DOCUMENTING: input your building



B. DEFINING: take-offs and specifications



C. ANALYZING: understanding energy patterns

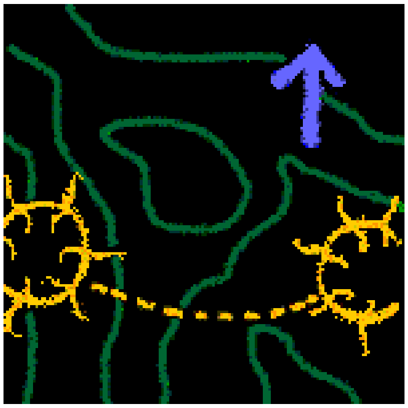
D. RE-DESIGNING: 'generate and test' cycles

E. EVALUATING: energy codes as indicators

Download the PDF vertion of the exercise

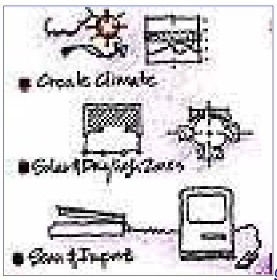
RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

TERRAIN MAP: outline of exercise



OVERVIEW

In this exercise, a schematic design developed in a design studio class, or a case study building is evaluated for its performance using the computer software, "Energy Scheming." Using feedback about your building's patterns of energy use, you then redesign the building, alternating between proposing new solutions and testing them, until the design meets the performance targets that you have set. In the last part, you can also compare the performance of your design to that of a building specified by energy codes.

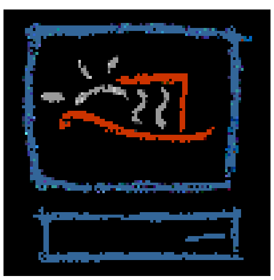


graphic outline

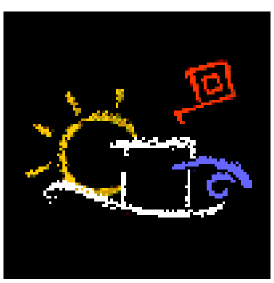
Objective:

- To gain experience with a design tool that can help architects to verify the quantitative thermal implications of non-thermal design decisions, and to explore the non-thermal design potentials latent in passive design.
- To understand the relationships between architectural form and its energy and lighting performance.
- To develop a process of cyclic architectural design that incorporates issues of energy and lighting.

A. DOCUMENTING: input your building

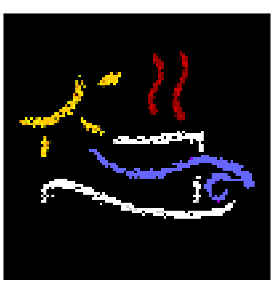


1. Assemble Schematic Plans and Elevations of Your Design
2. Identify the Building's Construction Type(s)
3. Diagram the Solar Concept
4. Determine Your Simulation Strategy
5. Diagram the Daylighting Zones
6. Get the Drawings into the Computer
7. Create a New Climate, if necessary



B. DEFINING: take-offs and specifications

1. Tuning Settings to Fit Your Building
2. Define Your Daylight Zone Icon
3. Set Performance Goals for Lighting and Heating
4. Create Plan Specifications
5. Create Elevation Specifications

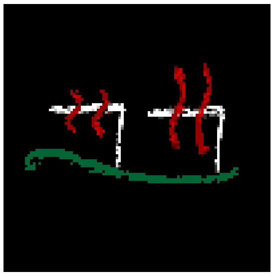


C. ANALYZING: understanding energy patterns

1. Use the Rule-of-Thumb Window Sizer
2. View the Graphic Report
3. Interpret and Assess the Building's Performance

D. RE-DESIGNING: generate and test cycles

1. .Re-Design to Meet Your Window Performance Targets
2. Re-Design to Reduce Net Flows and Peak Loads
3. Print the "Energy Performance Report"
4. Document Design Changes



E. EVALUATING: comparing with energy codes

1. Setting an Energy Budget: a range of values
2. Choosing Reference Criteria
3. Model Your Reference Case Building
4. Compare the Performance of the Two Designs

Download the PDF version of the exercise

General Notes:

- Your studio project is the recommended vehicle for this assignment. You may choose a pre-designed "case study" building, if the assignment requirements do not match the development of your project or if the content is somehow inappropriate to the nature of your project. If you choose to use a "case study approach," you will still need to "renovate" the existing design to achieve contemporary performance standards and engage the issues of solar heating, natural ventilation and daylighting, while preserving the building's design intentions and quality.
- Remember that the character and quality of the space that you create is important. You can not afford to lose the Vision of the project. The quantitative performance methods must support and improve your conceptual approaches. They set boundaries, but do not limit your creativity. It is certainly more challenging to design with energy and lighting in mind!

Grading Criteria

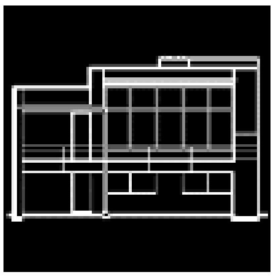
RECYCLING WITH *ENERGY SCHEMING*

TERRAIN MAP | DOCUMENTING | DEFINING | ANALYZING | RE-DESIGNING | EVALUATING

A. DOCUMENTING: import your building

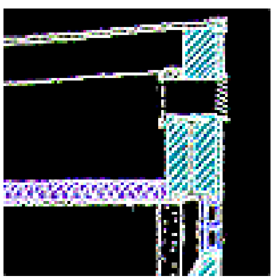
In Part A of this exercise, you assemble schematic plans and elevations of your design, identify the building's construction types, diagram the solar concept and daylighting zones, decide on a strategy for what part of your building to model, and import your design drawings into *Energy Scheming.*

Before you start read chapters One and Two of the *ES Manual*.



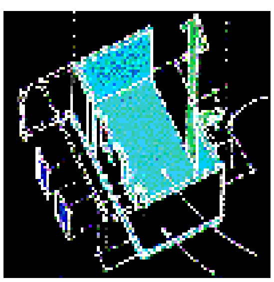
1) Assemble Schematic Plans and Elevations of Your Design

You ONLY need plan and elevation drawings to do take-offs in ES. While section drawings will definitely help you to design, ES does not make use of section information, so you do not have to import section drawings.



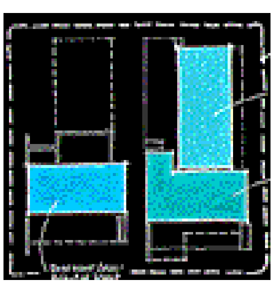
2) Identify the Building's Construction Type(s)

You should have a general idea of what construction assemblies you are using, although details of every part of the building are not required. Later, when you specify elements in ES, you will need to determine the construction of all floor, wall, roof, and window assemblies.



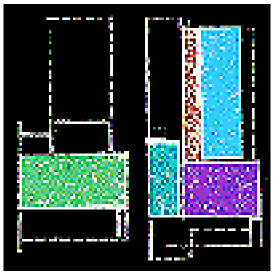
3) Diagram the Solar Concept

Understanding how your building's design impacts its ability to use solar energy is critical to knowing how to model it with a simulation program like Energy Scheming. One needs to understand the building's 'Solar Concept.'



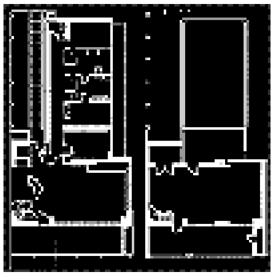
4) Determine Your Simulation Strategy

Before beginning to use ES, you need to develop a logic, using your understanding of your building's solar zones, for how you will evaluate your building's performance. In some cases, such as small or single occupancy buildings, this is appropriate. In other cases, it may not be and you may need to choose one part of the building to analyze.



5) [Diagram the Daylighting Zones]

Zoning for daylight allows the designer to size windows to match the daylight goals in different parts of the building. A Daylight Zone is an area of the building with similar needs for lighting (low or high daylight factor?) and a similar formal configuration.



6) [Get your drawings into the computer]

There are four basic options for getting drawings into *Energy Scheming.*

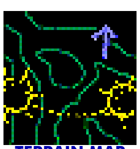
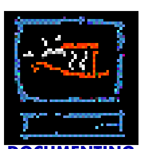
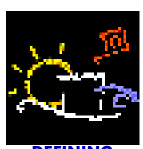
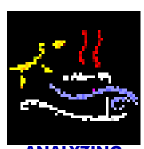
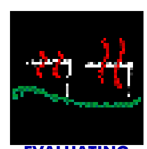
- Scan and import each drawing separately
- Paste up drawings on a single page and scan it
- Paste images into *Energy Scheming*
- Sketch your design in Energy *Scheming*

7) [Create a New Climate, if necessary]

ES comes with four built-in climates. Your instructor may have created additional climates for this assignment. Alternatively, you may need to create a new climate file in ES for your specific project.

[Part A Grading Criteria]

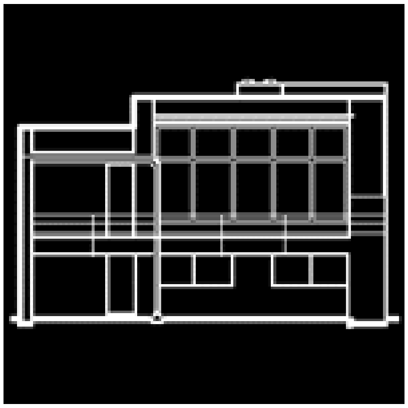
RECYCLING WITH *ENERGY SCHEMING*

TERRAIN MAP | DOCUMENTING | DEFINING | ANALYZING | RE-DESIGNING | EVALUATING

A. DOCUMENTING: import your building

assemble drawings



shanley example

1) Assemble Schematic Plans and Elevations of Your Design.

You ONLY need plan and elevation drawings to do take-offs in ES. While section drawings will definitely help you to design, ES does not make use of section information, so you do not have to import section drawings.

The drawings must be TO SCALE. They may be hand drawn sketches or done in any computer drawing program that will output as a PICT or TIFF format image file.

market building example

PLAN drawings should indicate room areas, although all openings do not have to be located.

ELEVATION drawings must show a preliminary design for window and door openings. Elevations with extensive curves (where the projection area of the curve in the plane of the elevation is significantly smaller than the actual area of the curved wall) should be drawn as "unrolled" flat elevations. In general, you will need all of the major elevations, but buildings with more complex geometries (for instance, extensive use of 45° walls) should have "straight on" elevations of each side.

Ignore party walls, as heat flow to attached, adjacent conditioned buildings is insignificant.

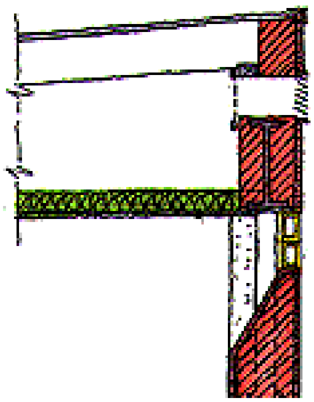
Turn in: Plans of all floors, complete elevations, and at least one building section. These drawings can be diagrammatic as long as they are to scale and show all the important thermal elements. Do this ON PAPER, not in ES. For a guide, see *shanley example*

Jump to the next section: **Identify the Building's Construction Type(s)**

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

A. DOCUMENTING: import your building

construction types



[shanley example](#)

2) Identify the Building's Construction Type(s).

You should have a general idea of what construction assemblies you are using, although details of every part of the building are not required. Is it a wood or concrete structure? Is the floor on grade or over a crawl space? Are you using thin walls with rigid insulation or thick walls with batt insulation? Etc.... Later, when you specify elements in ES,you will need to determine the construction of all floor, wall, roof, and window assemblies.

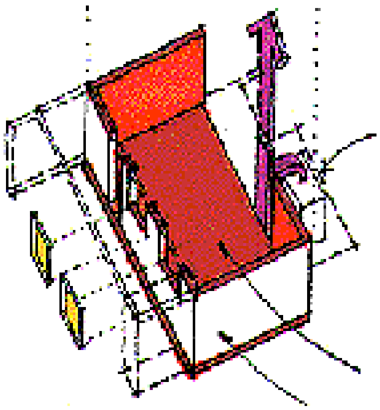
Turn in: A typical wall / floor / roof section. These drawings can be diagrammatic as long as they are to scale and show all the important thermal and construction elements. Do this ON PAPER, not in ES. For a guide, see the *shanley example*.

Jump to the next section: **Diagram the Solar Concept**

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

A. DOCUMENTING: import your building

solar concept



shanley example

3) Diagram the Solar Concept.

Understanding how your building's design impacts its ability to use solar energy is critical to knowing how to model it with a simulation program like *Energy Scheming*. One needs to understand the building's 'Solar Concept.' In this part of the exercise, think about how heat is collected, stored, and distributed. For this purpose, we will consider the building's 'Solar Zones.'

A Solar Zone, for the purposes of this assignment is defined as an area of occupied space, together with its associated solar collection area and thermal storage. A particular area of solar collection aperture is always associated or serves a particular area of floor space within the building. If two parts of the building are isolated from one another and thus can not exchange heat, they must be considered separate solar zones unless they are linked by supplemental ducts and fans. The solar aperture (collection area) of each zone would then need to be designed proportional to the heating load and floor area of the respective zones.

For instance, in a double loaded corridor dormitory facing south, the south rooms have direct gain potential through windows, so heat can be collected and stored within the room. Whereas, the corridor and north side rooms have no direct access to solar heat collected on the south, and thus are a separate solar zone. In diagramming such a building, you would want to think about how to get heat to the north side rooms, probably either through the roof (skylights, dormers, clerestories) or by moving hot air with fans from say, a thermal storage wall on the south side, to rooms on the north.

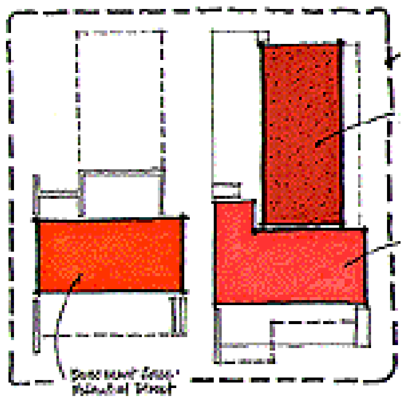
Turn in: Diagrams of your building's solar concept. Diagram the solar zones for the building three dimensionally. For each solar zone, show the collection aperture, the associated thermal storage, and the associated floor area. Do this ON PAPER, not in ES. For a guide, see the *shanley example*.

Jump to the next section: Determine Your Simulation Strategy

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

A. DOCUMENTING: import your building

simulation strategy



shanley example

4) Determine Your Simulation Strategy

Before beginning to use ES, you need to develop a logic, using your understanding of your building's solar zones, for how you will evaluate your building's performance. ES treats the entire building as a single thermal zone. It assumes that heat collected in one part of the building can be used to offset losses in another part of the building. Thus, it is a schematic design tool that gives you schematic level performance information. In many cases, such as small or single occupancy buildings, this is appropriate. In other cases, it may not be and you may need to choose one part of the building to analyze.

Decide whether you will treat your design as one thermal zone or multiple thermal zones. *Energy Scheming* can handle only one solar zone per building file. This choice should be based on the following considerations:

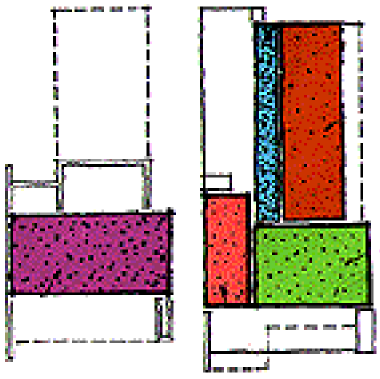
- ***For buildings early in the design process***
  Treat the building as a single zone for a design early in the process of development. If you do not have detailed information about your building, then it is most appropriate to use a single ES file and treat the whole building as one zone. The abstraction of a single zone will still give you useful feedback for your design decisions, even if the building is quite complex.
- ***For very large, complex, or repetitive buildings***
  The building may need to be broken down into several zones.
  - If you have a *high rise building with repetitive floors,*
    you may evaluate just a typical floor.
  - If you have an *extruded, repetitive bay building,*
    you may choose to evaluate just a typical section or bay.
  - If you have a *highly thermally complex building,*
    where heat can not be easily transferred from one zone to another (for instance, an auditorium and a set of hotel rooms, a bagel kitchen and a warehouse, or a black box with tiny windows and a glass box), then you will need to choose one part to evaluate in ES. Although several zones may be appropriate for your design, for the purposes of this assignment, choose one *major* thermal zone to use in ES. If you follow this path, choose the *most significant portions* of your building.
- ***For small buildings,***
  make the whole building a single zone and thus evaluate the building's energy performance in *Energy Scheming* as a single ES file. This is the approach used in the example building, one that is appropriate for the majority of buildings encountered.
- ***For "disaggregated" schemes***
  If the design calls for discreet parts, such as a set of freestanding pavilions connected by outdoor circulation, then you will want to use multiple zones because you essentially have different buildings which can not share heat gains and losses.

Turn in: A diagram of your simulation strategy, showing the building's thermal zones and which part of the building you will be analyzing in ES. This is a fairly important decision and your instructor will want to check your assumptions, so that the rest of your work will give you useful design feedback. Remember that most buildings at the schematic design stage will be fine treated as a single ES file; you should vary from this rule only if you have good cause to think that a single file will be too abstract. Do this ON PAPER, not in ES. For a guide, see the *shanley example*

Jump to the next section: **Diagram the Daylighting Zones**

A. DOCUMENTING: import your building

daylight zones



shanley example

5) Diagram the Daylighting Zones.

Zoning for daylight allows the designer to size windows to match the daylight goals in different parts of the building. A Daylight Zone is an area of the building with similar needs for lighting (low or high daylight factor?) and a similar formal configuration.

Energy Scheming, the designer may define multiple daylight zones (up to five) within each ES file. In a small building, each zone may represent a room. In a larger building, each zone will represent several rooms of similar character with respect to lighting. For example, a typical architecture school might be divided into zones for 1) brightly lit studios; 2) moderately lit office spaces; 3) internal corridors with no windows; 4) a computer lab with a specific lighting strategy; and 5) classrooms. Distinguish daylight zones by their difference in the desired daylight factor (DF). Group rooms into zones based on their similar need, similar format, and/ or contiguousness.

There are a couple of unique cases to consider also:

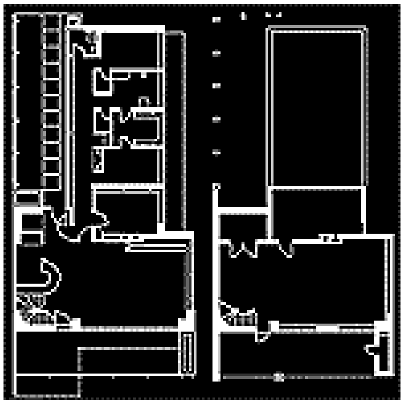
- ***Sunspaces and Atria***
  If your building has a sunspace or atrium, make it a separate daylight zone. These areas typically have very high light levels, so you do not want windows in these zones to be averaged with windows in zones where the lighting level is more critical.
- ***Thermal Storage Walls***
  A thermal storage wall, such as a water wall or Trombe wall should be treated as a separate daylight zone in ES, so that its glazing area can be separated in daylighting window sizing. Since all solar gain in ES is defined in window specifications, if the thermal storage wall is kept separate, its daylight will not be counted in the occupied space zones.

Turn in: a plan diagram of your building's five daylight zones and the daylight factor (DF) target for each zone. For DF targets, see SWL, strategy 59, WINDOWS: Size, pp. 127-129. Do this ON PAPER, not in ES. For a guide, see the *shanley example*.

Jump to the next section: Get the Drawings into the Computer

A. DOCUMENTING: import your building

import drawings



shanley example

6) Get your drawings into the computer.

There are four basic options for getting drawings into *Energy Scheming.* If you are designing on paper, you can scan and import each drawing separately . Alternatively, you can paste up drawings on paper into a single page which can be scanned. Thirdly, if you are designing on a computer, you can import PICT or TIFF images to *Energy Scheming.* Finally, you can sketch your design directly in the *Energy Scheming* drawing window.

Plans and elevation can be simplified, if necessary to retain clarity, to diagrams representing massing and solid/voids. But, in general, it will keep your design issues more in the fore if you work with drawings that are not too abstracted. The information required in elevations is more detailed than that for plans, so elevations should be more detailed and larger in ES than plans.

Options for Paper Drawings

A. Single Import File

If you are in the very early stages of design, you can photocopy reduce and paste up all of your drawings onto a single page and then scan the page into Photoshop for use in ES. This is the easiest and fastest way to get drawings into ES. You should start with good copies of high contrast.

B. Multiple Import Files

If you are farther along in your design, you will (usually, but not necessarily) want to scan each drawing separately. In this case, each individual drawing must be reduced to a single page and then scanned and used to create an ES input file.

Options For Computer Drawings

C. Import CAD Drawings

If you are creating the plans and/or elevations in a computer application, your images should be saved as 2-D TIFF or PICT format, which ES can import. You may work in whatever software with which you are comfortable.

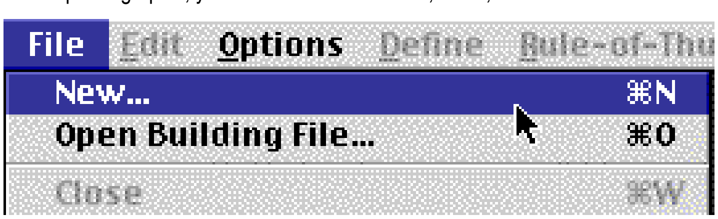
D. Draw in Energy Scheming.

You may draw the building to scale in the ES drawing window and avoid importing. This probably only makes sense if your building is VERY schematic and simple. The drawing tools really work better to make minor modifications to an existing drawing, rather than drawing a building from scratch.

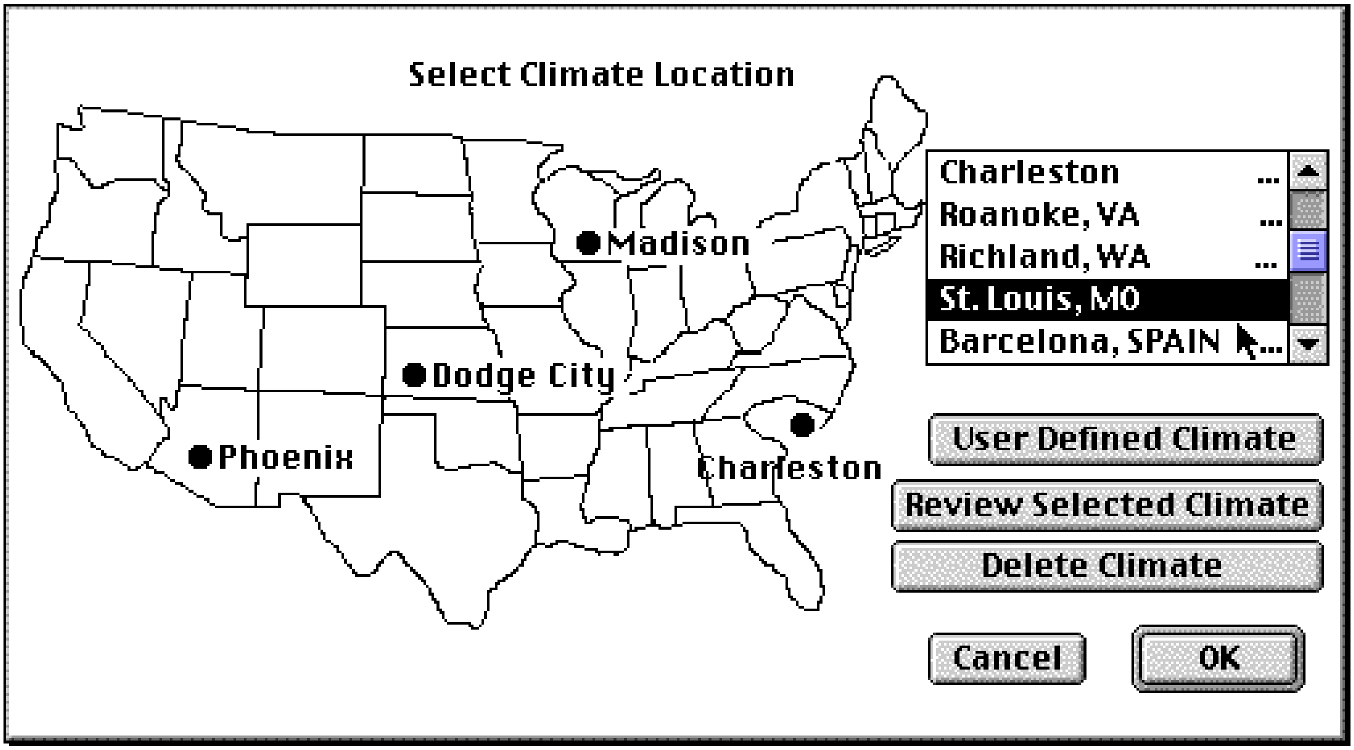
See the section, "Building Drawings" in Chapter 5 of the ES manual for help.

Creating a New ES File

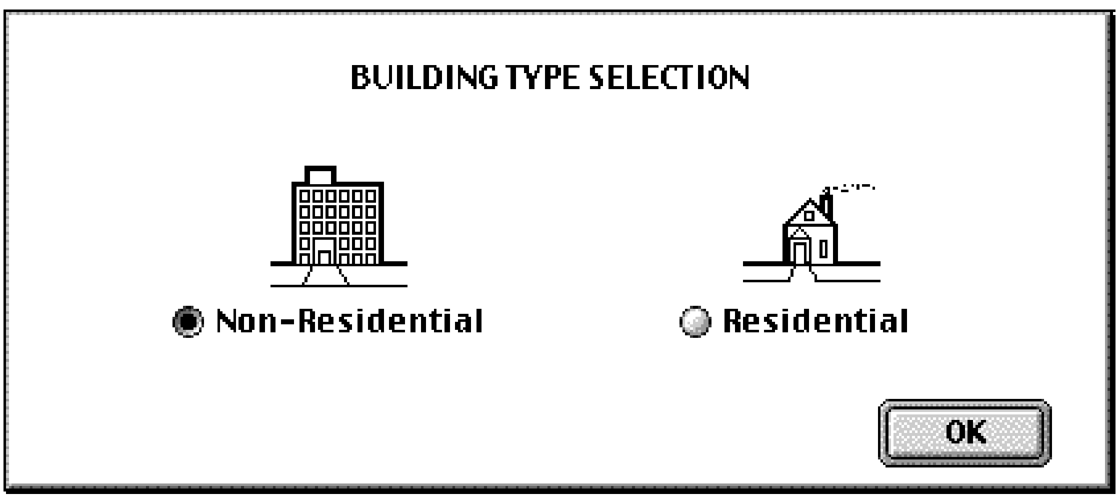
Before you can import a graphic, you must first create a new, blank, ES file. To create a new file, choose the "File / New..." menu:



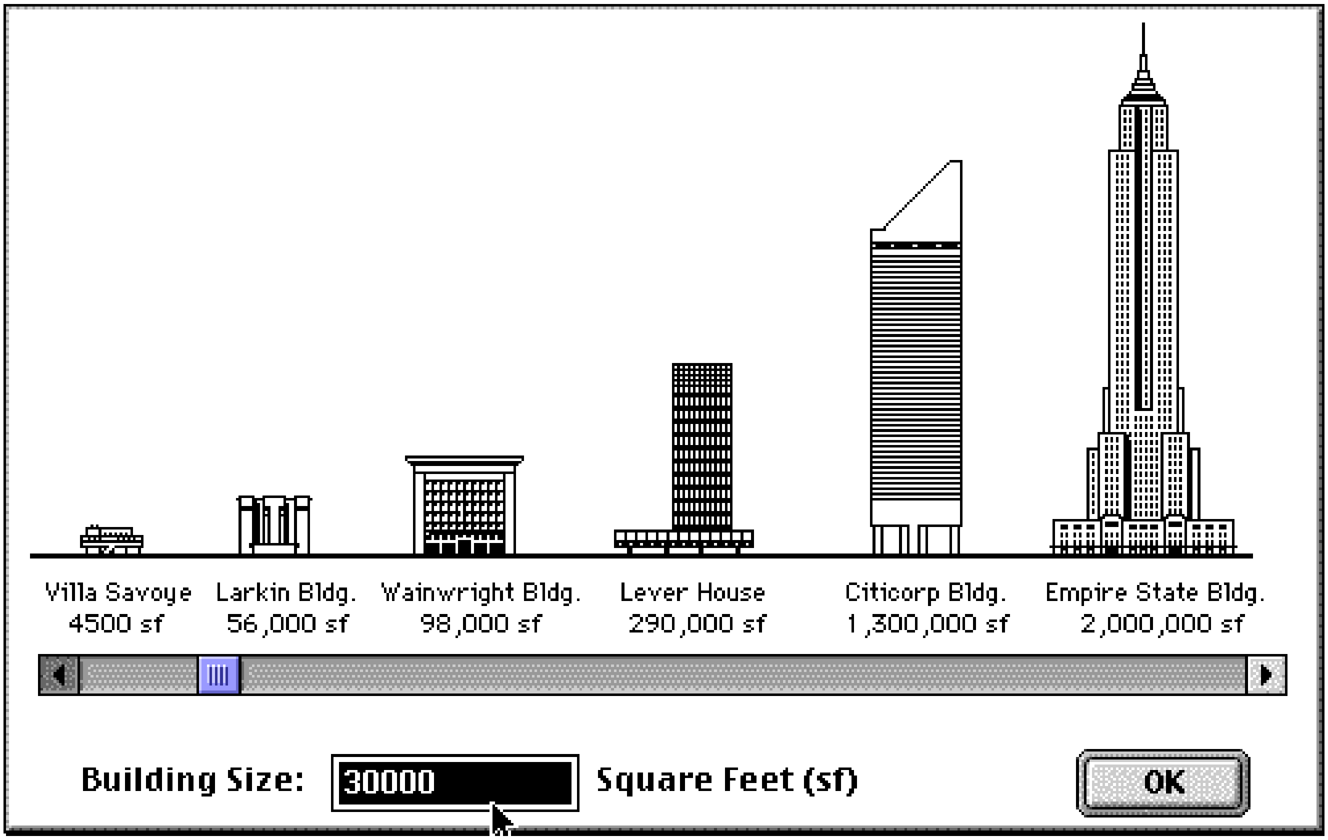
When creating a new ES building file, you must select a few settings. The first screen asks you to locate the building site in a climate. Scroll to choose the closest match for your site. If there is no appropriate climate, you can set one up later. If this is the case, just pick any climate for now. Then click OK.



The next screen asks you to choose between Non-Residential and Residential building types. ES will use this information to set certain defaults for things like occupancy schedules. Click on the appropriate radio button, then click OK.

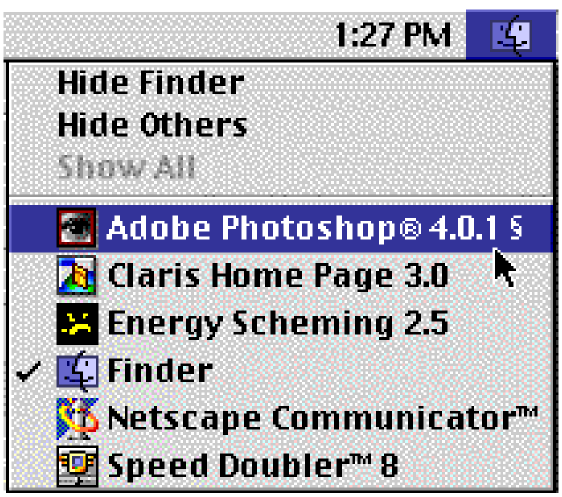


Finally, you will need to input the total square footage of the building or part of the building that you are analyzing. Be sure that if you are using ES to design only one part of your building, such as a typical floor or bay, you input the floor area for that part and not for the whole building. ES uses this information when calculating several things, including your feedback for solar heating in the rule-of-thumb window sizer. Set your size using the scroll bar or type the exact size, then click OK.



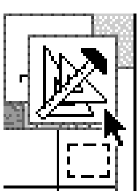
Import Your Drawings

Use the finder icon (far upper right) to switch back to your drawing or imaging program. "Select" (all) and "Copy" (under EDIT menu) your drawing from the draw/image image program.



Use the finder again to switch back to ES (make it active in the front). Make sure the drawing layer in ES is active by selecting the triangle and T-square icon. Make one click with the mouse inside the active drawing window of ES.

Choose "Paste" (under the EDIT menu) to import your composite drawing file to ES. If your drawing is bigger in any dimension than the ES drawing window, you may be asked to choose for ES to scale your drawings to fit its window.



You should see a dashed box around the drawings. Before doing anything else, scroll around the ES drawing window to be sure all the drawing is visible in the window. Drag the box to where you want it, leaving some white space on the *left side*, if possible (so take-off icons will be easily visible later). When you click outside the box, the drawing is converted to a pixel based "paint" or "bitmap" format. You can then sketch over it with the ES drawing tools, use the eraser tool, etc. You may want to darken some major lines or use the rectangle tool to define windows, if necessary.

Save and Back-up

You are ready to begin using *Energy Scheming*. SAVE and BACK-UP your work. Right now, make a second copy of the ES file you just created. If anything goes wrong or you lose the file, you will have a place to start over. You should have at l;east two copies of your work. At least one of these should be on a portable media you control, such as a zip disk.

Turn in:

A print out of the Energy Scheming drawing window showing your drawing input file. For a guide, see the *shanley example*.

Jump to the next section: **Create a New Climate**

A. DOCUMENTING: input your building

working with a single import file

A. Single Import File. If you are in the very early stages of design, you can photocopy reduce and paste up all of your drawings onto a single 8-1/2 x 11 page and then scan in a single page to Photoshop for use in ES This is the easiest and fastest way to get drawings into ES. You should start with good copies of high contrast.

i. First photocopy reduce and paste up your drawings onto a single page. Since your drawing will end up as a bitmap image (all black and white pixels), make sure that your originals are high contrast with no light pencil lines. A black felt pen (medium or bold lines, not fine point) drawing will show up well in ES.

ii. Scan each of the drawings into Photoshop. You can preview the scan and select only the part of the drawing that you need. This makes scanning faster and file size smaller. It may be best to scan in grayscale, unless your original is a ink line art. Color is not required and many Photoshop adjustments can not be made to line art (high contrast bitmap). Scanning at high resolutions is not necessary. Eventually, your images will end up as 72 dpi bitmaps in ES. Since you may need to resize your images, scanning at 150 dpi and resizing or reducing the resolution later is a good idea.

Adjust and tune your images as necessary. In Photoshop, you can "Crop," to save only the drawing portion of you file; "Rotate," to correct for any misalignment of the drawing as scanned; "Sharpen," to make lines crisper, or "Adjust Levels "to tune your values, eliminate gray backgrounds and darken lines, as necessary.

After your images are tuned and look good, resize each image to no more than 7" wide at 72 dpi. A long elevation at 7" wide leaves a little space in ES for the icons that appear down the left side of your screen. To resize your image, use the "IMAGE / Image Size" menu. ES 3.0 has a larger drawing window about the size of an 11x17 page, so drawings may be much wider than in earlier versions. Still if you have enough detail in the 7" wide drawings, smaller drawings will save you lots of scrolling around in ES later.

Save each scanned image to your home account and to portable media such as a zip disk. Be sure to save as 72 dpi BITMAP. To convert to bitmap, chose Bitmap from the Mode submenu on the Image menu (Image>Mode>Bitmap) and set to 50% threshold, do not dither. Keep your images on file, even after your ES file is created. You may need the backup.

iii. Return to the import drawings page to complete the process.

---

back to import drawings

A. DOCUMENTING: input your building

working with multiple import files

B. Multiple Import Files. If you are farther along in your design, you will (usually, but not necessarily) want to scan each drawing separately. In this case, each individual drawing must be reduced to 8-1/2 x 14 or the largest size your scanner will take, then scanned and used to create an ES input file.

i. Each drawing must be reduced to a size that can be scanned (about 8-1/2 x 14). Photocopy reduce as necessary to get to a size that can be scanned. Since your drawing will end up as a bitmap image (all black and white pixels), make sure that your originals are high contrast with no light pencil lines. A black felt pen (medium or bold lines, not fine point) drawing will show up well in ES.

ii. Scan each of the drawings into Photoshop. You can preview the scan and select only the part of the drawing that you need. This makes scanning faster and file size smaller. It may be best to scan in grayscale, unless your original is a ink line art. Color is not required and many Photoshop adjustments can not be made to line art (high contrast bitmap). Scanning at high resolutions is not necessary. Eventually, your images will end up as 72 dpi bitmaps in ES. Since you may need to resize your images, scanning at 150 dpi and resizing or reducing the resolution later is a good idea.

Adjust and tune your images as necessary. In Photoshop, you can "Crop," to save only the drawing portion of you file; "Rotate," to correct for any misalignment of the drawing as scanned; "Sharpen," to make lines crisper, or "Adjust Levels "to tune your values, eliminate gray backgrounds and darken lines, as necessary.

After your images are tuned and look good, resize each image to no more than 7" wide at 72 dpi. A long elevation at 7" wide leaves a little space in ES for the icons that appear down the left side of your screen. To resize your image, use the "IMAGE / Image Size" menu. ES 3.0 has a larger drawing window about the size of an 11x17 page, so drawings may be much wider than in earlier versions. Still if you have enough detail in the 7" wide drawings, smaller drawings will save you lots of scrolling around in ES later.

Save each scanned image to your home account and to portable media such as a zip disk. Be sure to save as 72 dpi BITMAP. To convert to bitmap, chose Bitmap from the Mode submenu on the Image menu (Image>Mode>Bitmap) and set to 50% threshold, do not dither. Keep your images on file, even after your ES file is created. You may need the backup.

iii. On another computer, (leaving the scanner free) create a single document with all of your plans and elevations. This may be done in a variety of applications, including Photoshop and Canvas. Do not try this in PageMaker, because you can not export your files. This step may also be accomplished directly in Photoshop or you may choose to use any drawing, paint, or CAD program that will allow you to work with "objects." This is important because you will need to move the drawings around.

The point of this step is to arrange the appropriate plan(s) and elevations(s) into a single drawing of approximately 8-1/2 x 11 proportion (the proportion of the ES 2.5 drawing window or 11x17 for ES 3.0 and higher). You may need to resize the individual drawings (using either handles or a scaling command), to get them all to fit. Drawings may be turned vertically or horizontally if necessary. In general, you will want more detail in elevations than in plans, so the plans can be reduced to a rather small size if needed. Be sure to "Save" this composite import file to your home account and to portable media such as a zip disk. You may need it later.

iv. Return to the import drawings page to complete the process.

---

back to import drawings

A. DOCUMENTING: input your building

working with importing cad drawings

C. Import CAD Drawings.
If you are creating the plans and/or elevations on the computer, you can just follow instructions on Multiple Import Files page, beginning at step iii. Your images should be saved as 2-D TIFF or PICT format, which ES can import. You may work in whatever software you are comfortable with and may be able to complete the above steps from within your favorite package.

i. *Creating a single image file to import.*
Create a single document with all of your plans and elevations. This may be done in a variety of applications, including Photoshop and Canvas. Do not try this in PageMaker, because you can not export your files. This step may also be accomplished directly in Photoshop or you may choose to use any drawing, paint, or CAD program that will allow you to work with "objects." This is important because you will need to move that drawings around.

The point of this step is to arrange the appropriate plan(s) and elevations(s) into a single drawing of approximately 8-1/2 x 11 proportion (the proportion of the ES 2.5 drawing window or 11x17 for ES 3.0 and higher). You may need to resize the individual drawings (using either handles or a scaling command), to get them all to fit. Drawings may be turned vertically or horizontally if necessary. In general, you will want more detail in elevations than in plans, so the plans can be reduced to a rather small size if needed. Be sure to "Save" this composite import file to your home account and to portable media such as a zip disk. You may need it later.

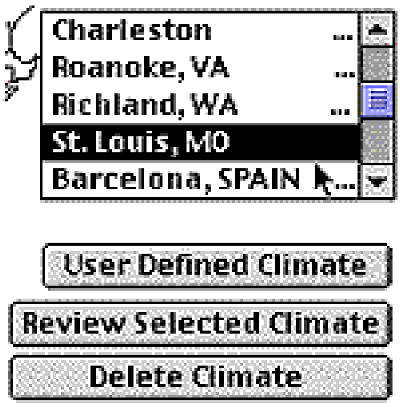
ii. Return to the import drawings page to complete the process.

---

back to import drawings

A. DOCUMENTING: import your building

create a climate



shanley example

7) Create a New Climate, if necessary
ES comes with four built-in climates. Your instructor may have created additional climates for this assignment. Alternatively, you may need to create a new climate file in ES for your specific project.

For specific instructions on how to input data for your climate, see the page on Creating New Energy Scheming Climate Files.

The climate database on this web site includes climate data for representative sites throughout the continental U.S., Alaska, Hawaii, and a few of the U.S. possessions. To find information about your climate, you can start with the main Climate page. Or, you can select from a list of cities for which ES climate data has been collected on the Climate Data for Energy Scheming page.

For a guide, see the *shanley example*.

Jump to the next section: **DEFINING Front Page**

EXAMPLE PROJECT

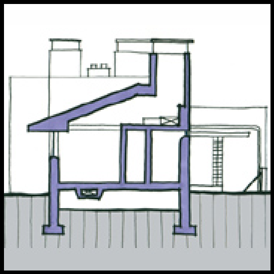
shanley dental building, clayton, mo

harris armstrong, architect, 1936

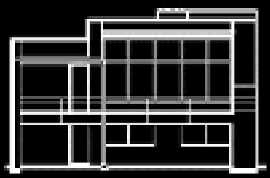
Worked Example

Re-Cycling with *Energy Scheming* exercise

Model



Final Drawings



Drawings

Site Photos

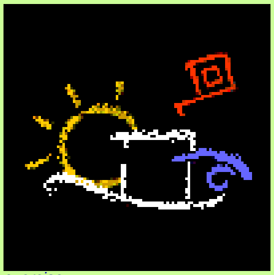
EXAMPLE PROJECT: example exercise

outline of example problem pages

exercise

A. DOCUMENTING: input your building (example)

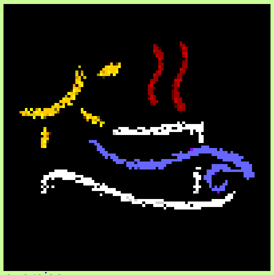
1. Assemble Schematic Plans and Elevations of Your Design
2. Identify the Building's Construction Type(s)
3. Diagram the Solar Concept
4. Determine Your Simulation Strategy
5. Diagram the Daylighting Zones
6. Get the Drawings into the Computer
7. Create a New Climate, if necessary



exercise

B. DEFINING: take-offs and specifications (example)

1. Tune Settings to Fit Your Building
2. Define Your Daylight Zone Icon
3. Set Performance Goals for Lighting and Heating
4. Create Plan Specifications
5. Create Elevation Specifications



exercise

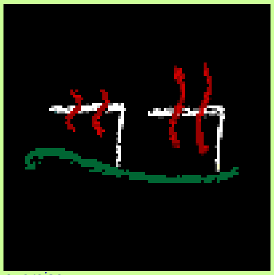
C. ANALYZING: understanding energy patterns (example)

1. Use the Rule-of-Thumb Window Sizer
2. View the Graphic Report
3. Interpret and Assess the Building's Performance

exercise

D. RE-DESIGNING: generate and test cycles (example)

1. Re-Design to Meet Your Window Performance Targets
2. Re-Design to Reduce Net Flows and Peak Loads
3. Print the "Energy Performance Report"
4. Document Design Changes



exercise

E. EVALUATING: comparing with energy codes (example)

1. Set an Energy Budget
2. Choose Reference Criteria
3. Model Your Reference Case Building
4. Compare the Performance of the Two Designs

PDF Download the PDF version of the exercise

RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

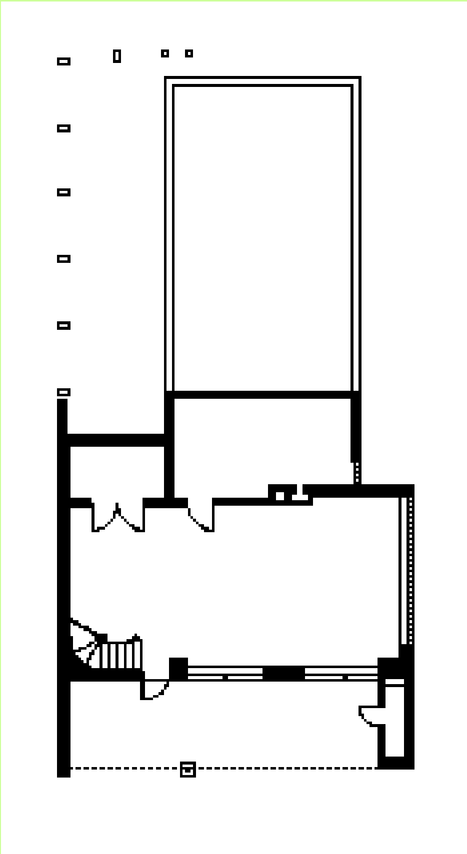
A. DOCUMENTING: input your building

drawings

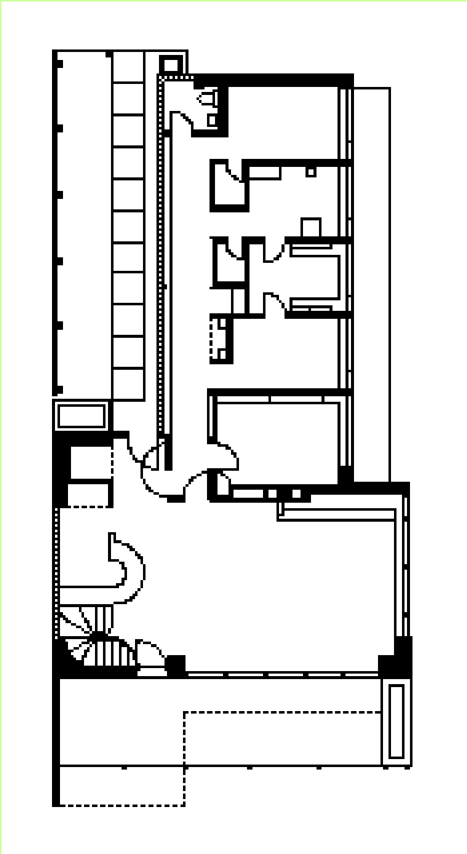
exercise

1) Assemble Schematic Plans and Elevations of Your Design.

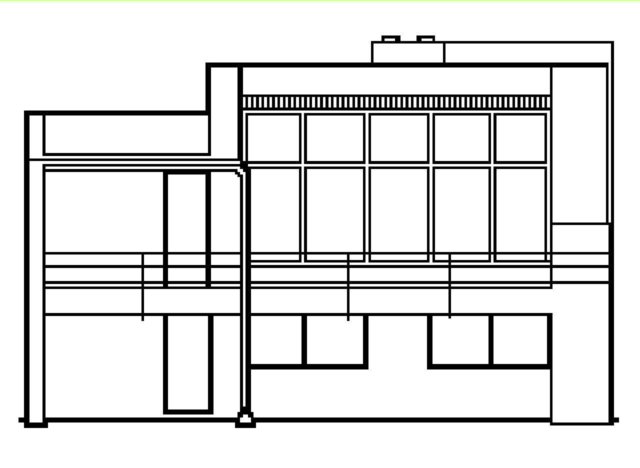
market building example



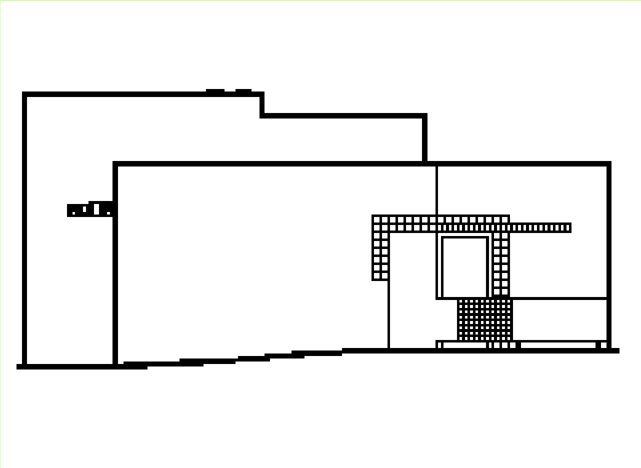
Basement Floor Plan



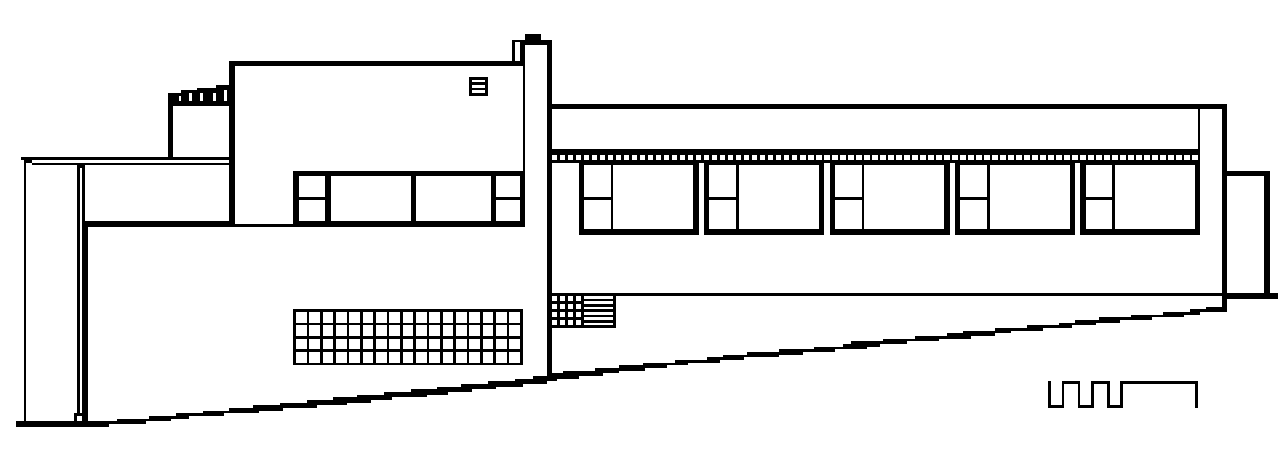
Main Floor Plan



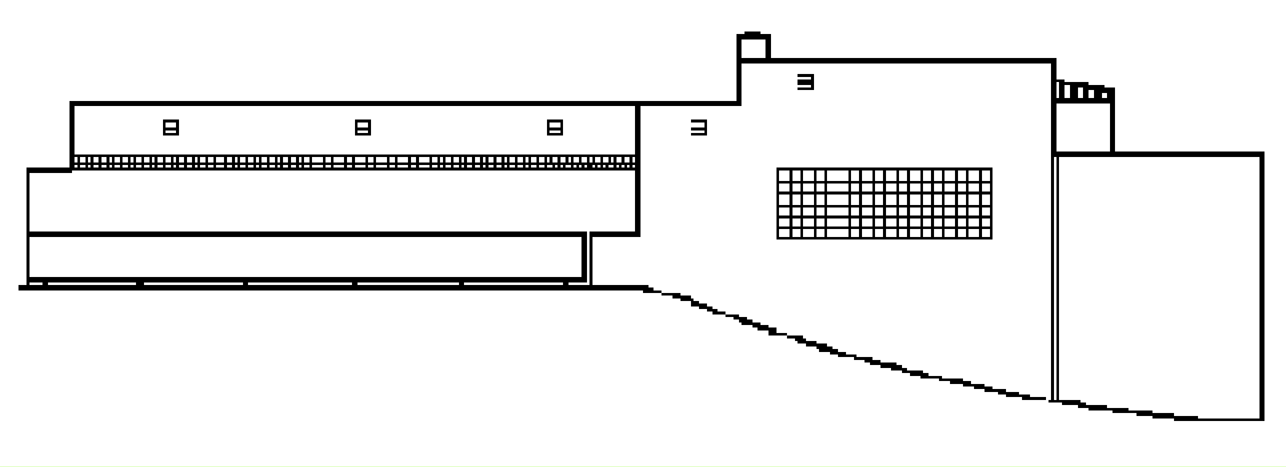
South Elevation



North Elevation



East Elevation



West Elevation

Jump to the next EXAMPLE section: Identify the Building's Construction Type(s)

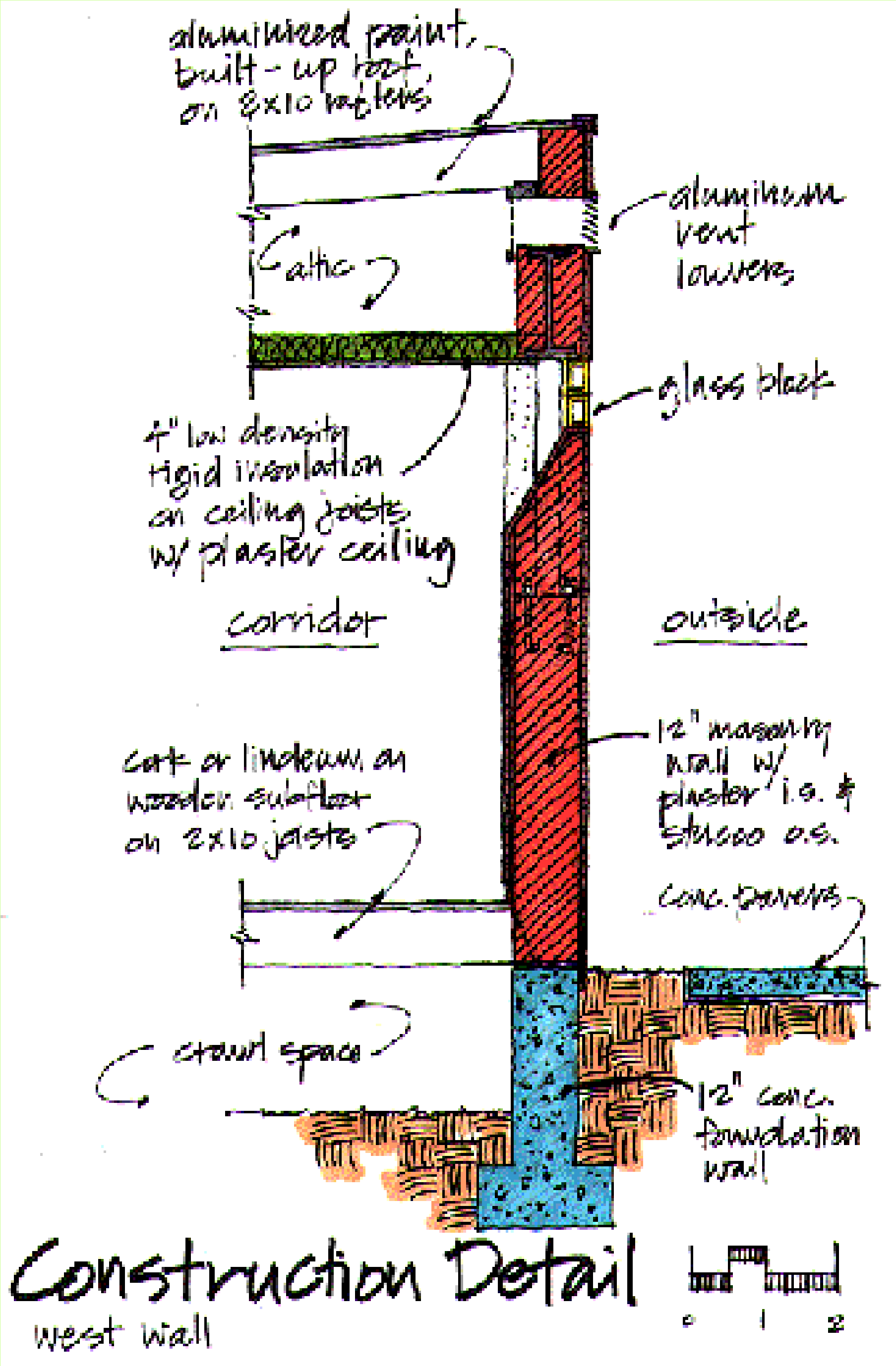
RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

A. DOCUMENTING: input your building

construction

2. Identify the Building's Construction Type(s)

exercise



Walls:
The Shanley building's walls are mostly uninsulated 8" concrete block with plaster inside and stucco outside. The section shown is the west wall that uses a thicker masonry wall, most likely concrete, but possibly brick or block. The sketch shows the graphic symbol hatching used by the architect in the surviving detail drawing. The east wall of the examination wing is a third type of thinner, 6" concrete block. On the main floor, the walls provide the only available thermal mass.

Floors:
The basement recreation area floor is an uninsulated concrete slab-on-grade. The main floor has an uninsulated wood frame structure, with most of the examination wing over a crawl space and the rest over the unoccupied basement storge and mechanical spaces.

Roof:
The roof is a shallow attic construction, ventilated at both ends to remove excess heat built-up. The structure is 2 x 10 wood frame rafters, most likely with a built-up asphalt and felt roofing, which is covered with a reflective, aluminized paint. Thin 2 x 4 ceiling joists hold a four inch insulating layer over a plaster ceiling.

Windows:
Windows are of two types, glass block and double layer clear glass. All windows in this centrally air-conditioned building are fixed, except for double hung windows used in the strip on the east facade. East and south windows have both overhangs and opaque roll-down, external canvas shades that run on wires. The double glazing has a unique system of calcium chloride dessicants to keep the pre-thermopane windows from fogging.

Jump to the next EXAMPLE section: Diagram the Solar Concept

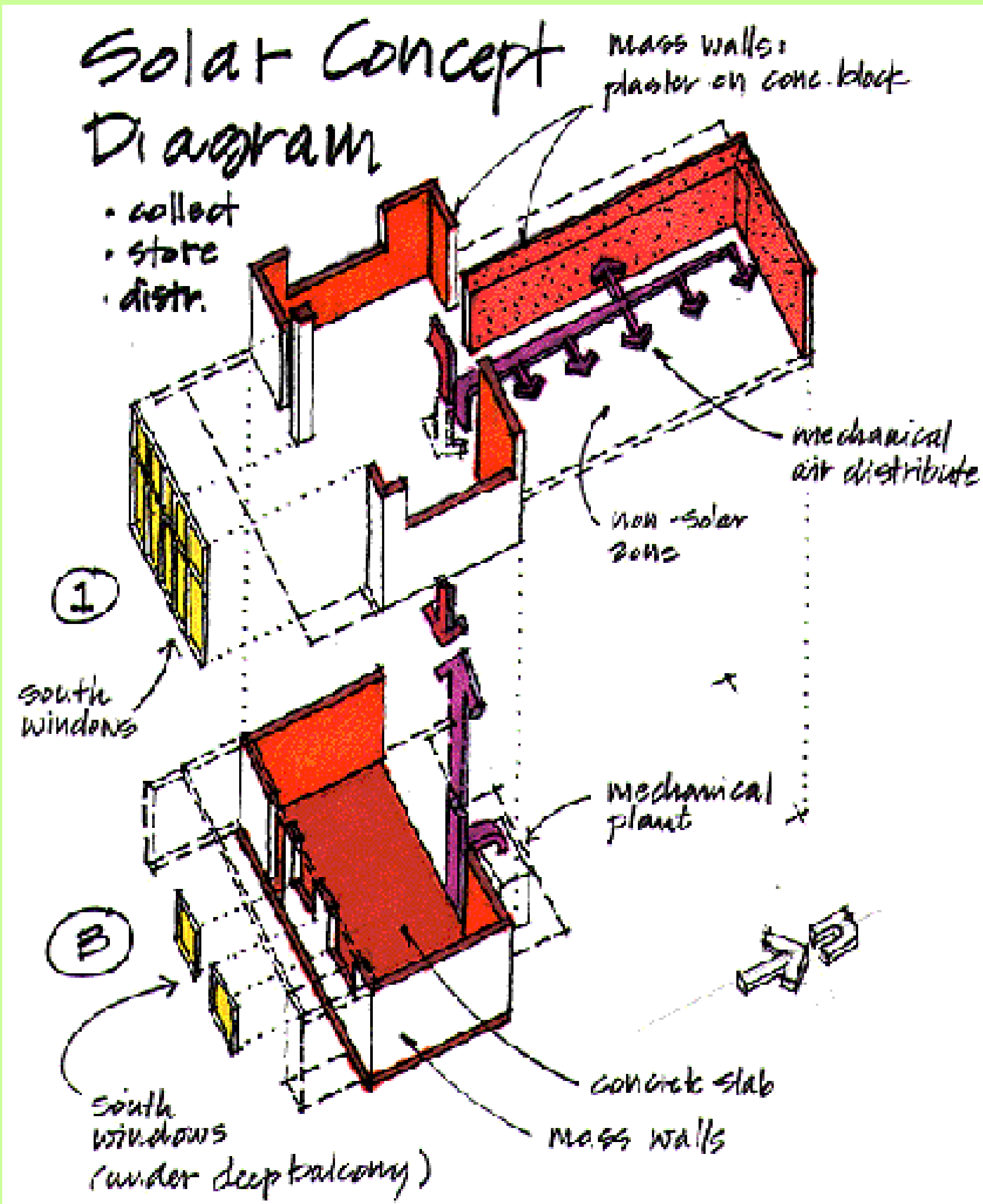
RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

A. DOCUMENTING: input your building

solar concept


3. Diagram the Solar Concept

exercise



Does this Building HAVE a Solar Concept?

As designed, the Shanley building may or may not be considered a solar heated building. Although Armstrong was clearly conscious of many climatic issues of building in the temperate Midwest, it is not clear whether the south-facing glass of the waiting area is intended as a heating strategy, in addition to its architectural and experiential roles. We do know that the architect was later hired by the LOF company to design a solar house to demonstrate its thermopane products.

Part of the exercise will be to determine whether the significant amount of solar energy collected on the south side can be stored in the available mass, and whether its magnitude is enough to offset heat loss through the uninsulated walls and floors.

Solar Zones

This building could be considered to have three distinct solar zones:

1. the basement level
2. the south facing rooms
3. the northern examination wing

The basement is isolated from the upper floor, so it must be heated from windows in its south side. The south facing reception and waiting areas can also be heated via direct gain windows in the south wall. The examination wing, however has neither a direct access to south light nor a spatial connection to sun collecting rooms. It is therefore considered a separate zone. Our redesign of the Shanley Building will have to address the heating of the north wing.

Collection

Large south facing windows run floor to ceiling in the waiting room. Heavy, opaque drapes can be drawn at night to reduce heat loss through the glass. There is more potential collection area in the lower level south windows, but they are shaded by a very large overhang, in the form of the main floor balcony. This factor will have to be accounted for in the shading specification when we get to defining windows in *Energy Scheming*. The examination wing has no south facing windows.

Storage

Solar heat collected from the windows can be stored in the basement level slab and in massive exterior walls that surround the south-facing reception and waiting rooms. These massive elements can be considered in a "solar zone," because they are in rooms that collect sun. The examination wing has a thick mass wall along the west elevation of the corridor. Since the main floor is all wood framed with a wood subfloor and non-massive floor coverings, there is no thermal storage capacity in the main floor. The examination rooms have a thinner, 6" concrete block wall underneath the windows of their east walls. Interior partition walls are constructed of non-massive light framing. The massive elements in the examination wing are considered to be in a "non-solar" zone, because they have no sun collecting apertures. Unfortunately, the walls are uninsulated, so what heat is stored in them from the inside may move quickly via conduction in the direction of the colder outside air.

Distribution

Heat collected from south windows and stored within the room (in the building's structure) is distributed by radiation whenever surfaces or air in the space is at a lower temperature than the mass temperature. Its distribution is quite simple. The examination wing is a more difficult problem. Because no sun is collected there, any excess heat collected by the windows in the south elevation must be moved via the medium of air to the north side of the building. Since the Shanley Building has a "closed" section, with each room an independent cell, thermosiphoning circulation is not possible. However, the building's ducted mechanical system could conceivably be adapted for this purpose. The mechanical plant, including both a boiler and air conditioning system is located in the basement. Vertical chases for supply and return run through the back wall of the waiting area. Horizontal distribution is located in the attic as a simple linear run.

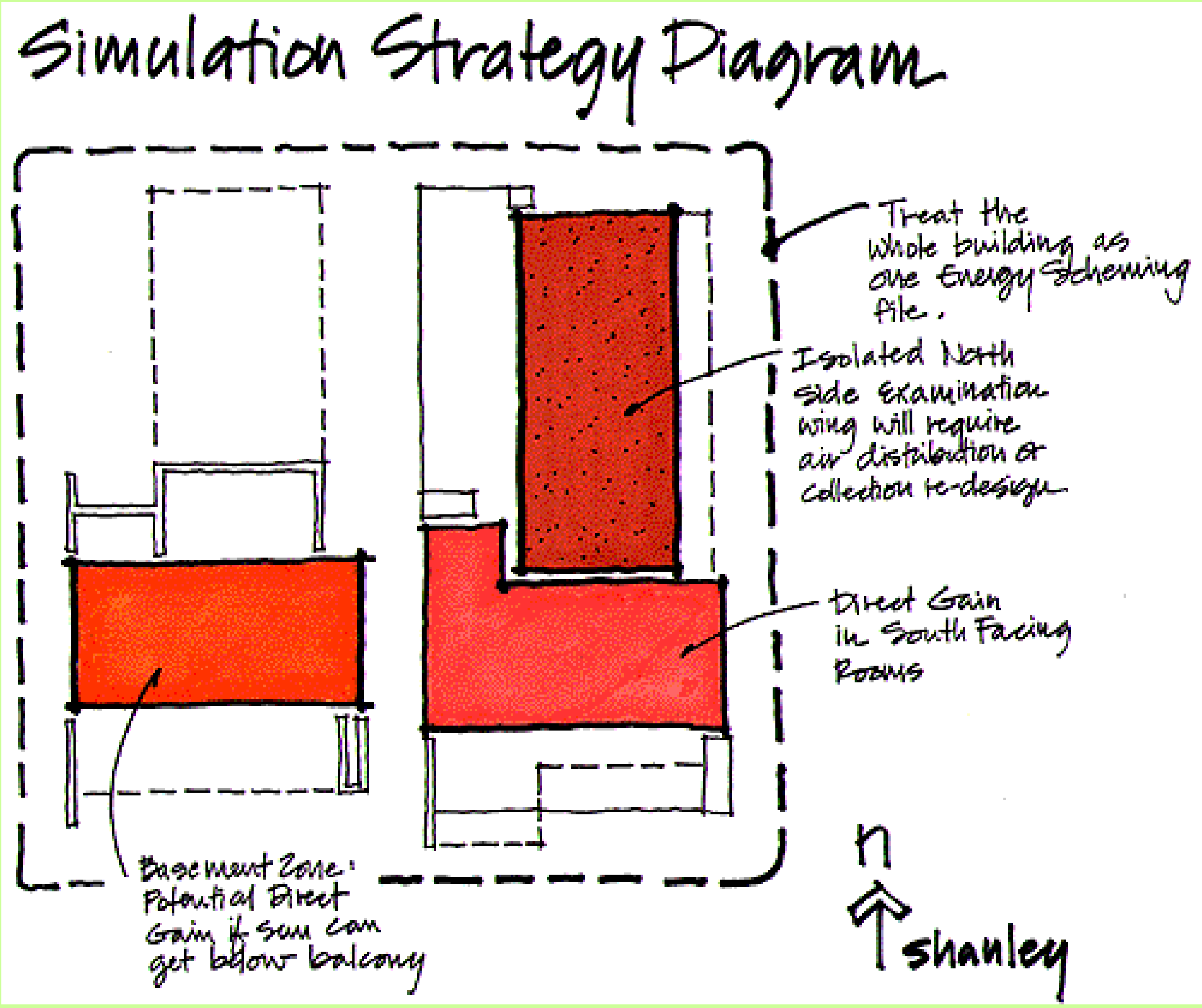
Jump to the next EXAMPLE section: Determine Your Simulation Strategy

A. DOCUMENTING: input your building

simulation strategy

4. Determine Your Simulation Strategy

exercise



As detailed in the discussion of solar zones in the Solar Concept section, the Shanley Building has three solar zones: the basement level, the south facing rooms on the main floor, and the northern examination wing. Since the building is small and we plan to have a way to solar heat each part, and because the excess warm air from one zone can be redistributed to other zones by fans and ducts, we will analyze the whole building in *Energy Scheming* as a sigle solar zone.

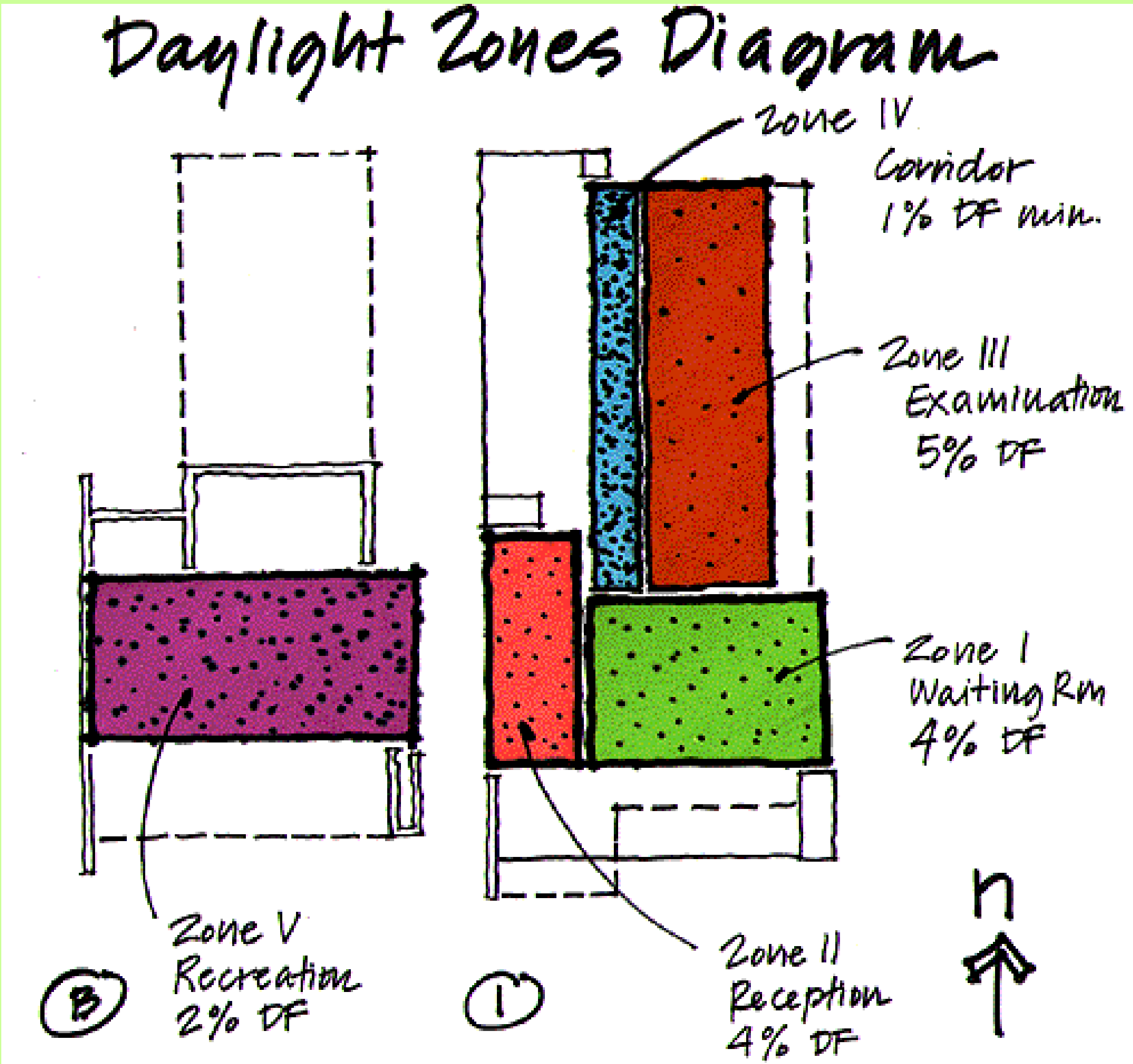
Jump to the next EXAMPLE section: Diagram the Daylighting Zones

A. DOCUMENTING: input your building

daylight zones

5. Diagram the Daylighting Zones

exercise



The plans for the Shanley Building have been divided into five daylight zones based on the building's organization and the needs for lighting within each zone.

Zone 1:
The waiting room is designed to be the major space of the building, with high ceilings, tall south facing windows, and a significant

east facing window. The intent of the design is to both contrast the closed, mysterious entry sequence, and to give the patients a good view of the city while waiting. Activities are not critical, but would include reading. A 4% DF would provide ample daylight levels for reading and give the desired experience of brightness. Higher DF's may be acceptable in this space, if the thermal issues can be resolved.

Zone 2:
In the reception area, office staff would require a 4% daylight factor, if no significant task lighting is used. If task lighting is used, a lower DF of 2% might be acceptable. Some distinction between light levels in this zone and the adjacent waiting area seems to have been intended by the architect. Lit by west-facing glass block in the original design, afternoon overheating may limit expansion of glazing, if needed.

Zone 3:
The examination rooms would generally benefit from a relatively high level of lighting. Even though intense task lights are used by the dentist, a high level of background illumination might help to reduce the patient's perception of glare causes by the extreme contrast between the examination lighting and the ambient light. Thus, a target of 5% DF has been chosen.

Zone 4:
The corridor space, lit by a thin west-facing strip of glass block has low requirements for lighting intensity. A 1% daylight factor (DF) will be sufficient, but a higher level would be acceptable to ease the transition from the brighter waiting room to the corridor, and back to higher brightness in the examination rooms.

Zone 5:
Many of the original client's patients were children. The recreation room, located at the walk-out basement level, has non-critical tasks. Since it will be harder to light than a similar space entirely above grade, a moderate 2% DF target was chosen.

Jump to the next EXAMPLE section: Get the Drawings into the Computer

RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

A. DOCUMENTING: input your building

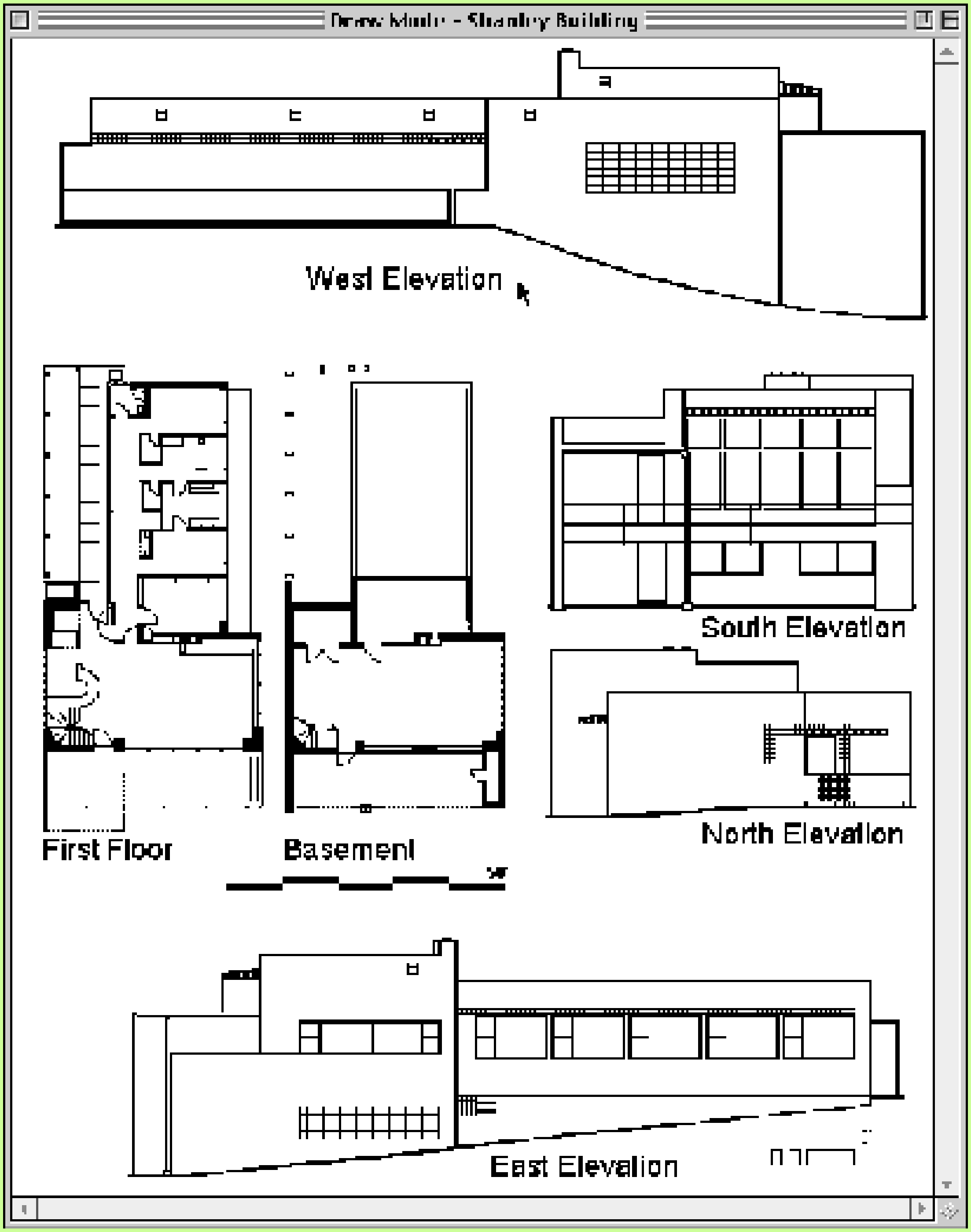
import file

6. Get the Drawings into the Computer

exercise

Here is the Drawing Layer of the Shanley Building Energy Scheming file, above, and the process that we used to create it below. You can click on the image above for a slightly larger full size view.

- **Scanning**
  Hand drawings were scanned into Photoshop, each as a separate Photoshop format (.PSD) file. Since our originals were were high contrast, we scanned them as 'line art" at 150 dpi, full size. Then we tuned them up a little in Photoshop, redrawing some of the fine of lines that got lost in the scanning.
- **Organizing as a Single File**
  When the tune-up was done on each file, which took only a couple of minutes each, we created a new Photoshop file that was 8.5 x 11 inches at 72 dpi. The drawing window is much bigger in Energy Scheming 3.0 and higher, but we wanted to make it easy for you (and us) to print our pages on letter size. If you have a larger or more complex building, you may want to use more of the drawing window. Each drawing was then copied into the new Photoshop file, arranged, and re-scaled until everything fit nicely. Notice that the plans are at one scale and that the elevations are all at a different scale and appear larger. During the process of defining drawings in ES, we will be able to set the scale of each drawing.
- **Saving Back-ups**
  Each file, along with the composite file for importing was saved as a back-up. You never know...
- **Creating a new ES File**



- To import drawings into ES, you need both ES and your source software running at the same time. With the source file open in Photoshop, we created a new, blank ES file, setting climate to St. Louis, Building Type to Non-Residential, and Building Size to 3000 sf.
- **Importing**
  Finally, we copied the composite image from Photoshop and pasted it into Energy Scheming. After positioning the image on the ES drawing window, we clicked outside the dashed selection fence, then saved our new file.
- **Saving an Empty File**
  It is a good idea to save an archive copy of the new ES file before your do any take-offs. You may want to be able to start over on a fresh file at some point in the future.

Jump to the next EXAMPLE section: Create a New Climate

RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

A. DOCUMENTING: input your building

create a climate

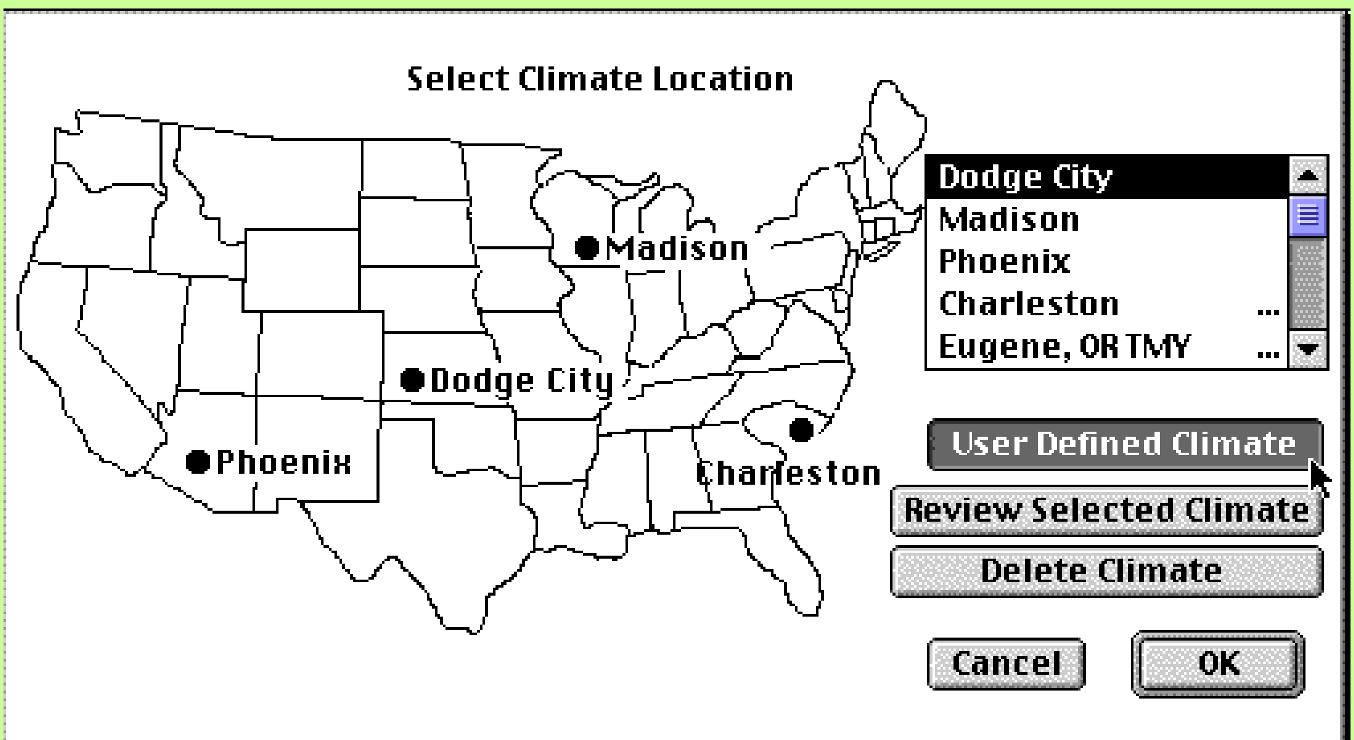
 **7. Create a New Climate, if necessary**

exercise

Since we were using a new version of Energy Scheming to work this example, we needed to create a new climate for St. Louis, MO. The Shanley Building is located in Clayton, MO, a suburb of St. Louis and the region's first "edge city." Luckily, we were able to use one of the Climate Data pages included in the database on this web site. The Architecture + Energy Project has collected climate data for representative sites throughout the continental U.S., Alaska, Hawaii, and a few of the U.S. possessions.

To find information about your climate, you can start with the main Climate page. Or, you can select from a list of cities for which ES climate data has been collected on the Climate Data for Energy Scheming page. Following the links, we started with the ES climate data for St. Louis. Because once one begins the process of inputting new climate data, one can not switch out of ES to go to another software, we printed the St. Louis ES climate data, so we would have it as a reference.

Since St. Louis has been used as the example climate, you can get to the pages for how to Create a New Climate for a full detailed explanation of the procedure. To go there, click on the button for "User Defined Climate" in the image below.



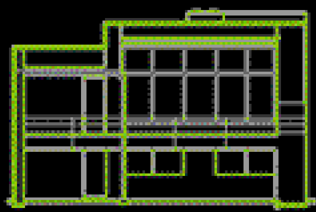
This is the last section of this part of the example. Return to the outline for more.

Return to the EXAMPLE OUTLINE

Teaching Architecture + Energy

Hosted by Washington University in St. Louis

Welcome to the Teaching Architecture + Energy project at Washington University. This site is part of a collaborative network of energy technology teachers in architecture schools, sponsored in part by the U.S. Dept. of Education . Our goal is to make it easier for architecture students to understand energy concepts and to design energy efficient buildings. The curricula developed here and at other universities is centered around Energy Scheming, a energy simulation tool that helps the student think about energy as an integral part of building design.



Climate:
context for design

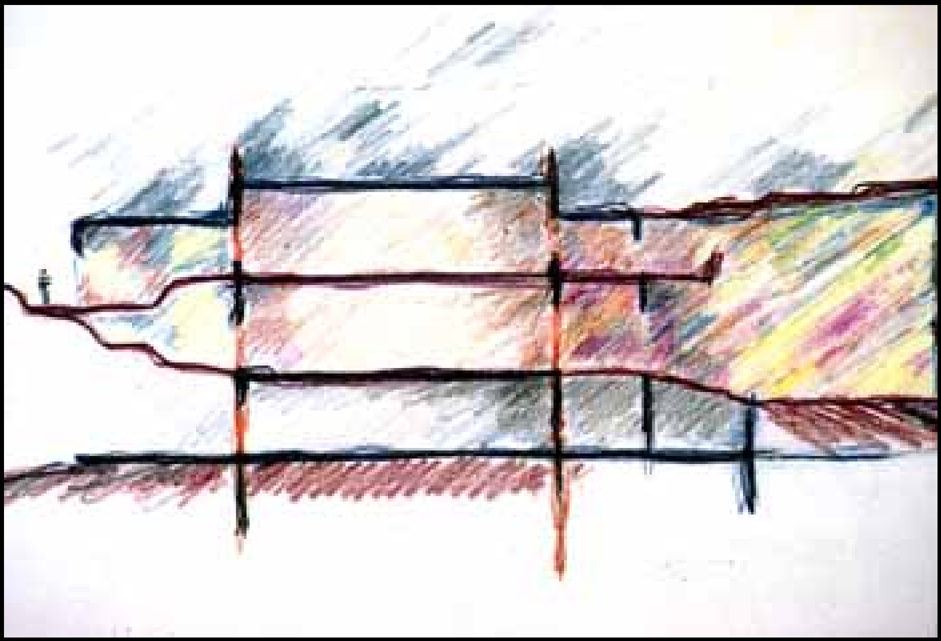
Exercises:
"recycling with energy scheming"

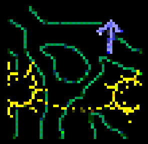
Example:
shanley building

Student Work

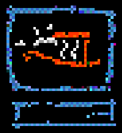
Legal Disclaimer

RECYCLING WITH *ENERGY SCHEMING*:
Schematic Design & Performance

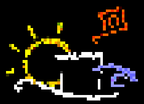




TERRAIN MAP: outline of exercise



A. DOCUMENTING: input your building



B. DEFINING: take-offs and specifications

C. ANALYZING: understanding energy patterns

D. RE-DESIGNING: 'generate and test' cycles

E. EVALUATING: energy codes as indicators

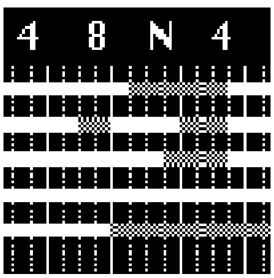
B. DEFINING: take-offs and specifications

In Part B of this exercise, you establish performance goals, evaluate your first schematic design and understand its strengths and weaknesses, in terms of energy and daylighting. You will take-off all of the "architectural elements" of your project while leaving some settings at their default.

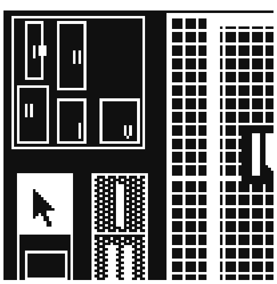
If you have not already, read Chapters 1 and 2 of the ES Manual. Also, please read Chapter 4, "Input Requirements" and Chapter 5, Procedures," of the ES Manual.

In part A, you already defined basic information about the project: the climate, the building type (residential or non-residential), and the building's total floor area. Make sure that the building's floor area you entered is accurate. You should include all occupied and conditioned floor area, including upper floors. Do not include things like unheated basements, mechanical areas, garages and attics. See the section, "Preliminaries" in Chapter 5 of the ES manual for help.

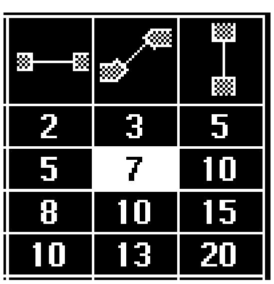
Part B, DEFINING, includes the following steps:



1) Tuning Settings to Fit Your Building
First you will need to set a few options so that the assumptions Energy Scheming makes about your building are accurate. Most of these settings will stay the same throughout your use of ES for a particular building.



2) Define Your Daylight Zone Icon
Before you can specify windows or electric lighting, you must create a "Daylight Zone Icon" (under the "DEFINE" menu), so that you will be able to use multiple daylight zones.



3) Set Performance Goals for Lighting, Heating, and Ventilation
There are several ways that ES can help you to understand the performance of your design. The "Rule-of-Thumb Window Sizer" gives quick feedback about window sizes in relation to Solar Heating, Daylighting, and Natural Ventilation. In order to make use of this information, you need to set some performance goals.

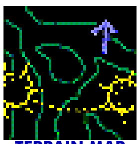
4) Create Plan Specifications
Now that you have defined settings and parameters to fit your building, you are ready to take off the building elements that can be defined in a plan drawing.

5) Create Elevation Specifications

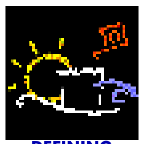
Continue taking off building elements in the elevations.

Part B Grading Criteria

RECYCLING WITH *ENERGY SCHEMING*

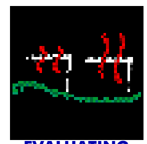

TERRAIN MAP


DOCUMENTING


DEFINING

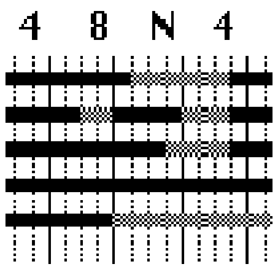

ANALYZING


RE-DESIGNING


EVALUATING

B. DEFINING: take-offs and specifications

settings

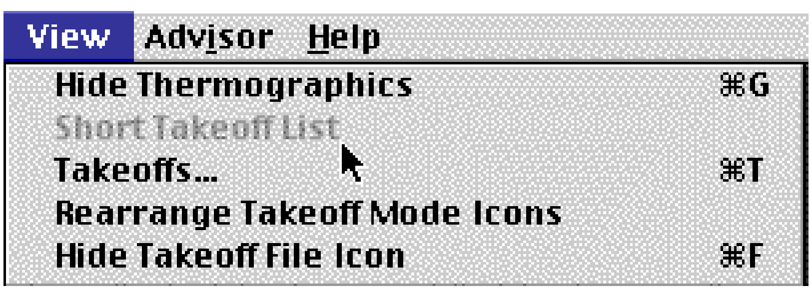


shanley example.

1) Tuning Settings to Fit Your Building.
First you will need to set a few options so that the assumptions Energy Scheming makes about your building are accurate. Most of these settings will stay the same throughout your use of ES for a particular building.

- **Select the Long Takeoff List**
- **Define Infiltration or Ventilation Rate**
- **Set the "Evaluation Days"**
- **Check the Schedules**
- **Check the Interior Temperature Settings**
- **Set the Order of Energy Strategies**

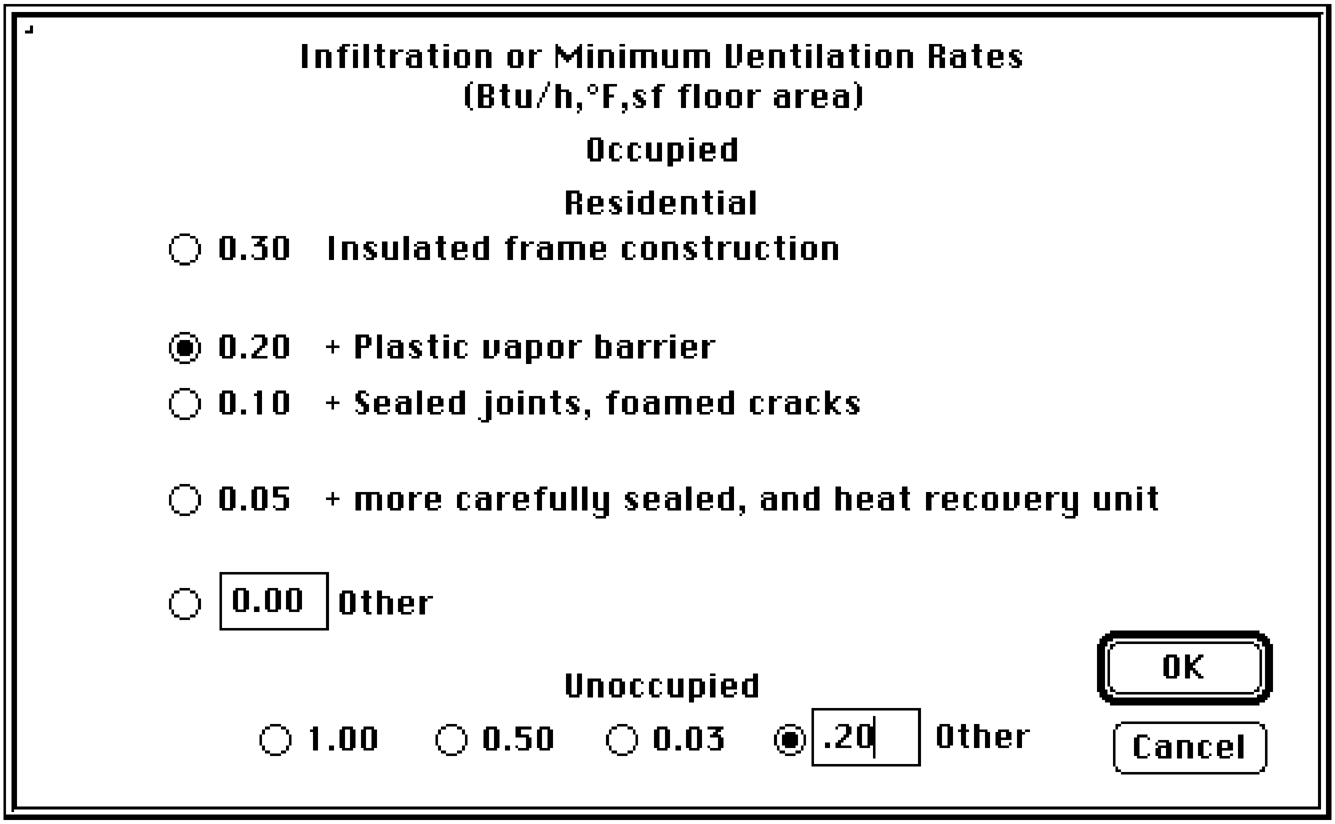
Select the Long Takeoff List
Make sure that "SHORT TAKEOFF LIST" is NOT checked (IS greyed-out) under the "VIEW " menu before beginning, meaning that your are then working in the LONG TAKEOFF MODE. The Long Takeoff Mode allows you to specify lights, people, and equipment.



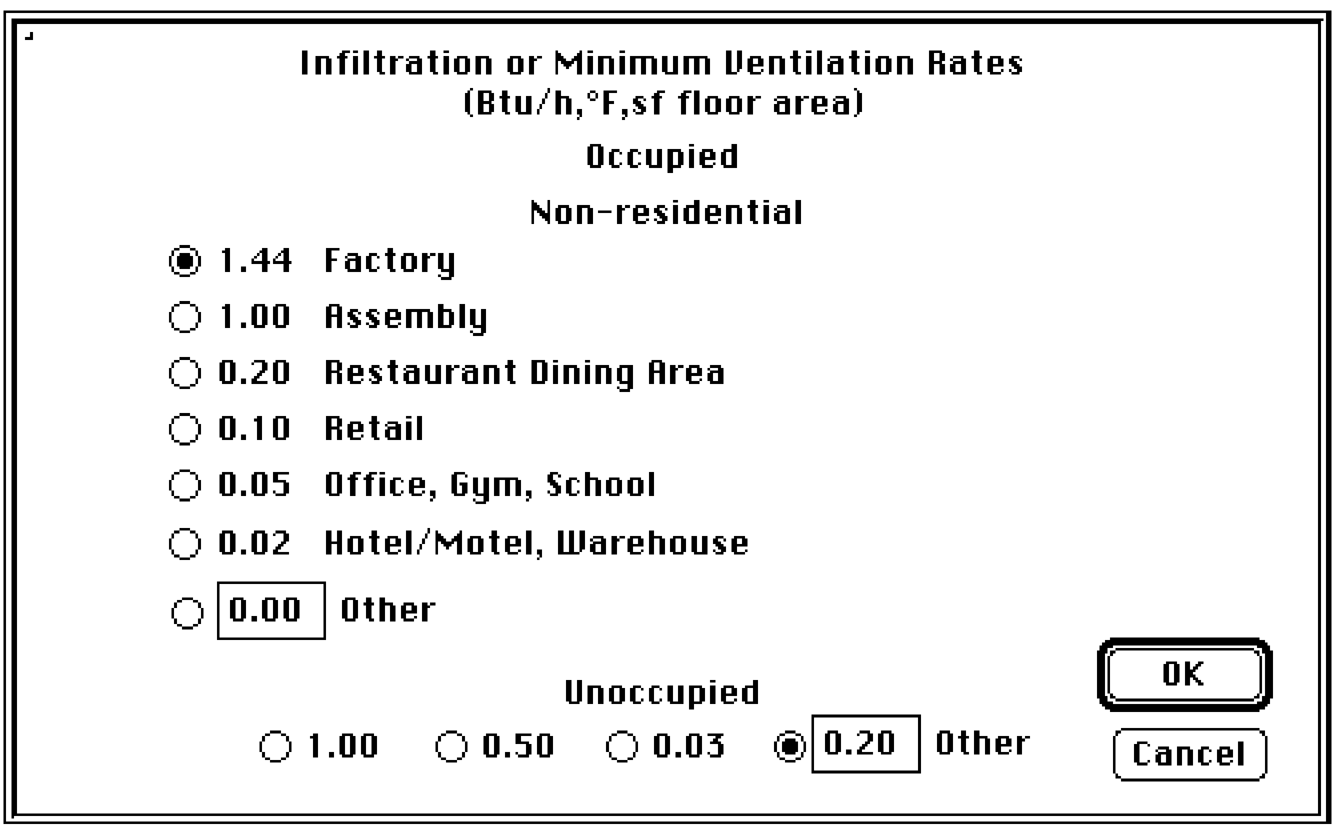
Under the OPTIONS menu, set Preferences to open files in "Long Takeoff Mode."

Define Infiltration or Ventilation Rate
Select the "DEFINE / Infiltration/Min. Ventilation Rate" menu. The dialog box that you get for this setting is dependent upon whether you have defined the building as Residential or Non-Residential. If you selected "Residential" when you defined the project, you will get options based on construction type and details. If you chose Non-Residential when defining the project, you will get options based on occupancy type.

For Residential Buildings
Select the option that matches your construction type. Older, uninsulated buildings will have higher rates. Unoccupied values are for times when the building is unoccupied. In residential buildings, it accounts for how occupants open windows and doors when they are in the building. For low occupant density buildings, unoccupied rates will be close to occupied rates, unless mechanical ventilation is scheduled.



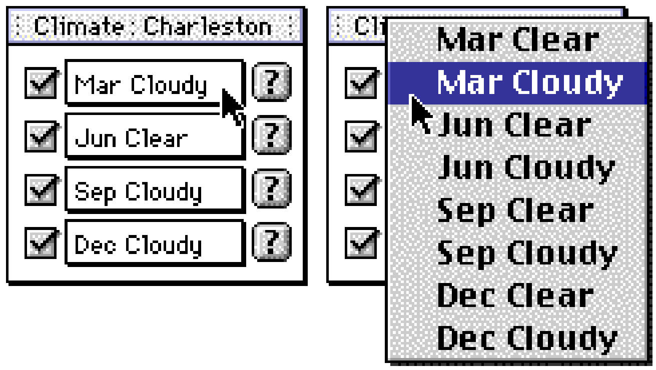
For Non-Residential Buildings
Select the option that most closely matches your occupancy. If your building has a mix of occupancy types, estimate a weighted average based on the relative floor areas of each occupancy type. Commercial buildings are often ventilated on a schedule. For instance, a factory will not need to be ventilated at a high rate when its production processes are shut down on off hours. The same principle holds true for occupancies like assembly spaces or kitchens.



Set the "Evaluation Days"
You can set four evaluation days in Energy Scheming. Most climate files created with data found on the web site have at least eight days, one cloudy and one clear day in each of four seasons. Some also have two extreme days. The evaluation days are

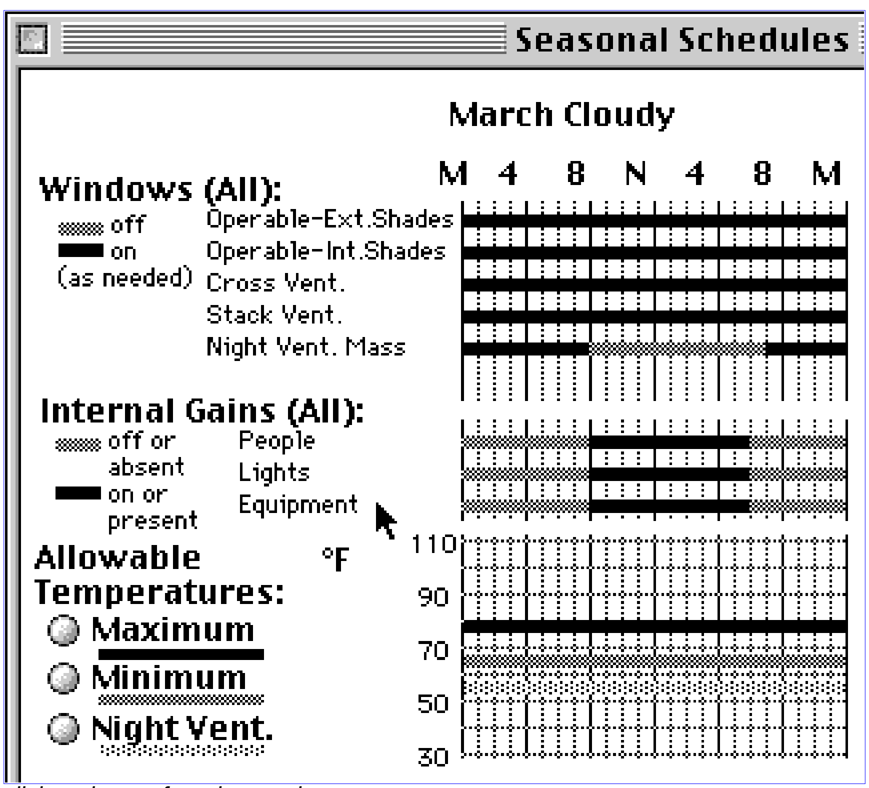
set from the Climate Palette on the Graphic Report window. To get there, choose "VIEW / Graphic Report." On the Graphic Report window, you will see the palette shown below. If it does not show the correct climate, change your climate by selecting "DEFINE / Project."

For this exercise, you will want to select the most "typical" day in each of four seasons. Determine whether, in your climate, the typical condition in each season is "mostly clear" or "mostly cloudy." Click and hold down on each day to select a different day. You can review and edit climate data for that day by clicking on the question mark. Make sure all four days are checked. Deselecting the checked box turns that day off and ES will not calculate performance for that day.



Check the Schedules
The building's occupancy schedule affects internal loads from lights, people and equipment. Under the "DEFINE / Schedules..." menu, make sure the default settings approximate the conditions for your building. For a commercial building, the default will be occupancy during work hours. If your building occupancy schedule does not match the default, modify the schedules for Lights, People, and Equipment to fit your building's profile. For most buildings, lights, people, and equipment follow the same schedule. See the section, "Setting Schedules" in Chapter 5 of the ES manual for help.

Note: For this exercise, *leave the schedules for shades and ventilation at the defaults!* If a strategy shows a black bar for "on," then it will be used only as needed.



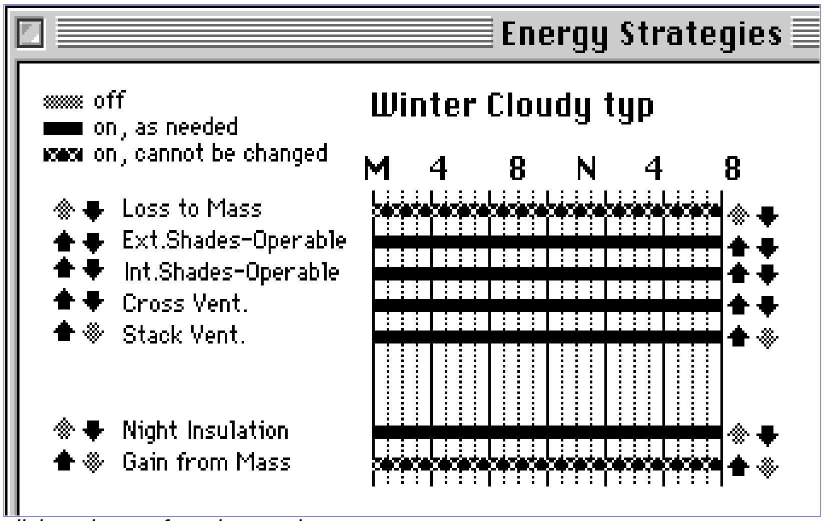
click on image for a larger view

Check the Interior Temperature Settings
Wider temperature ranges for allowable indoor temperature will decrease heating and cooling loads, but your assumptions must match reasonable expectations about your users. From the Seasonal Schedules window, make sure the default settings approximate the conditions for your building. The default settings are 65 degrees F minimum and 78 degrees F maximum.

This is a standard internal temperature range. In hot climates, 80 degrees is the upper end of the comfort zone. With mild air movement, such as with ceiling fans, most people feel comfortable up to 83 degrees F. Elderly people will need warmer settings in winter and will feel cold at 65 degrees F. Active facilities, such as a gymnasium will be fine at 60 degrees F. for a minimum. If your building occupancy does not fit well with the default settings, modify the maximum and minimum temperature settings. See the section, "Setting Schedules" in Chapter 5 of the ES manual for help.

Set the Order of Energy Strategies

Energy Scheming calculates passive energy strategies in the order that you choose. You can also turn on or off any of the strategies to see its effect. The default order of energy strategies is most appropriate for summer months when cooling is the priority. From the DEFINE menu, choose "Energy Strategies..." A window like the one below allows you to set separately the order in which ES will apply energy strategies for each day.



click on image for a larger view

Heating Season Days

For evaluation days where heating is a priority, usually the winter and spring days in envelope load dominated buildings, you must reset the strategy order so that ES will take the effects of thermal mass into account properly. For days that you think will need heating, click on the UP arrow next to the 'Loss to Mass' strategy until it is moved to the top of the list. This will tell ES to store excess solar heat in the building's mass before using cooling strategies to reduce overheating.

Night Insulation

Your version of ES may show Night Insulation on as the default. Turn Night Insulation to OFF during daylight hours of occupancy. Otherwise, if there is net heat loss, ES will use night insulation to counteract it, thus blocking out desirable daylight. During cooling season days, turn Night Insulation to OFF; generally occupants will not bother with it in the summer.

Cooling Season Days

Since the use of Night Insulation is unlikely in the summer, move it down in the priority list, below 'Gain from Mass.' This will let ES use excess heat in the mass for heating on cool summer nights without employing night insulation.

Other Strategies

For now, leave all of the other settings at the default.

See the section, "Sorting Energy Strategies" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

Turn in

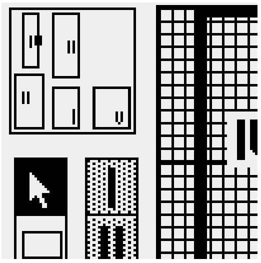
- A record of your settings for Ventilation/Infiltration Rate.
- A record of the evaluation days you have chosen.
- A printout of the energy performance report, done at the end of Part B, will show your settings for Schedules and Energy Strategies.

- For a guide, see the *shanley example.*

Jump to the next section: Define Your Daylight Zone Icon

B. DEFINING: take-offs and specifications

daylight zone icon



2. Define Your Daylight Zone Icon

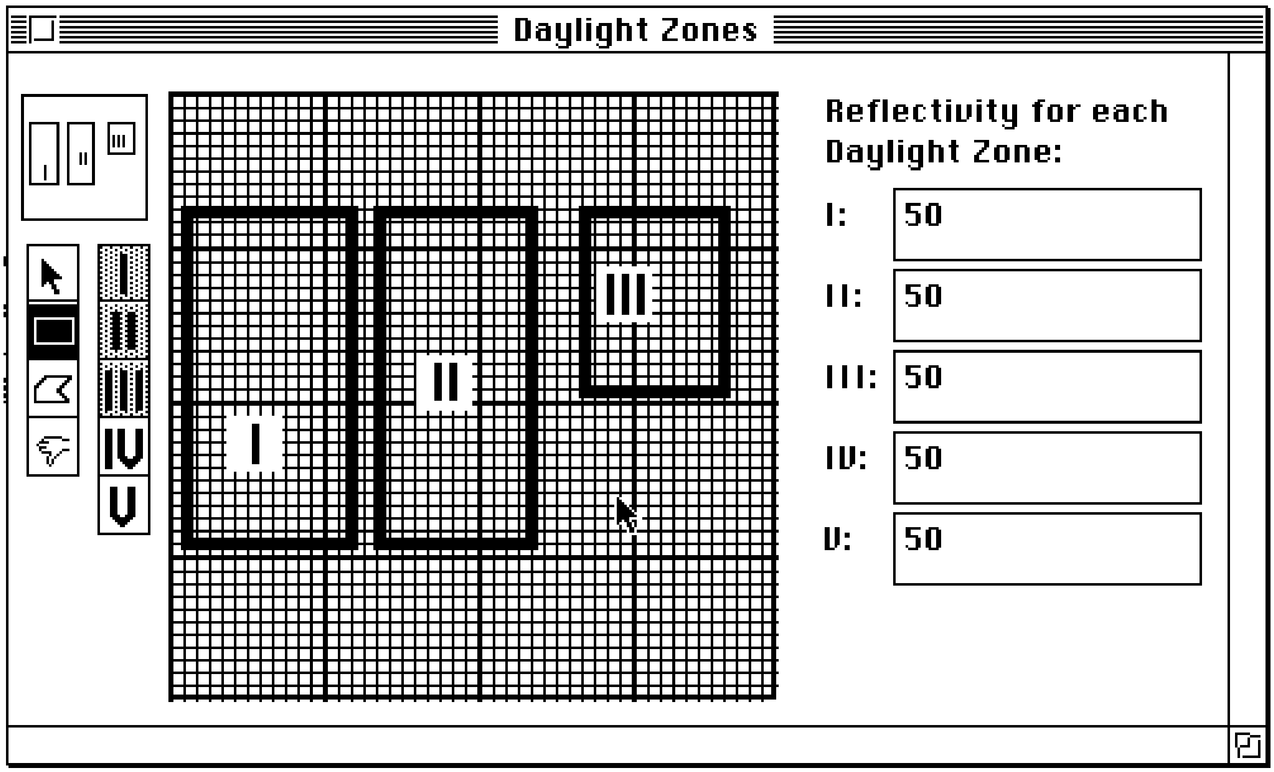
Before you can specify windows or electric lighting, you must create a "Daylight Zone Icon" (under the "DEFINE" menu), so that you will be able to use multiple daylight zones

shanley example.

When you specify windows or electric lights, the icon that you create will appear in the spec window, so that you can associate the spec with a particular daylight zone.

See the section, "Daylight Zone Icons" in Chapter 5 of the ES manual for help.

Click on a part of the Daylight Zones window below for more information about each step in the process:



SAVE and BACK-UP your work.

Turn in

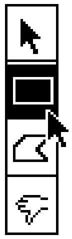
- A screen capture of the daylight zone icon screen.

For a guide, see the *shanley example.* You will not be able to print the windows directly unless you use a screen capture technique.

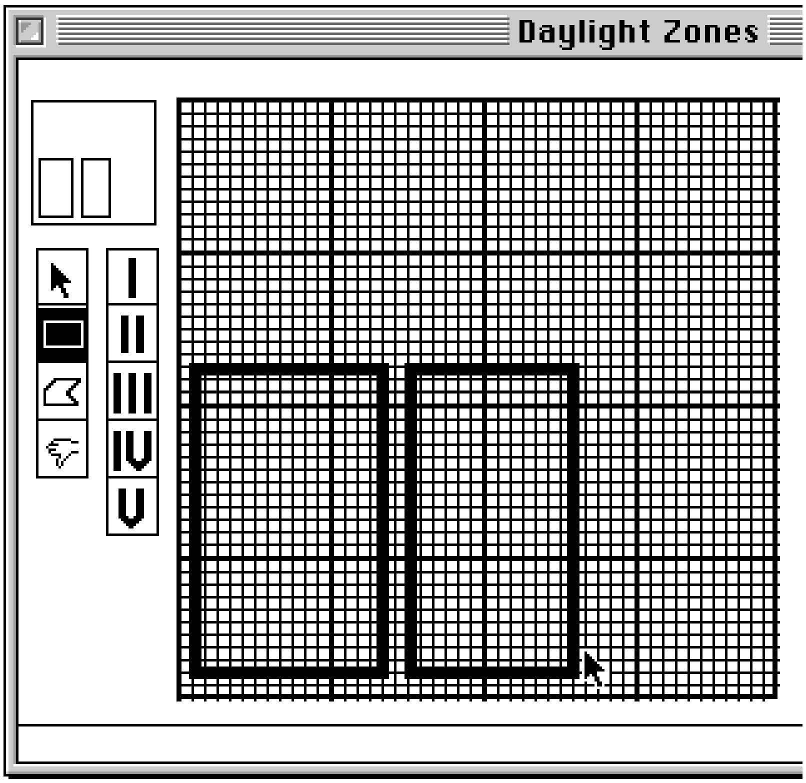
Jump to the next section: Set Performance Goals

daylight zone icon: drawing zones

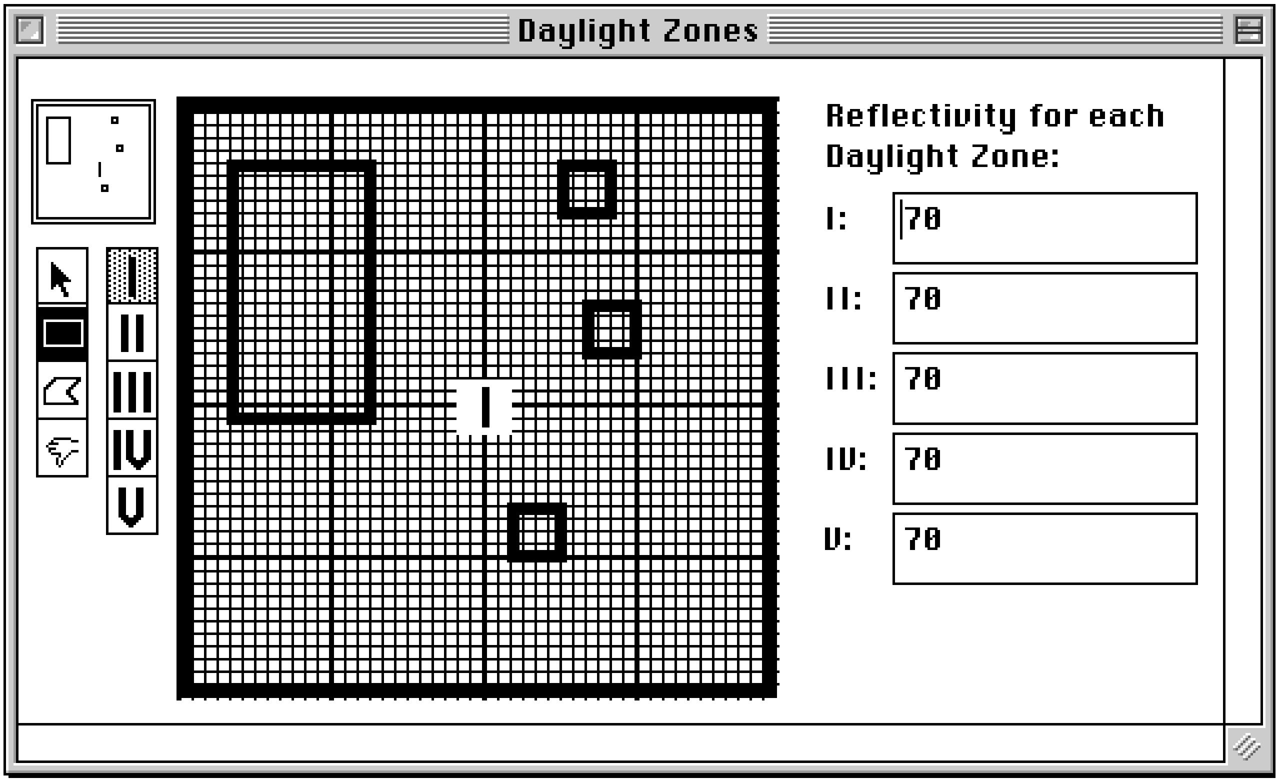
- Using your daylight zone diagram from Part A DOCUMENTING as a guide, design and then draw an icon for your building that represents its daylight zones. Use either the rectangle tool or the polygon tool to draw a shape for each of your zones (up to five).



- Make the zones AS BIG AS POSSIBLE in your gridded drawing window. If your zones are too small, they will be hard to click on later. Make sure your zone lines do not overlap. If you make a mistake, use the "Thumbs Down" tool to delete a zone.



- Check to make sure that you DO NOT see a thick black line around the outside of your drawing grid. If you do, it means that you started your work in the short takeoff mode and then switched to the long takeoff mode. You will need to delete the large perimeter square now.
- Check your icon once again and review the instructions above. Edit your work if necessary now. It can not be changed later without extra work.
- The screen image below shows several mistakes: 1) The large zone around the perimeter of the grid needs to be deleted; 2) Some zones are too small and will be hard to select; 3) The reflectances are probably too high. If your daylight zone icon has any of these problems, correct it now.


Daylight Zones
Reflectivity for each Daylight Zone:
I: 70
II: 70
III: 70
IV: 70
V: 70

Screen Capture Options

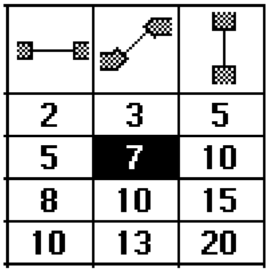
Only the graphic report, numeric reports, and the advisor report can be printed from ES. To export any screen or graphic from ES for use in another application, such as a word processor used to create your assignment report, use a screen capture technique. Options include:

- *Apple System Screen Capture.*
  The key command "COMMAND-SHIFT-3" will take a snapshot of the screen that can be opened in Photoshop or any image editor that will read PICT format. When you do this, you will hear an audible click. The image is stored on the local hard drive (MacIntosh HD) and is named, "PictureN, " where N is a sequential number. If you take several screen captures, they will be labeled, "Picture 1," "Picture 2," "Picture 3, " etc. To open them, first start Photoshop or your favorite imaging program, choose FILE /Open, and navigate to your local hard drive where you will find the images. The image will be of the entire screen, so you will want to crop it to just the part you need. The image is created by default in RGB color. If the source captured is gray scale, you can convert the image to grayscale to make a much smaller file (in Photoshop, choose IMAGE / Mode...).
- *Screen Snap Utility.*
  If you are working on your own Mac or a Mac that you can configure by adding files to the system folder, you may want to try out the screen snap utility *Snap Jot.* It is freeware. Download Snap.Jot and place it in the Extensions Folder within your System Folder. Download SnapJot DA and place it in the Apple Menu Items Folder within your System Folder. You can use *Snap Jot* to take a picture of any portion of your screen.
- *Energy Scheming Screen Snap.*
  ES version 3.0 and higher has a built-in screen capture function available for selected screens.

SAVE and BACK-UP your work.

B. DEFINING: take-offs and specifications

performance goals



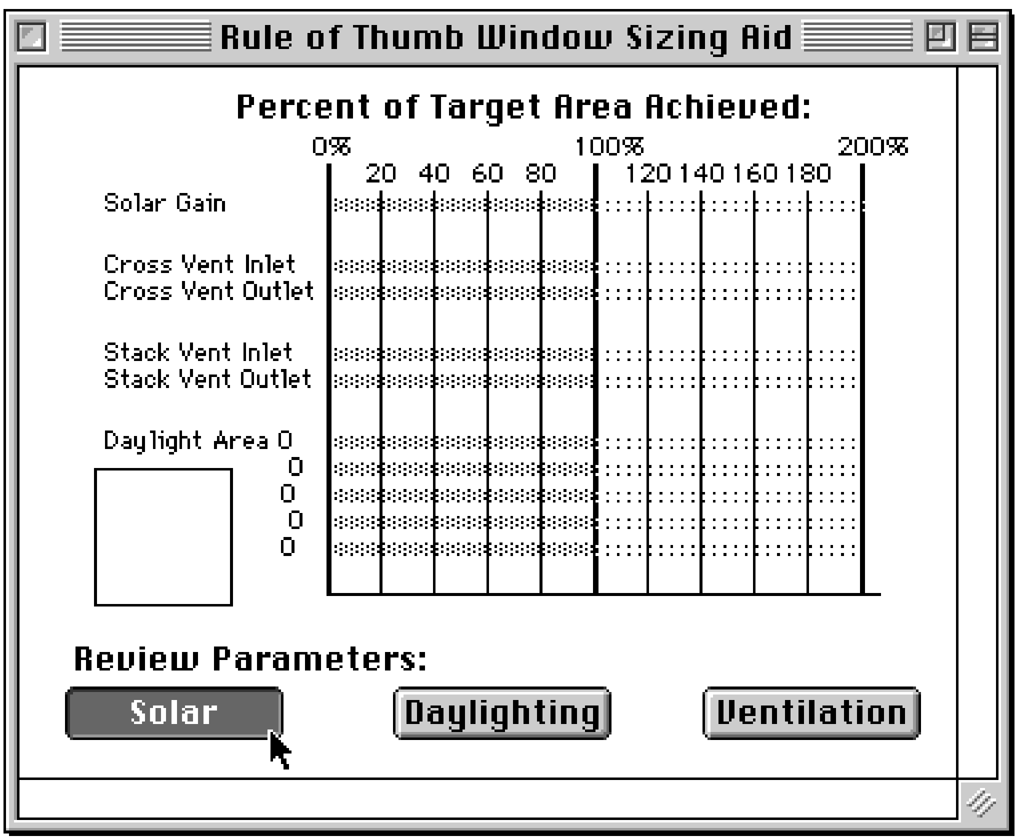
shanley example.

3) Set performance goals for lighting, heating, and ventilation.
There are several ways that ES. can help you to understand the performance of your design. The "Rule-of-Thumb Window Sizer" gives quick feedback about window sizes in relation to Solar Heating, Daylighting, and Natural Ventilation. In order to make use of this information, you need to set some performance goals.

There are several ways that ES can help you to understand the performance of your design. One way is using the "Rule-of-Thumb Window Sizer," which uses Rule-of-Thumb (R/T) methods covered in most basic energy texts to give you feedback about the window sizing for Solar Savings Fraction (SSF), Daylight Factors (DF), and Natural Ventilation, both cross ventilation and stack ventilation.

In order to make use of this information, you first need to set some performance goals. For instance, for solar heating, the "Window Sizer" gives you feedback about the window area needed, in relation to your building's floor area, to achieve a particular SSF goal.

On the image below, click on the buttons for each of the parameter to find out more.



SAVE and BACK-UP your work.

Turn in

- A record of your daylighting, solar heating, and ventilation goals. You will not be able to print the windows directly unless you use a screen capture technique.

SAVE and BACK-UP your work.

Turn in

- A record of your daylighting, solar heating, and ventilation goals. You will not be able to print the windows directly unless you use a screen capture technique.

For a guide, see the *shanley example.*

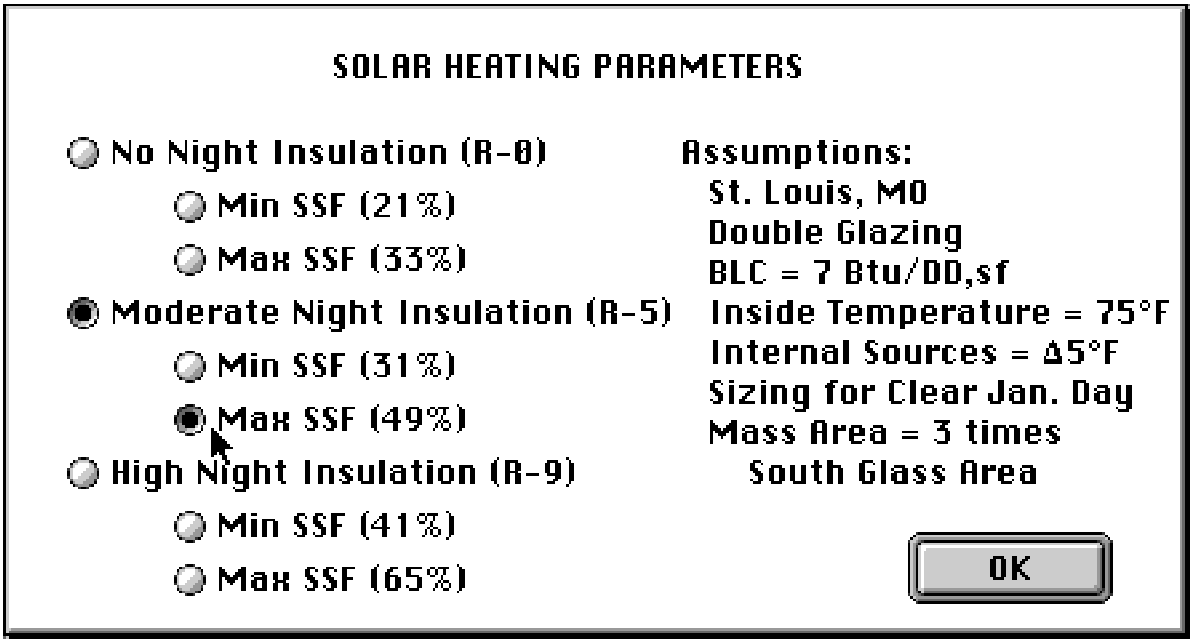
Jump to the next section: **Create Plan Specifications**

performance goals: solar parameters

Define Solar Heating Parameters

You can access the "Solar Parameters," from either the RULE-OF-THUMB Menu or from the Window Sizer screen. The SSF options are generated by ES from the climate file for your city. For now, a moderate level (R-5) of night insulation and a high SSF goal is recommended for most buildings.

See the section, "The Window Sizer / Solar Heating Parameters" in Chapter 5 of the ES manual for help.



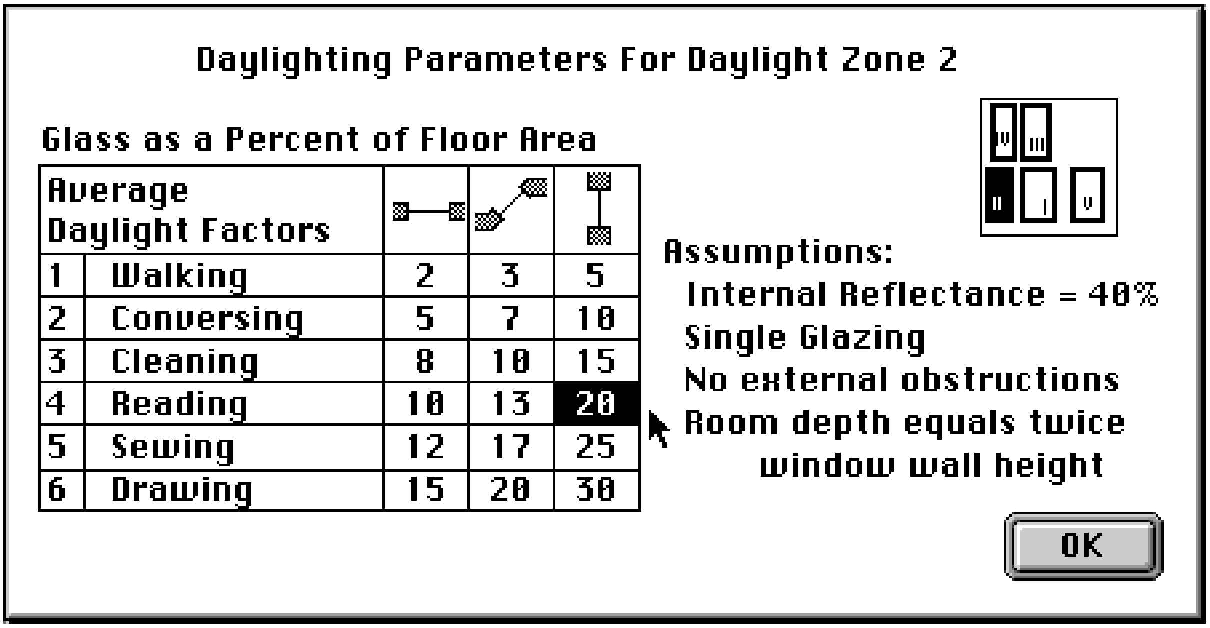
- *Advanced option:*
  If you want to use an SSF goal somewhere between the minimum and the maximum R/T recommendation, you can modify the climate file. To do so, choose, "Define Project..." and then "User Defined Climate" to create a new climate file using the standard climate file for your site as a template. Enter your desired SSF goal in the Minimum or Maximum category of the General Info input screen (1st climte screen). You will also have to modify the collection area required by the appropriate linear proportion.
- If you are working in a shared computing environment, this will require that you make a copy of the software, so that your modifications will not effect other users and that your changes can be saved and used again without having to edit the climate again next time you work.

SAVE and BACK-UP your work.

performance goals: daylight parameters

Define Daylighting Parameters
You can access the "Daylighting Parameters," from either the RULE-OF-THUMB Menu or from the Window Sizer screen.

- Select a daylight zone by clicking on the daylight zone icon in the upper right.
- Set a daylight factor goal for that daylight zone by selecting a cell in the matrix. Daylight Factors (DF) are in far left column. For instance, a DF of 3 corresponds to a task such as reading.
- The icons at the top of the matrix represent different glass orientations. For vertical glazing with a 4% DF goal (reading), the zone would need a glass area equal to 20% of its floor area.
- Repeat the process for each zone.



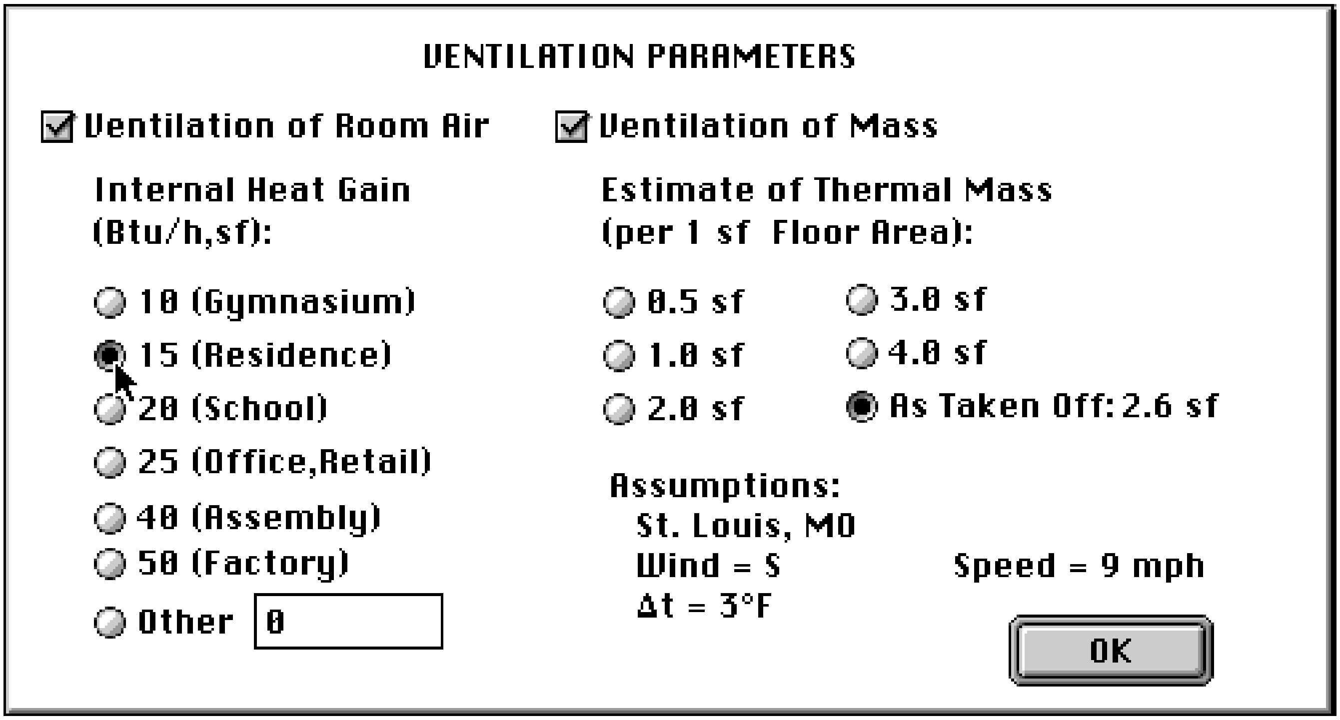
See the section, "The Window Sizer / Daylighting Parameters" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

performance goals: ventilation parameters

Define Ventilation Parameters
You can access the "Ventilation Parameters" from either the RULE-OF-THUMB Menu or from the Window Sizer screen.

- Select a rate of heat gain to be removed by ventilation. Select the occupancy type that most closely matches your building, considering the rate of internal gains from electric lights, people, and equipment.
- You may also select how ES calculates ventilation of mass by either choosing an estimate of thermal mass area or using the actual takeoff numbers. The estimated values are good if you want feedback about ventilation before you have actually defined all of the elements. Mass levels beyond 2.0 ft^2 of mass per ft^2 of floor area are difficult to achieve in most buildings. For this exercise, click on the radio button for "As Taken Off."



See the section, "The Window Sizer / Ventilation Parameters" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

B. DEFINING: take-offs and specifications

plan specifications

shanley example.

4) Create Plan Specifications.
Now that you have defined settings and parameters to fit your building, you are ready to take off the building elements.

Set up your Floor Plan Drawing(s).
The *ES Manual* has a detailed explanation of how to set up plan drawings. From the file cabinet, choose Plans. Then double click on the New Plan icon. From the Drawing Spec window, name the drawing and set its scale with the scale tool.
See the section, "Specifications from Plan Drawings" in Chapter 5 of the ES manual for help.

How many Drawings?
In general, you will need one plan drawing in ES for each different floor plan in your building. If you have a building with repetitive floors, you can use ES's cloning functions to clone the drawing with or without its associated takeoffs.

Where to Start?!
Once your drawings are set up, you are ready for takeoffs. Building elements are specified in ES as a part of a particular plan or elevation drawing. Because ES uses Electric Lighting Zones to define the floor area of daylight zones, it is a good idea to start with defining electric lighting, which is specified in plan drawings. You must specify electric lighting before the daylighting bars in the Window Sizer will work.

Click on one of the icons below for more information about creating specs and takeoffs for each element type:

SAVE and BACK-UP your work.

Turn in

- A screen capture of your plans showing lighting zones. Turn off all other plan takeoffs in the "VIEW / Takeoffs..." menu. You will not be able to print the takeoffs unless you use a screen capture technique.
- In the next section, Elevation Takeoffs, you will print the Energy Performance Report, which will document all your takeoffs.

For a guide, see the *shanley example.*

Jump to the next section: Create Elevation Specifications

B. DEFINING: take-offs and specifications

plan specifications: skylights

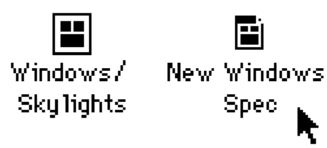
4) Create Plan Specifications.

Click on one of the icons below for more information about creating specs and takeoffs for each element type:

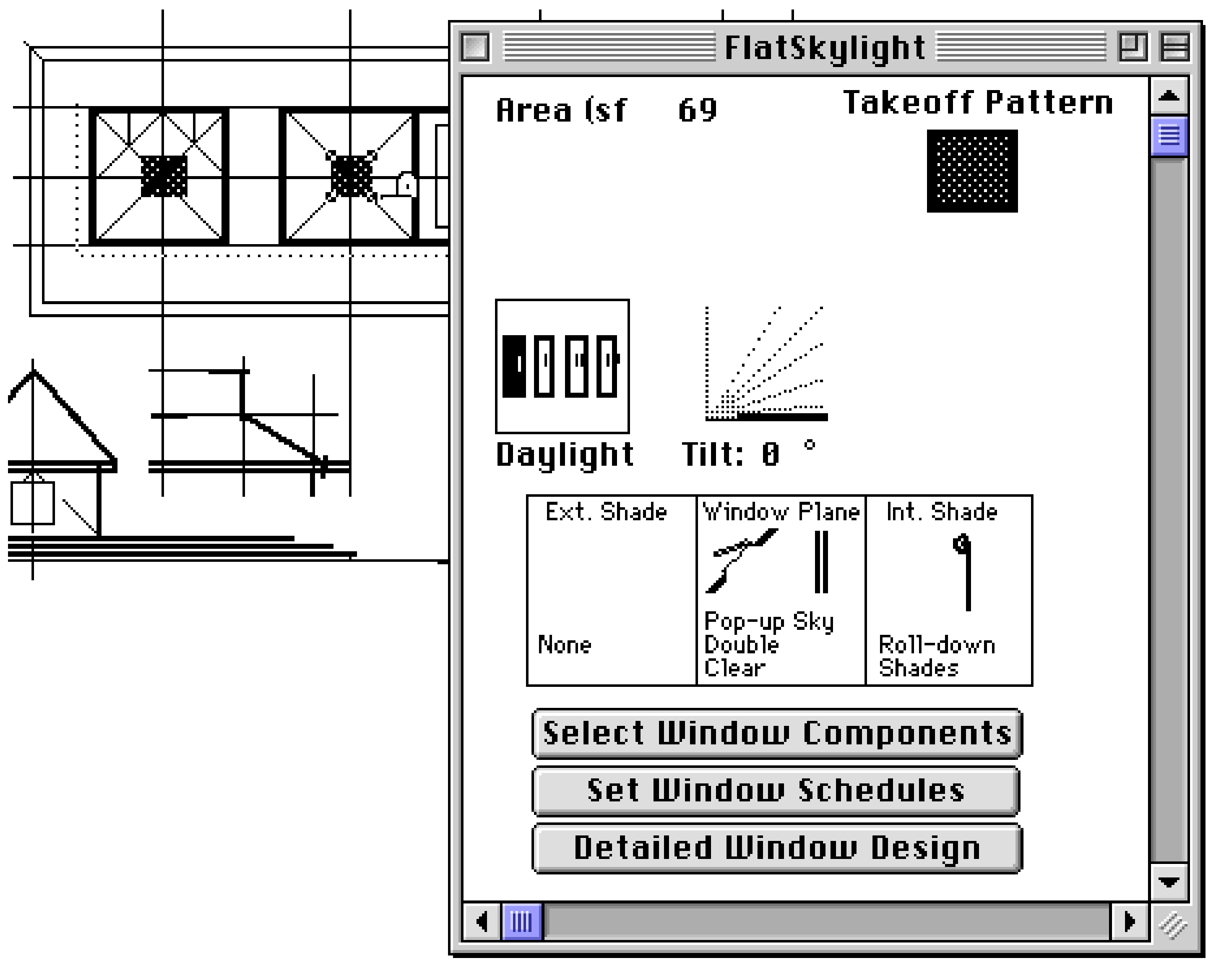
Flat Skylights

Flat (zero or near-zero slope), inoperable (fixed) skylights are the ONLY windows that you can specify from plans. Windows used as stack ventilation openings, MUST be specified in an elevation view, so that ES will properly calculate the stack height, which it does by measuring the height difference between inlets and outlets on the elevations.

- To set up Skylight Specs, double click on the Windows/Skylights icon then double click on the New Window Spec icon:

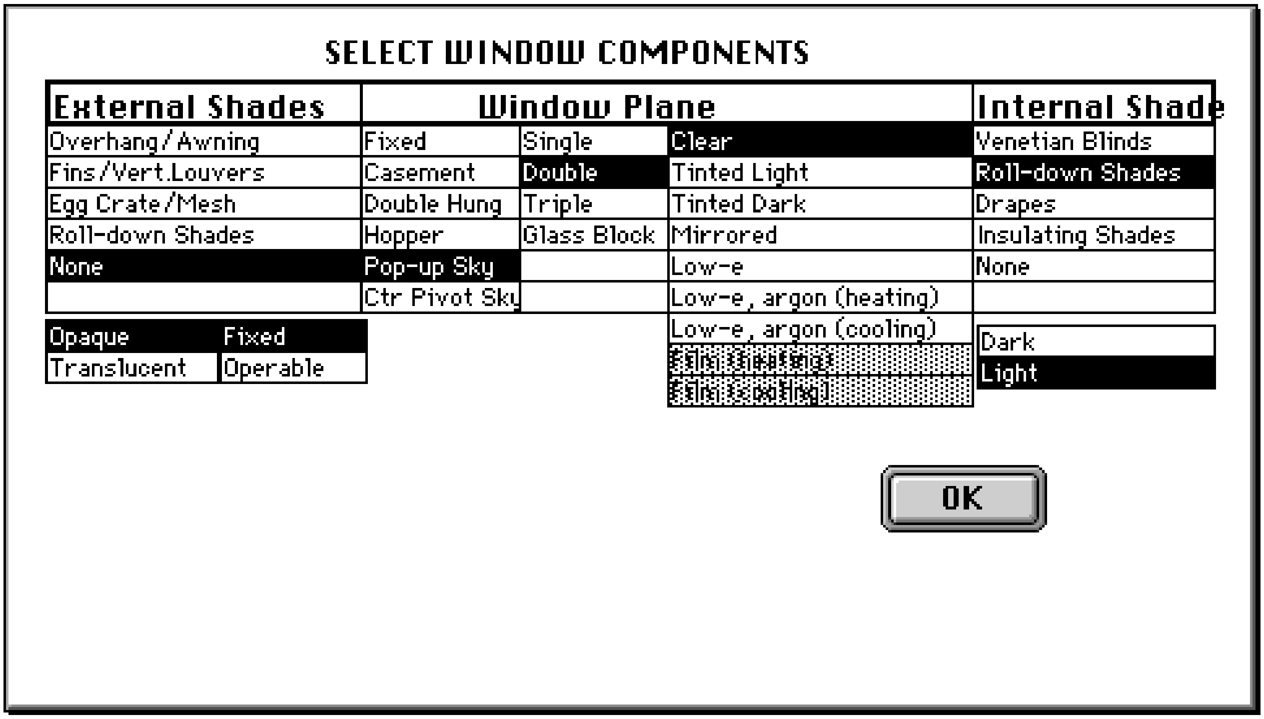


- You will get a spec window like the one below.



- Notice that the tilt options for skylights are grayed out in the spec window above, because skylights can only be flat.

- Skylight takeoffs are similar to takeoffs for Windows: First, select the daylight zone associated with the window by clicking on the Daylight Zone icon.
- Select the skylight components that are closest to your building's design:
  - Select the type of exterior shades, if any, in the Ext Shades icon.
  - Select the window type and glass type in the Window Plane icon.
  - Select the interior shading type, if any, in the Int. Shade icon.
  - OR, you can specify them in a table view by clicking on the Select Window Components button:



- In the table view, you can also define several additional specifics:
  - External shades as fixed or operable, and opaque or transparent.
  - Glass type may be defined
  - Internal shades can be defined as dark or light
- Use the tape measure or polygon tape measure to draw the area of the skylights.
- If you wish, you may also specify the Detailed Skylight Design, which follows the same logic as the Detailed Window Design.

See the section, "Plan Specifications: Windows / Skylights Specifications" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

Jump to the next section: Create Elevation Specifications

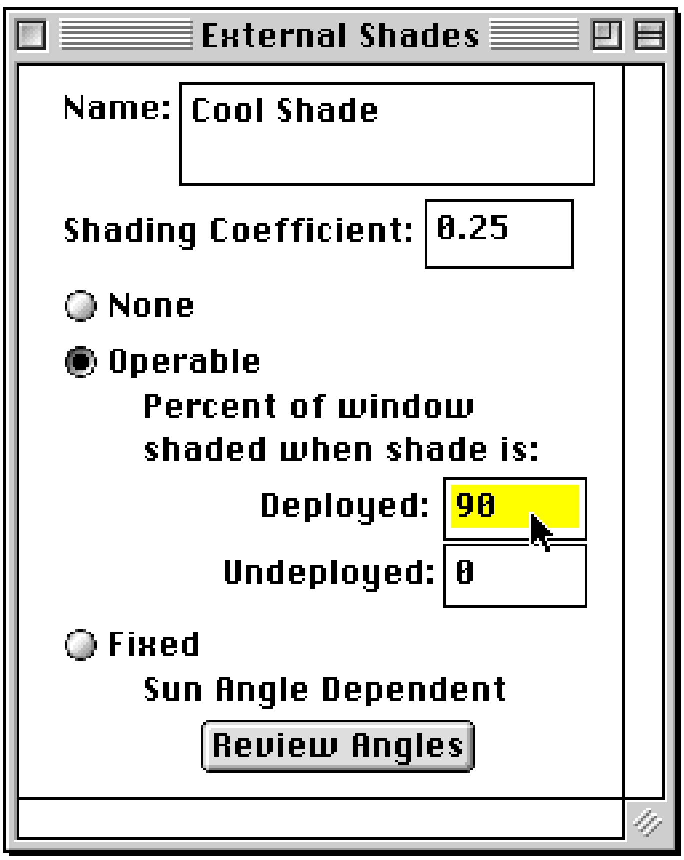
elevation specifications: windows

Detailed Window Design

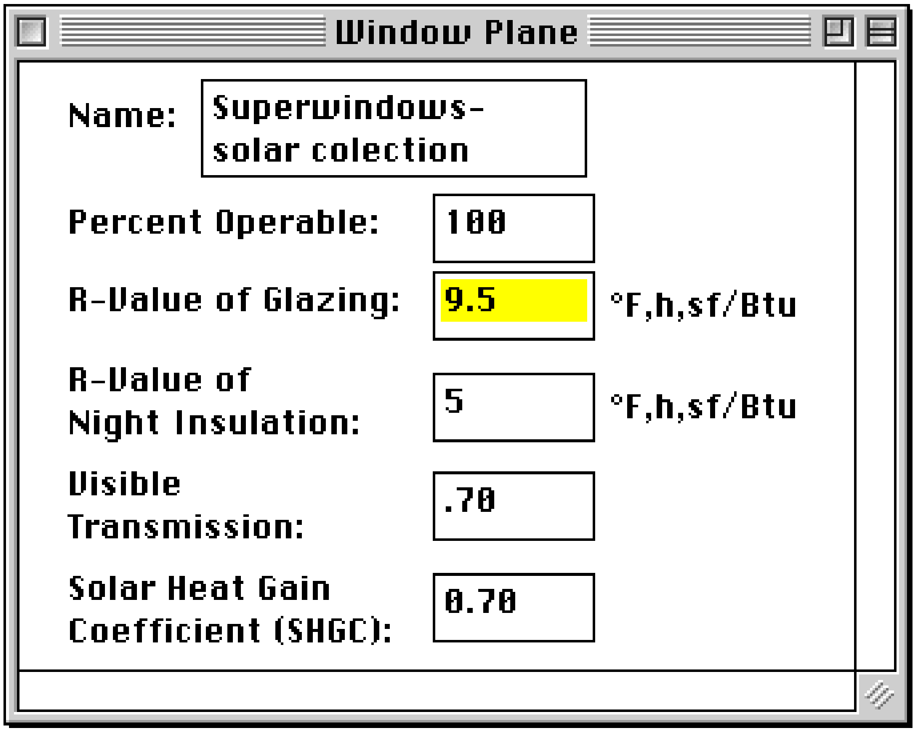
The window components available in ES are adequate for most designs, but you can also specify elements in very specific terms. *See the section, "Elevation Specifications: Windows / Skylights" in Chapter 5 of the ES manual for help.*

- Click on the Detailed Window Design button:

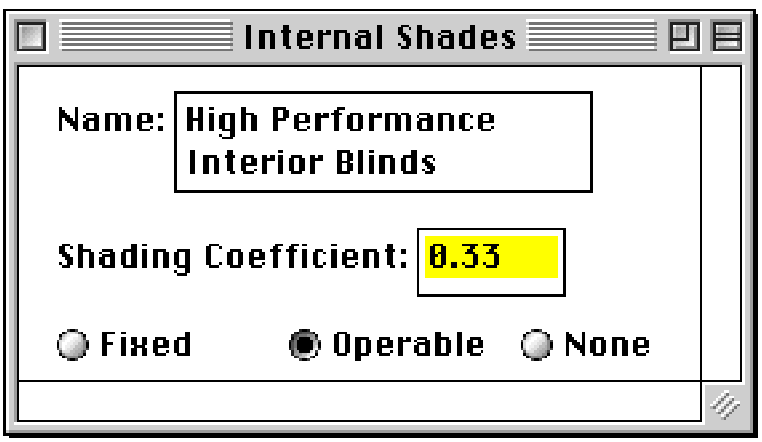
- A three-screen sequence will be [resented, one each for:
  - External Shades
  - Window Plane
  - Internal Shades
- **External Shades**



- **Window Plane**



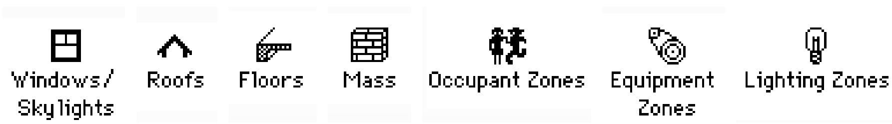
- Internal Shades



plan specifications: roofs

4) Create Plan Specifications.

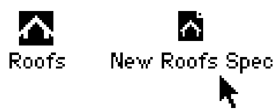
Click on one of the icons below for more information about creating specs and takeoffs for each element type:



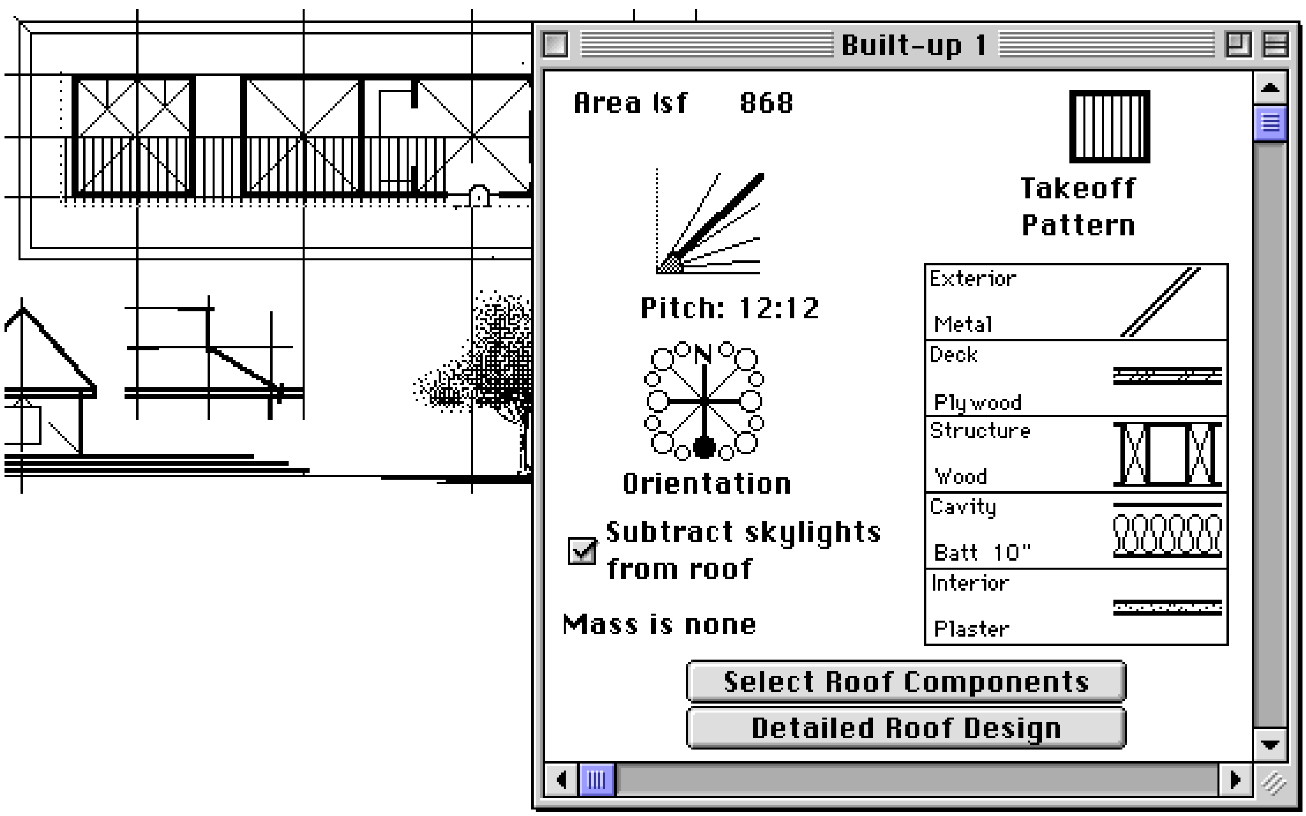
Roofs

Flat roofs, or roofs of very low slope must be specified in the plans. Sloping roofs may be specified in either Plan or Elevation views. Do a separate individual roof spec for each different type of roof construction.

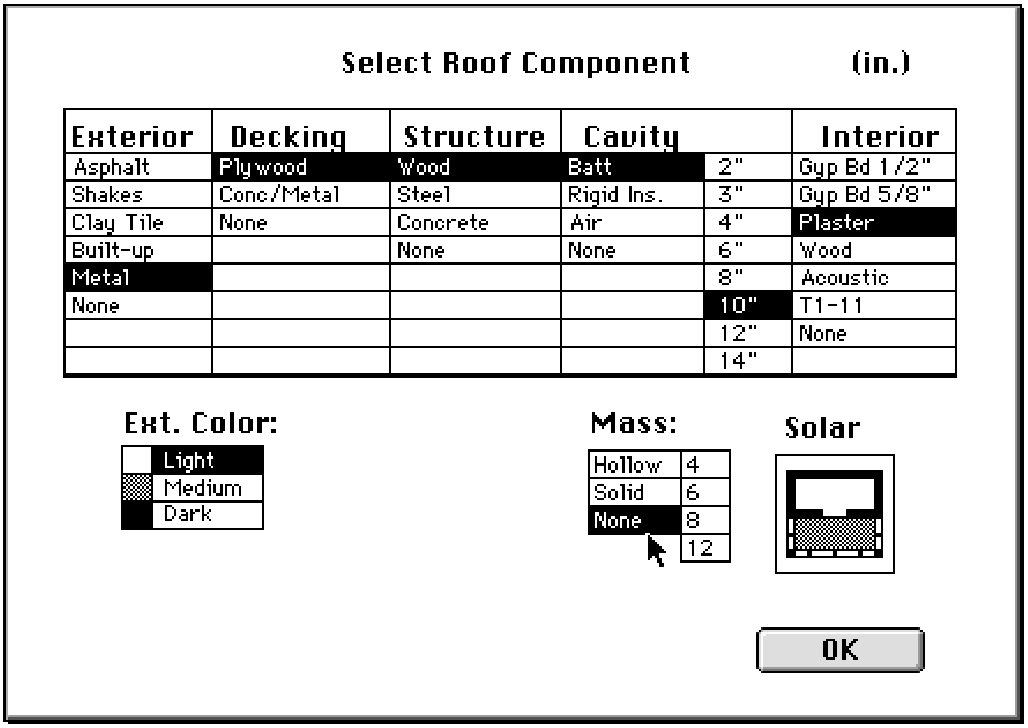
- To set up Roof Specs, double click on the Roofs icon then double click on the New Roof Spec icon:



- You will get a spec window like the one below.



- Click on the Pitch icon to select the slope of your roof.
- Click on the Orientation icon to set the roof's aspect.
- Select the construction components that are closest to your building. Unless your building is made of very unconventional materials, you should find a combination that will work for you from the options available in ES. You can click on the icons for each layer in your roof assembly or you can specify them in a table view by clicking on the select roof components button.



- NOTE: To take credit for mass in the roof, you must click on the "Select Roof Components" button. In the dialogue box that comes up, be sure to define:
    - the mass thickness that is exposed to the interior room air
    - whether the mass is hollow or solid
    - whether the mass is in a "solar" zone (room with direct sun) or "non-solar" zone (room linked to a room with direct sun)

  Remember, mass outside the insulation, or covered with insulating materials like carpet, does not count.
- Use the tape measure or polygon tape measure to draw the area of the roof.
- If you wish, you may also specify the Detailed Roof Design.

See the section, "Plan Specifications: Roof Specifications" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

Jump to the next section: Create Elevation Specifications

plan specifications: floors

4) Create Plan Specifications.

Click on one of the icons below for more information about creating specs and takeoffs for each element type:

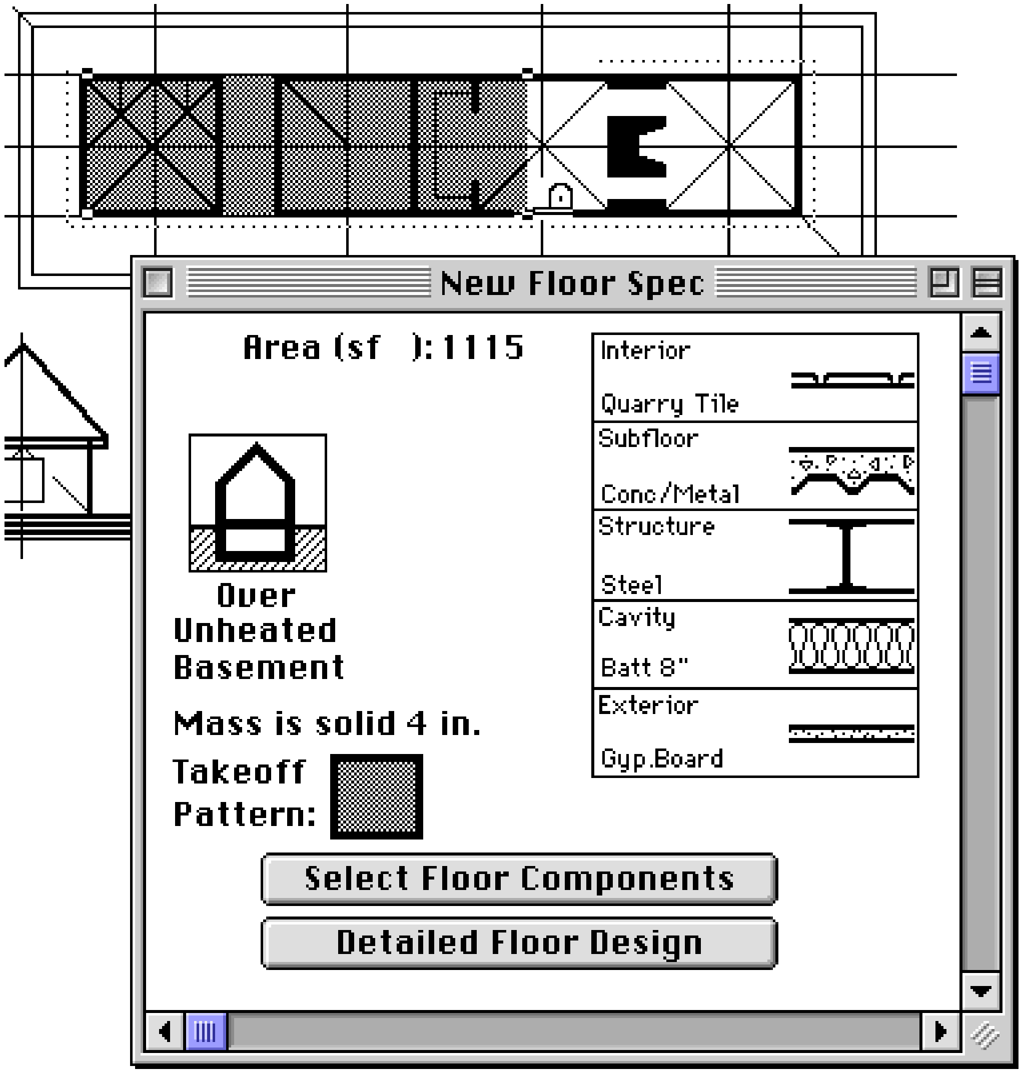
Floors

ONLY floor areas where heat loss or gain to the outside will occur should be taken off. This includes the perimeter of slabs (defined with the polygon tape measure), floors over crawl spaces and unheated basements, and overhanging or cantilevered floors where outside air is underneath. It does NOT include *intermediate* floors where a conditioned space is above and below the floor. In most buildings, this means that the lowest floor is taken off, but not the upper floors.

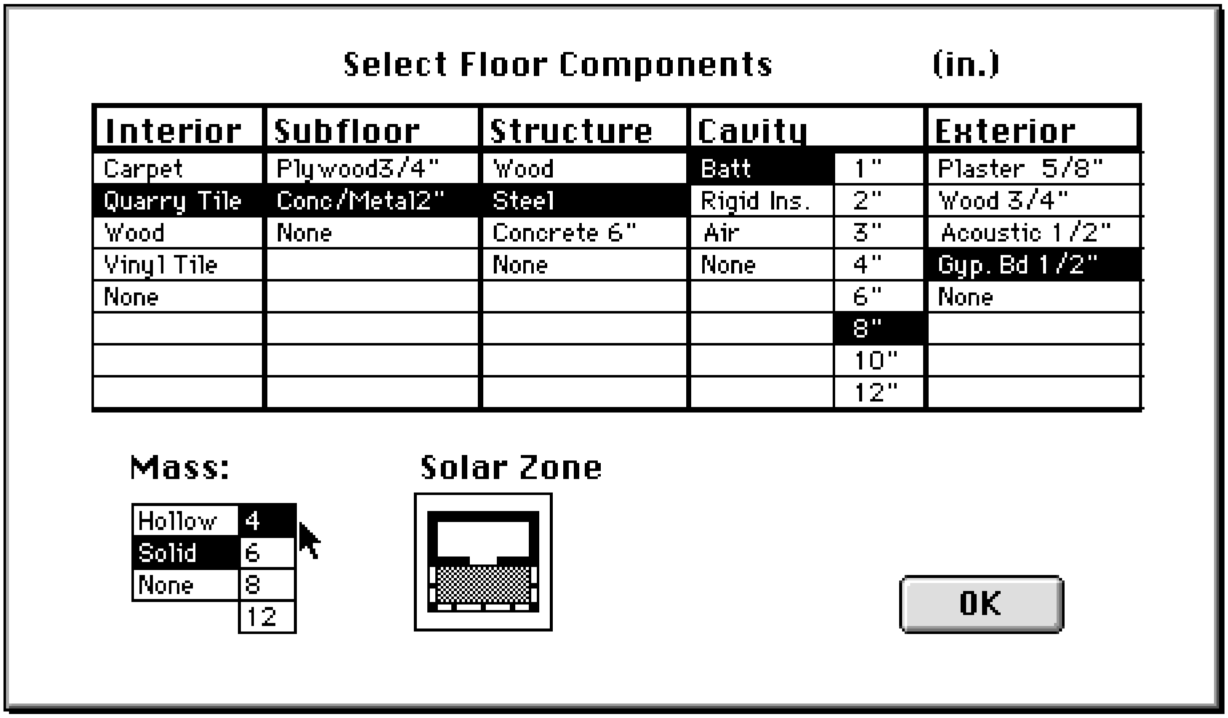
Create a different individual floor spec for each type of construction.

- To set up Floor Specs, double click on the Floors icon then double click on the New Floor Spec icon:

- You will get a spec window like the one below.



- Click on the icon for floor type to choose between the three options for underfloor conditions.
- Select the construction components that are closest to your building. Unless your building is made of very unconventional materials, you should find a combination that will work for you from the options available in ES. You can click on the icons for each layer in your floor assembly or you can specify them in a table view by clicking on the "Select Floor Components" button.



- To take credit for mass in the floor, you must click on the "Select Floor Components" button. In the dialogue box that comes up, be sure to define:
    - the mass thickness that is exposed to the interior room air
    - whether the mass is hollow or solid
    - whether the mass is in a "solar zone" (room with direct sun) or "non-solar zone" (room linked to a room with direct sun)

  Remember, mass outside the insulation, or covered with insulating materials like carpet, does not count.
- Use the tape measure or polygon tape measure to draw the area of the floor space . You must use the polygon tape measure for slab-on-grade.
- If you wish, you may also specify the Detailed Floor Design.

See the section, "Plan Specifications: Floors" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

Jump to the next section: Create Elevation Specifications

B. DEFINING: take-offs and specifications

plan specifications: mass

4) Create Plan Specifications.

Click on one of the icons below for more information about creating specs and takeoffs for each element type:

Thermal Mass

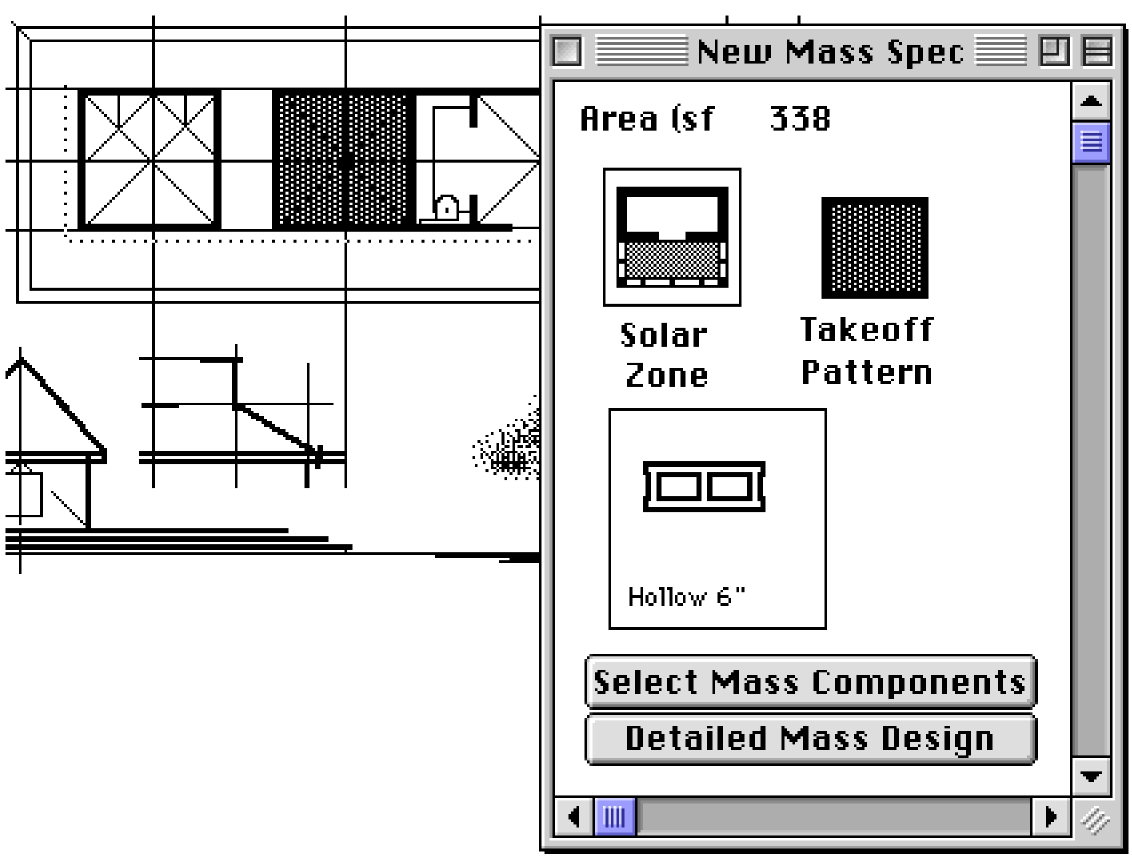
Any mass elements in the building which are NOT part of an exterior roof, wall, or floor that transfers heat conductively to the outside should be taken off using the mass icon. Take off internal mass in the PLANS if the mass is part of a HORIZONTAL surface, such as an exposed concrete intermediate floor or ceiling. VERTICALLY oriented mass, such as interior masonry bearing walls, should be taken off in the mass specification for ELEVATION drawings. Mass that is specified in wall, roof, or floor specs SHOULD NOT be specified again in the mass spec.

ES assumes that mass elements are exposed on only one side. If a mass element is exposed to room air on two sides, such as the top and bottom of a concrete spanning slab, then you should define the top and bottom as separate specifications, using one half of the actual mass thickness for each side.

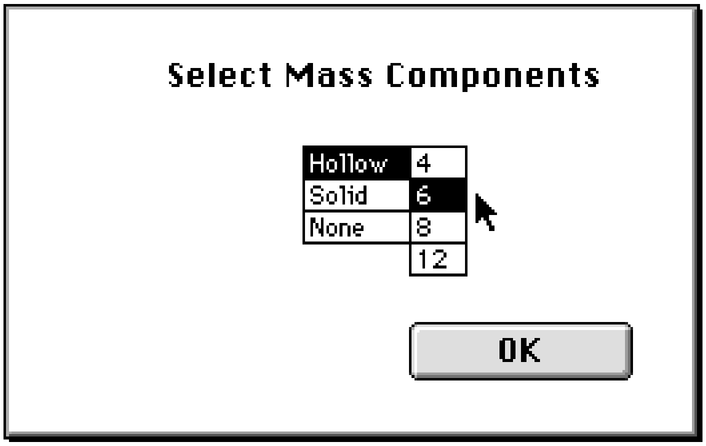
Create a different mass spec for each different type of horizontal mass.

- To set up Mass Specs, double click on the Mass icon then double click on the New Mass Spec icon:

- You will get a spec window like the one below.



- Click on the Solar Zone icon to spec whether your mass is in a room with south sun or not.
- Select the type and thickness of mass that are closest to your building by clicking on the icon. You can also specify the mass in a table view by clicking on the Select Mass Components button.

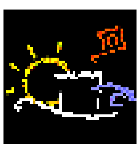


- Use the tape measure or polygon tape measure to draw the area of the mass.
- If you wish, you may also specify the Detailed Mass Design.

See the section, "Plan Specifications: Mass Specification" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

Jump to the next section: Create Elevation Specifications



Jump to other Sections of: B. DEFINING: take-offs and specifications

1. Tuning Settings to Fit Your Building
2. Define Your Daylight Zone Icon
3. Set Performance Goals
4. Create Plan Specifications
5. Create Elevation Specifications

plan specifications: occupants

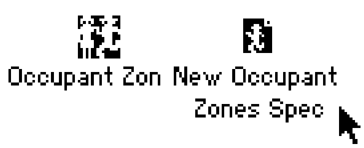
4) Create Plan Specifications.

Click on one of the icons below for more information about creating specs and takeoffs for each element type:

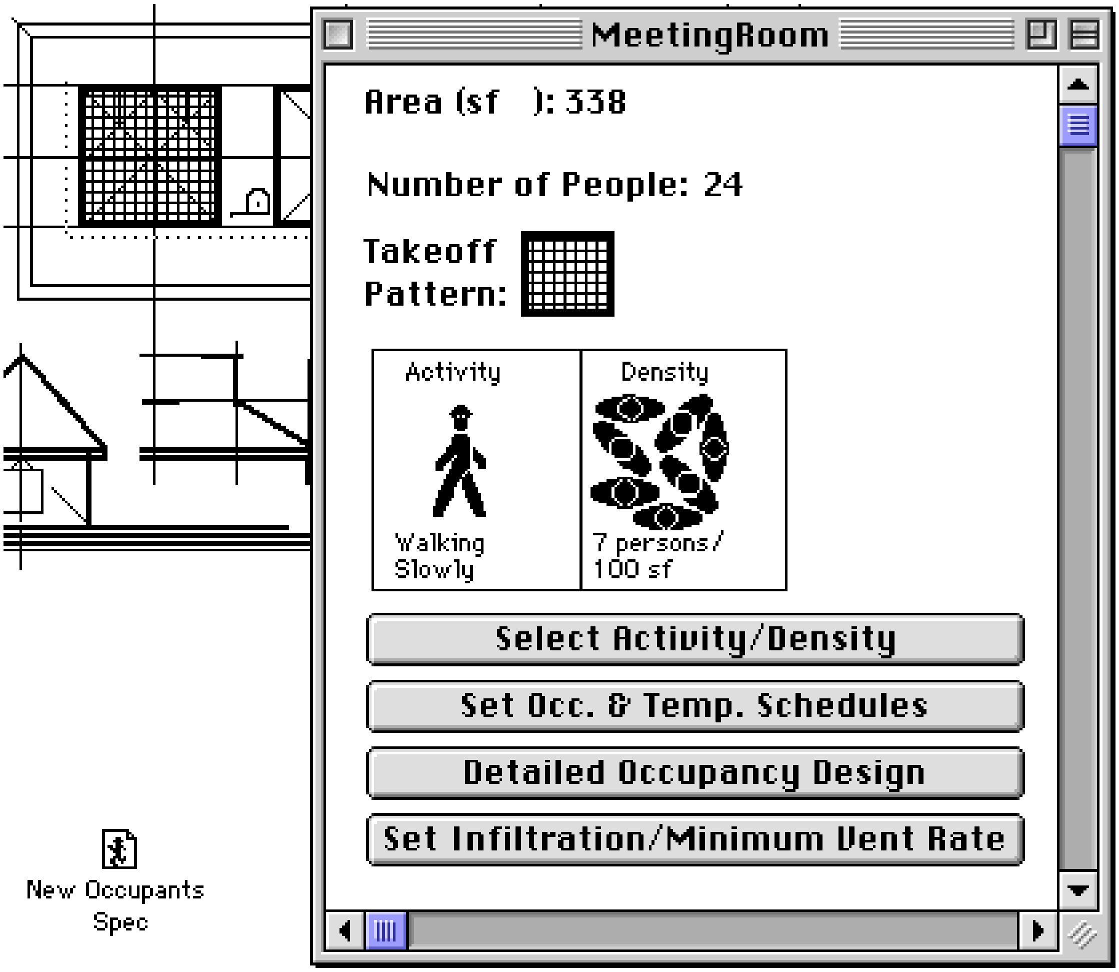
Occupants (People)
People make heat in buildings. Occupant loads increase with the higher metabolic rates of physical exertion. Higher occupant densities, such as assembly spaces will create more internal occupant load per square foot than a low occupant density.

Create a different individual occupant spec for each different occupancy condition in your building. If an area is unoccupied, do not create a spec for it.

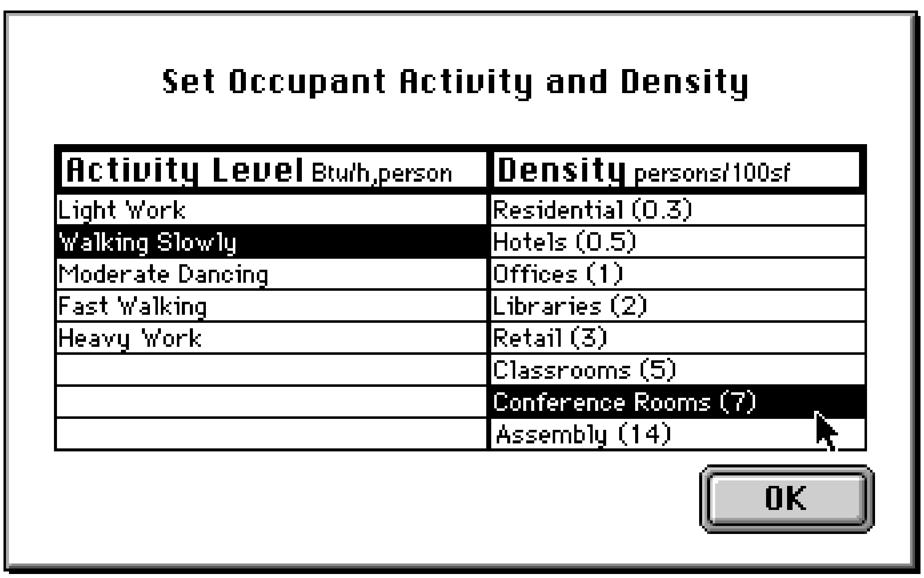
- To set up Occupant Specs, double click on the "Occupants" icon, then double click on the "New Occupant Zones Spec" icon:



- You will get a spec window like the one below.



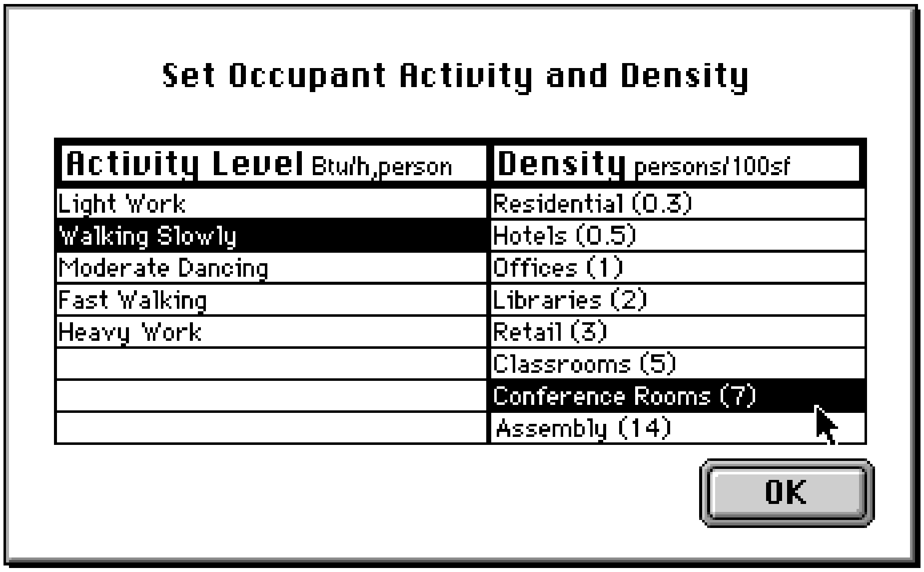
- Click on the icons for Activity and Density to choose the conditions that match the zone of your building.
- You can also specify occupants in a table view by clicking on the "Select Activity / Density" button:



- Use the tape measure or polygon tape measure to draw the area of the occupant zone.
  NOTE!: After your occupant zone is taken off with the tape measure tool, look in the spec window at the number of occupants calculated. If this is too high or too low, adjust the size of the occupant zone until you get the right number of people.
- If you wish, you may also specify the Detailed Occupant Design.

See the section, "Plan Specifications: Occupancy Zones" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.



- Use the tape measure or polygon tape measure to draw the area of the occupant zone.
  NOTE!: After your occupant zone is taken off with the tape measure tool, look in the spec window at the number of occupants calculated. If this is too high or too low, adjust the size of the occupant zone until you get the right number of people.
- If you wish, you may also specify the Detailed Occupant Design.

See the section, "Plan Specifications: Occupancy Zones" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

Jump to the next section: **Create Elevation Specifications**

B. DEFINING: take-offs and specifications

plan specifications: equipment

4) Create Plan Specifications.

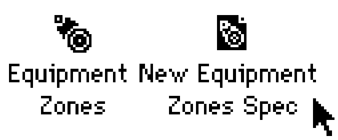
Click on one of the icons below for more information about creating specs and takeoffs for each element type:

Equipment

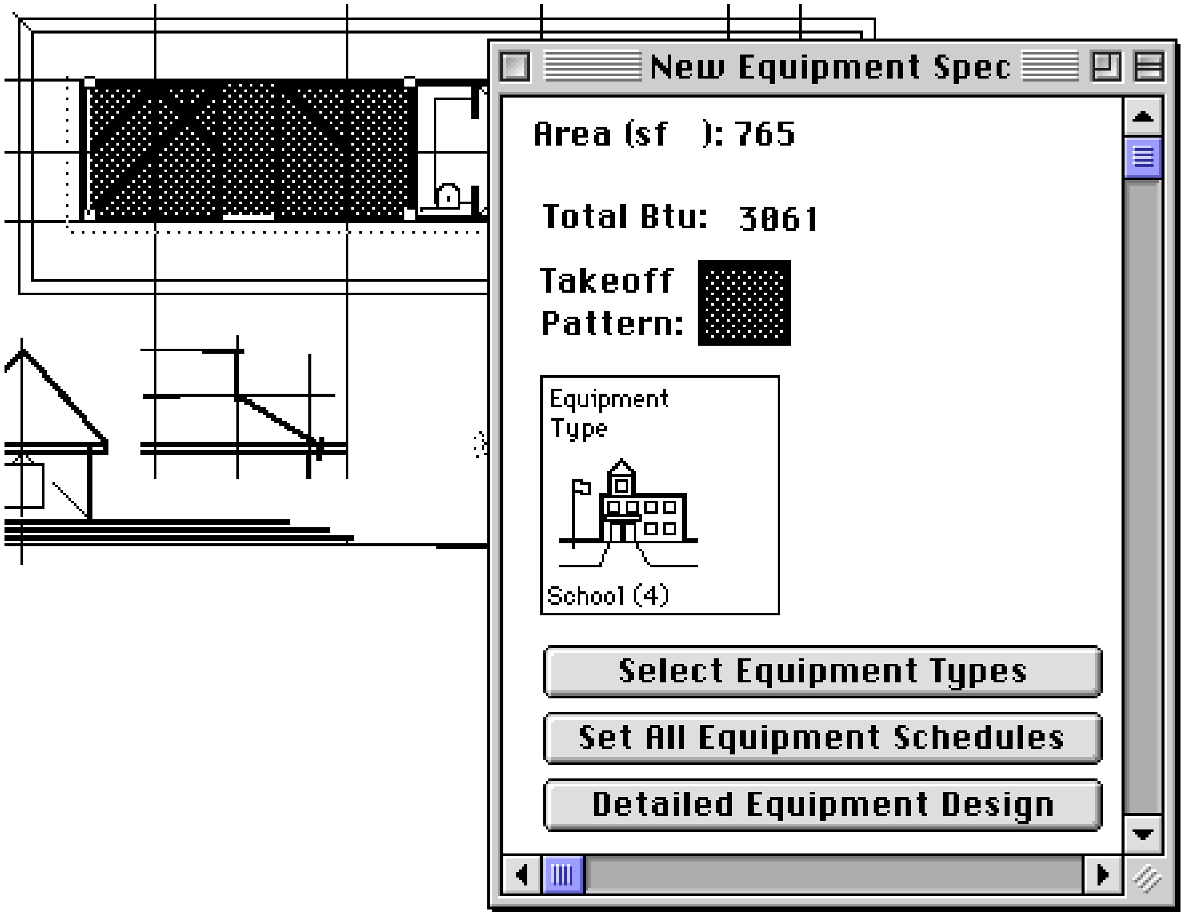
Equipment gains refer to the heat produced by machines inside the occupied parts of the building. It generally DOES NOT refer to waste heat from the building's mechanical heating or cooling system, since that type of equipment is generally located in separate, unconditioned space and is most often separately ventilated. Take off any zones of the building that have mechanical sources of heat, such as office equipment, computers, kitchen appliances, etc.

Create a different individual equipment spec for each different equipment load condition in your building. For instance, an architecture school might have studios with a low rate, offices with a moderate rate, and a computer lab with a high rate of equipment load. If an area is unoccupied or does not have significant equipment, do not create a spec for it.

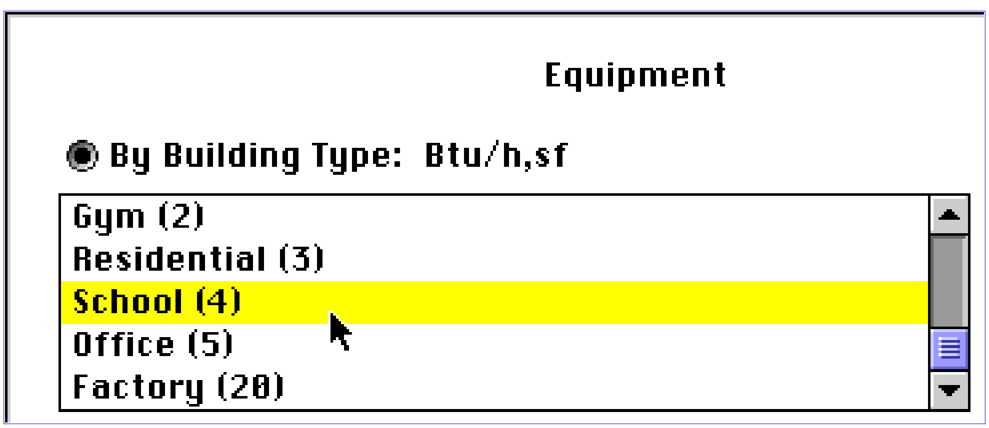
- To set up Equipment Specs, double click on the "Equipment" icon then double click on the "New Equipment Zones Spec" icon:



- You will get a spec window like the one below.



- Click on the icon in the spec window to choose the zone's equipment type according to its occupancy.
- You can also specify occupants in a table view by clicking on the "Select Equipment Types " button:



- Use the tape measure or polygon tape measure to draw the area of the Equipment zone.
- If you wish, you may also specify the Detailed Equipment Design.

See the section, "Plan Specifications: Equipment Zones" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

Jump to the next section: Create Elevation Specifications

B. DEFINING: take-offs and specifications

plan specifications: electric lighting

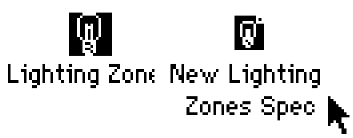
4) Create Plan Specifications.

Click on one of the icons below for more information about creating specs and takeoffs for each element type:

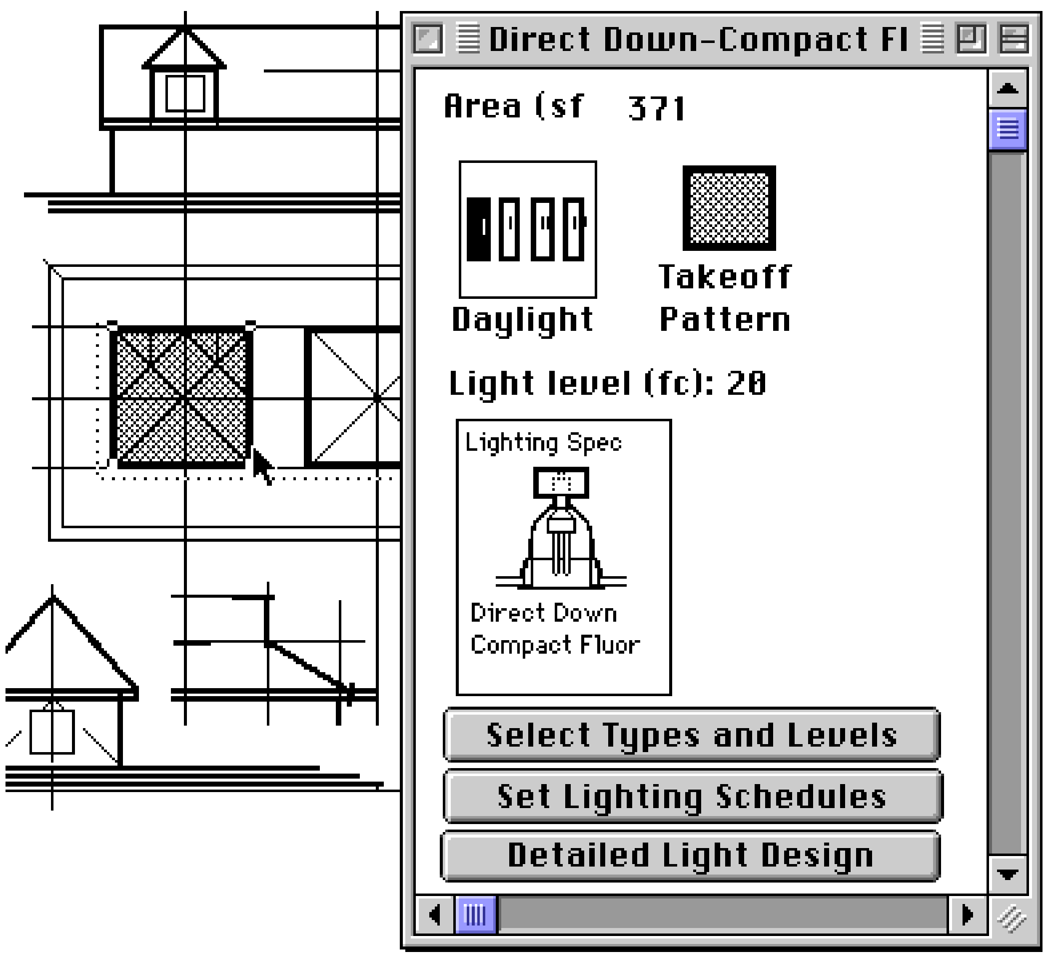
Electric Lighting

You can use the lighting specs to define as many different floor areas as you have lighting types or levels. More than one lighting spec can be associated with a particular daylight zone.

- To set up electric lighting zones, double click on the Lighting Zone icon, then double click on the New Lighting Spec icon:

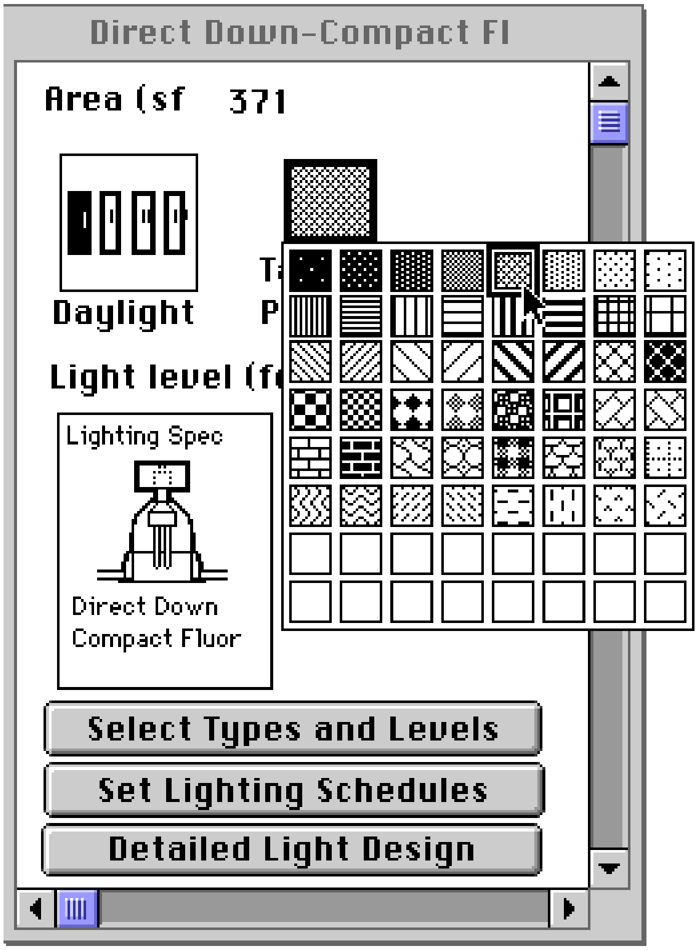


- You will get a spec window like the one below.

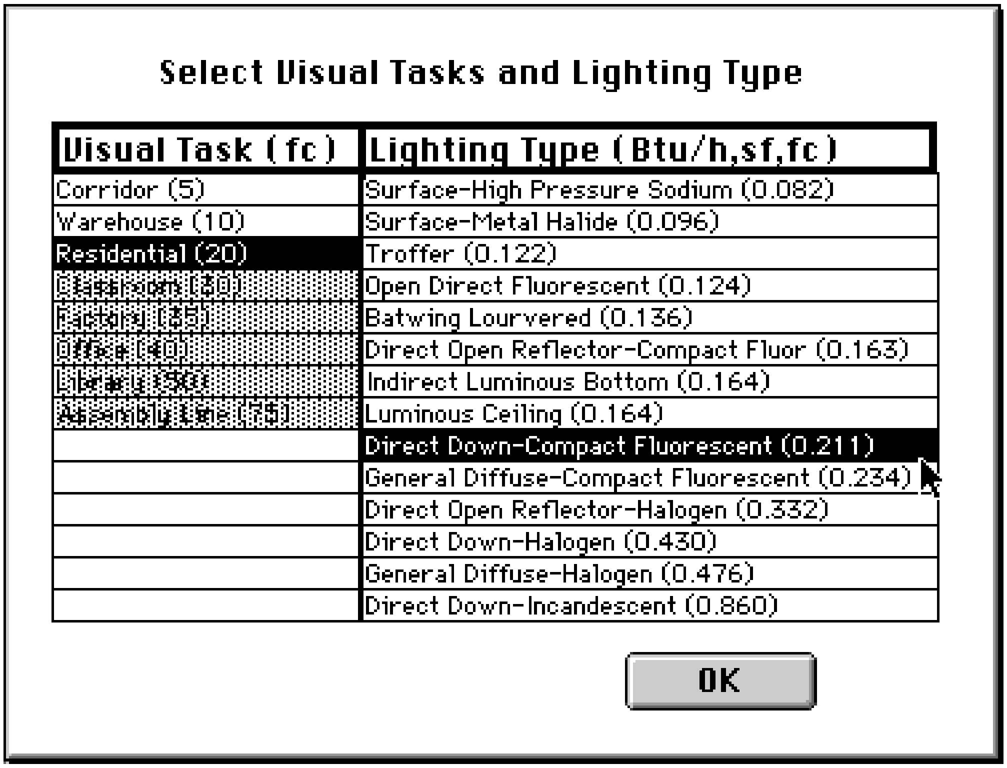


- Select the appropriate daylight zone in the daylight zone icon. Zone I is selected in the example.

- Use the tape measure or polygon tape measure to draw the area of the zone. The total of all Electric Lighting Zones associated with a daylight zone MUST sum to be exactly the same area as that daylight zone in plan. ES uses the electric lighting takeoff area to calculate the R/T area for daylighting in the Window Sizer.
- If desired, you can change the pattern of the takeoff by holding down on the Takeoff Pattern in the spec window.



- Select the "Lighting Types and Levels" by clicking on the button with that name. You can also click on the luminare icon to cycle through the lighting types. Notice that, depending on the lighting type you choose, some light levels foot - candles under the Visual Task column will be greyed-out, indicating some the type is inappropriate for that illuminance intensities.



- *When a Portion of the Electric Lights Will Always Be Off*
  Energy Scheming assumes that all the lights, in every part of the building, are turned on when the building is occupied and there is insufficient daylight available. In many buildings, this will overestimate gains from lighting. BUT, be sure not to reduce the AREA of the electric lighting zones; if you do, then the daylight calculations in the R/T Window sizer will be wrong. Instead, account for part of the lights being turned off (as is usually the case in a residence) by lowering the VISUAL TASK footcandle (fc) level in the Electric Lighting Spec window. If, for instance, you need 40 fc of light, but only half of the lights will ever be on at any one time, use 20 fc as your lighting level specification.
- *Other Lighting Types*
  If the options do not fit your lighting system well enough, you may choose to use the Detailed Light Design input method.

See the section, "Plan Specifications: Electric Lighting Zone Specifications" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

Jump to the next section: Create Elevation Specifications

B. DEFINING: take-offs and specifications

elevation specifications

5) Create Elevation Specifications.
Now that you have defined settings and parameters to fit your building, you are ready to take off the building elements.

shanley example.

Set up your Elevation Drawings.
The ES Manual has a detailed explanation of how to set up elevation drawings. From the file cabinet, choose Elevations. Then double click on the New Elevation icon. From the Drawing Spec window, name the drawing and set its scale with the scale tool. *See the section, "Specifications from Elevation Drawings" in Chapter 5 of the ES manual for help.*

How many Drawings?
In general, you will need one elevation drawing in ES for each different elevation of your building. You may want to review the suggestions about what drawings to use in ES found in Part A . DOCUMENTING. If you have a building with repetitive bays of Elevations, you can use ES's cloning functions to clone the drawing with or without its associated takeoffs.

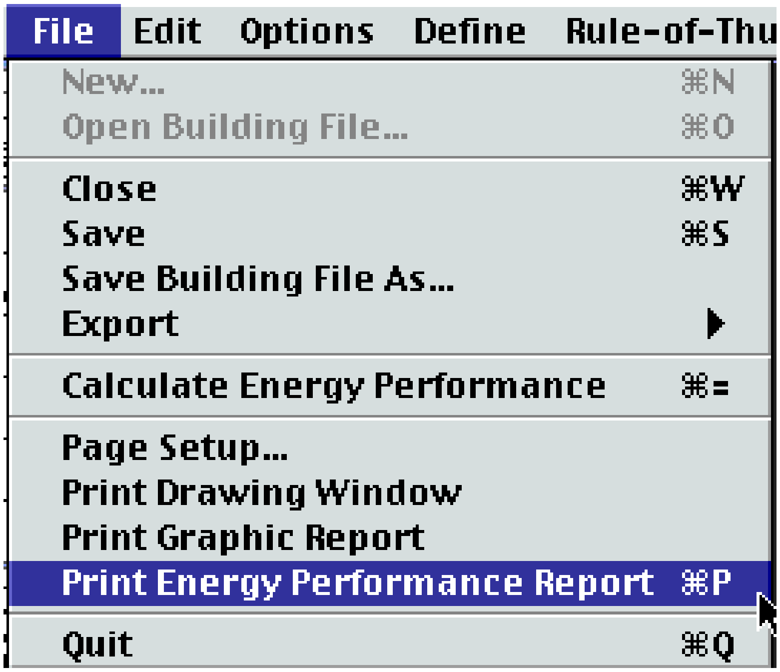
Where to Start!
Once your drawings are set up, you are ready for takeoffs. Building elements are specified in ES as a part of a particular plan or elevation drawing.

Click on one of the icons below for more information about creating specs and takeoffs for each element type:

SAVE and BACK-UP your work.

Turn in

- A screen capture of your Elevations, showing walls, roofs, and windows. Turn off all other elevation takeoffs (Mass) in the "VIEW / Takeoffs..." menu. You will not be able to print the takeoffs unless you use a screen capture technique.
- A printout of the energy performance report, with items checked as shown in this window.



For a guide, see the *shanley example.*

B. DEFINING: take-offs and specifications

elevation specifications: walls

4) Create Elevation Specifications.

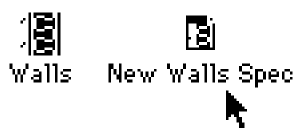
Now that you have defined settings and parameters to fit your building, you are ready to take off the building elements.

Click on one of the icons below for more information about creating specs and takeoffs for each element type:

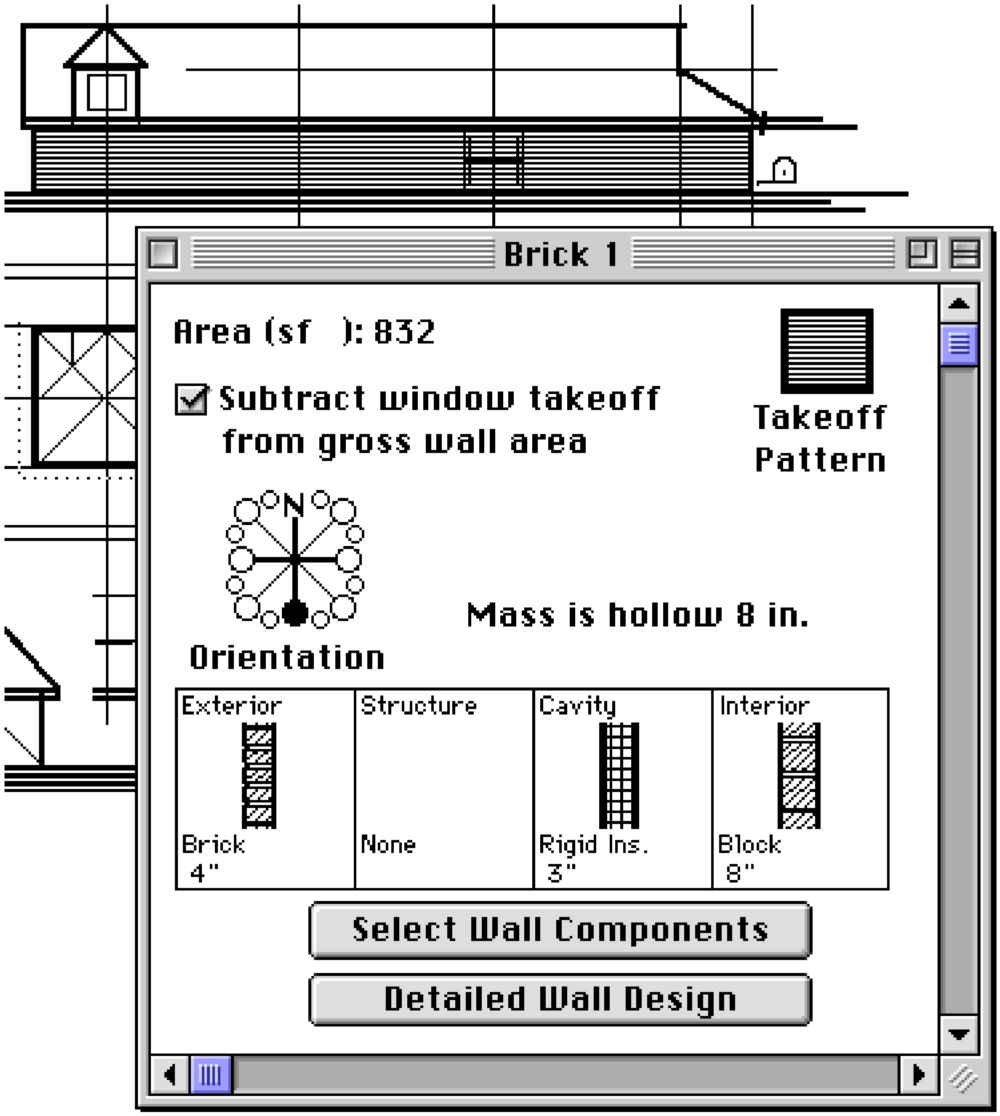
Walls

Walls are easy to define in ES. Create a different individual wall spec for each type of construction in each elevation. ES will automatically subtract any window area for window takeoffs that are drawn over the wall takeoffs. That makes your work simple!

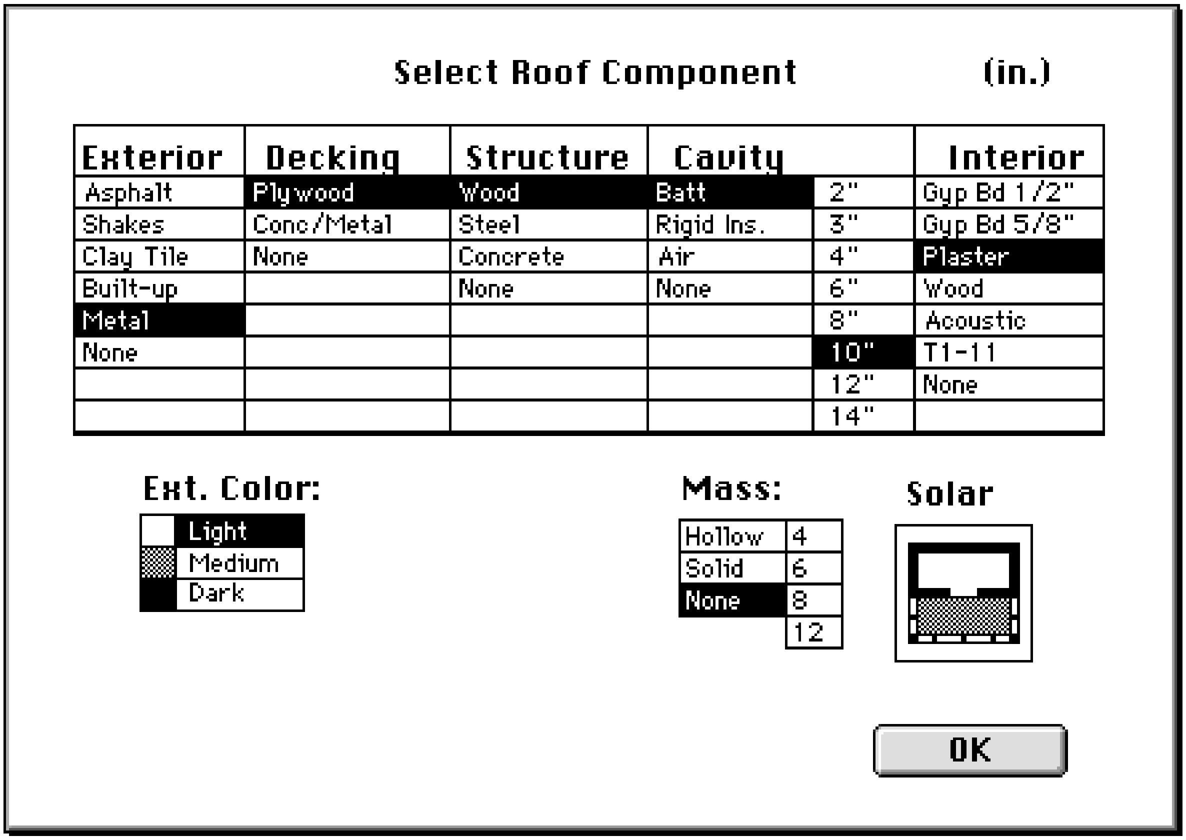
- To set up Walls Specs, double click on the Walls icon then double click on the New Wall Spec icon:



- You will get a spec window like the one below.



- Wall orientation defaults to the orientation of the elevation drawing. If the wall takeoff you are working on is oriented in some other way, such as an angled wall in an elevation, define a different orientation by clicking on the orientation (compass) icon.
- Select the construction components that are closest to your building. Unless your building is made of very unconventional materials, you should find a combination that will work for you from the options available in ES. You can click on the icons for each layer in your wall assembly or you can specify them in a table view by clicking on the "Select Wall Components" button.



- To take credit for mass in the wall, you must click on the "Select Wall Components" button. In the dialogue box that comes up, be sure to define:
  - ❍ the mass thickness that is exposed to the interior room air
  - ❍ whether the mass is hollow or solid
  - ❍ whether the mass is in a "solar zone" (room with direct sun) or "non-solar zone" (room linked to a room with direct sun)

  Remember, mass outside the insulation, or covered with insulating materials like carpet, does not count.
- Use the tape measure or polygon tape measure to draw the area of the wall.
- If you wish, you may also specify the Detailed Wall Design.

See the section, "Elevation Specifications: Walls" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

B. DEFINING: take-offs and specifications

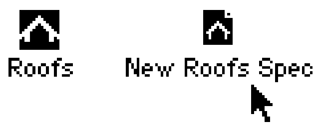
elevation specifications: roofs

4) Create Elevation Specifications.
Now that you have defined settings and parameters to fit your building, you are ready to take off the building elements.

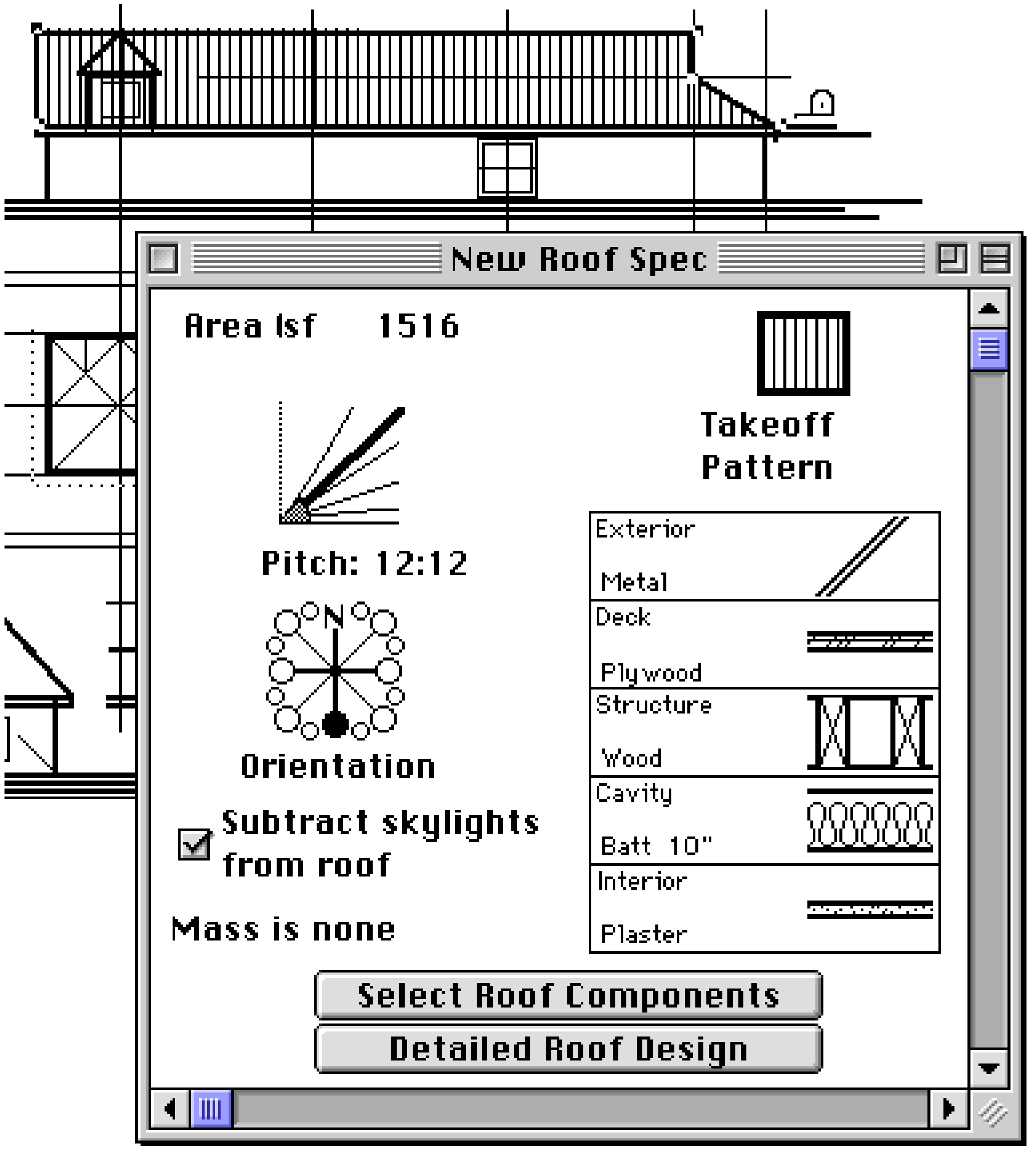
Click on one of the icons below for more information about creating specs and takeoffs for each element type:

Roofs
Flat roofs, or roofs of very low slope must be specified in the plans. Sloping roofs may be specified in either Plan or Elevation views. Do a separate individual roof spec for each different type of roof construction.

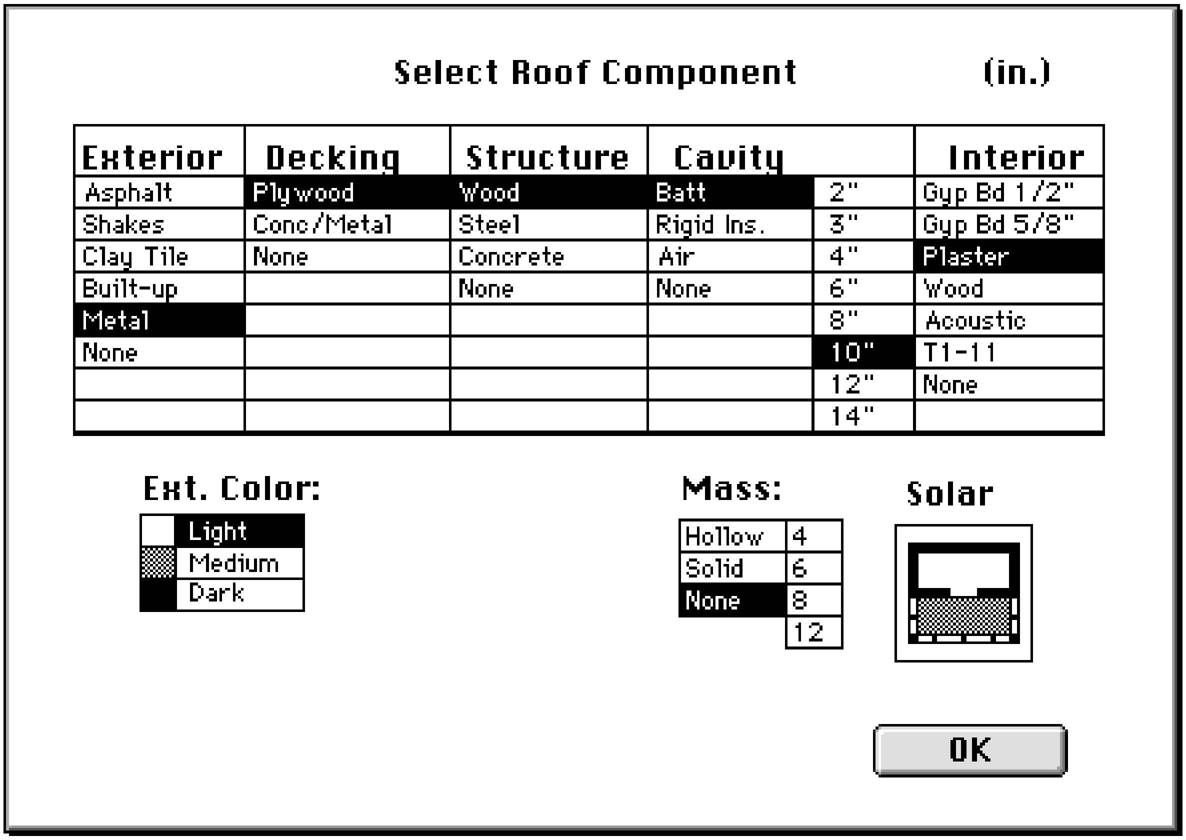
- To set up Roof Specs, double click on the Roofs icon then double click on the New Roof Spec icon:



- You will get a spec window like the one below.



- Click on the Pitch icon to select the slope of your roof.
- Click on one of the compass points in the Orientation icon to set the roof's orientation.
- Select the construction components that are closest to your building. Unless your building is made of very unconventional materials, you should find a combination that will work for you from the options available in ES. You can click on the icons for each layer in your roof assembly or you can specify them in a table view by clicking on the select Roof Components button.



- NOTE: To take credit for mass in the roof, you must click on the "Select Roof Components" button. In the dialogue box that comes up, be sure to define:
  - the mass thickness that is exposed to the interior room air
  - whether the mass is hollow or solid
  - whether the mass is in a "solar zone" (room with direct sun) or "non-solar zone" (room linked to a room with direct sun)

  Remember, mass outside the insulation, or covered with insulating materials like carpet, does not count.
- Use the tape measure or polygon tape measure to draw the area of the roof.
- If you wish, you may also specify the Detailed Roof Design.

See the section, "Elevation Specifications: Roofs" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

B. DEFINING: take-offs and specifications

elevation specifications: windows

4) Create Elevation Specifications.

Click on one of the icons below for more information about creating specs and takeoffs for each element type:

Windows

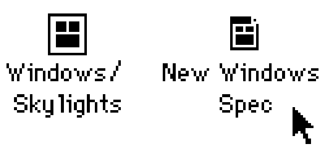
All operable windows should be specified in the elevations. Flat (zero or near-zero slope), inoperable (fixed) skylights are the ONLY windows that you can specify from plans. Windows used as stack ventilation openings, MUST be specified in an elevation view, so that ES will properly calculate the stack height, which it does by measuring the height difference between inlets and outlets on the elevations.

Common Mistakes with Windows

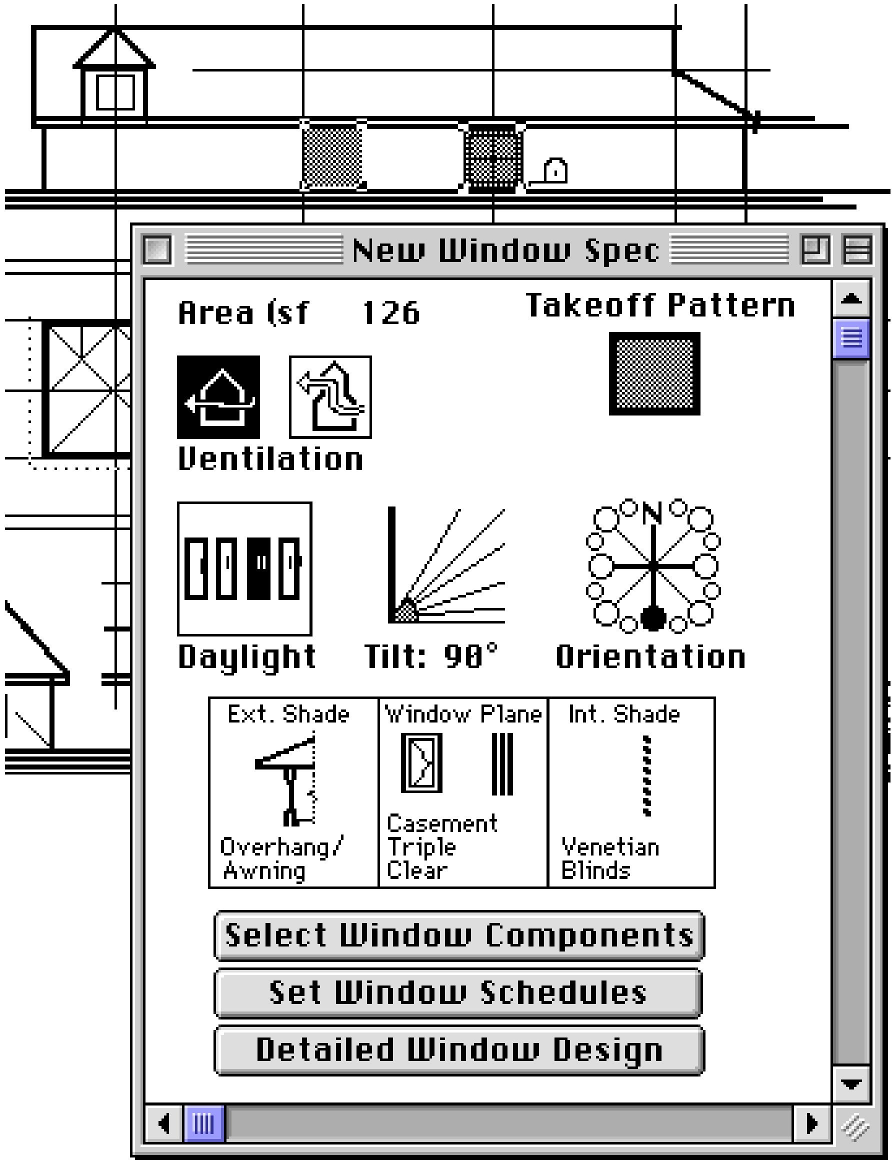
Specific notes on avoiding mistakes with the Stack Reference Line, Daylight Zones, Opaque Shades, Night Insulation, Tress and Site Obstructions

Window Specifications

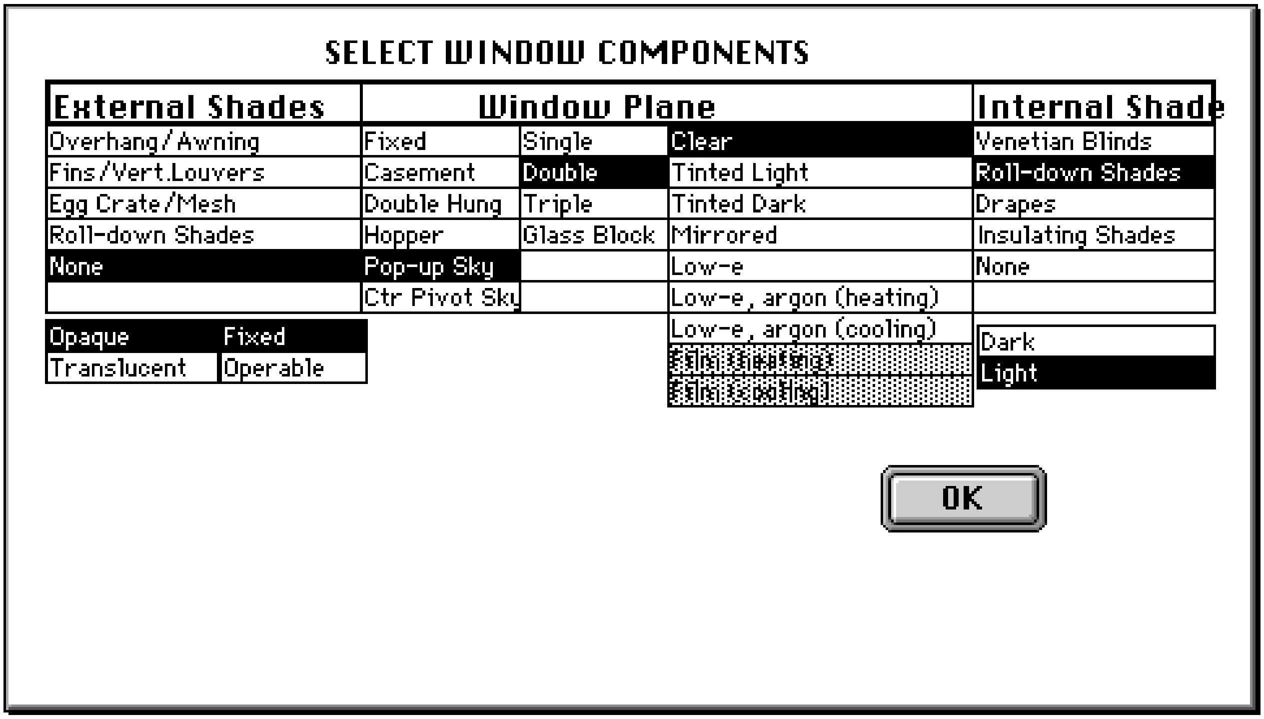
- To set up Window Specs, double click on the Windows/Skylights icon then double click on the New Window Spec icon:



- You will get a spec window like the one below.



- Define the window's role in ventilation: click on the Cross Ventilation icon if the window is an inlet or outlet for cross ventilation. Click on the Stack Vent icon if the window is part of a stack ventilation strategy. When you select stack venting for the first time in an elevation, ES will prompt you to draw a reference line. For more info, see Common Mistakes with Windows.
- First, select the daylight zone associated with the window by clicking on the Daylight Zone icon.
- Define the window's tilt angle in the Tilt icon.
- Define the window's orientation, if different from the elevation (such as for the angled parts of a bay window) in the Orientation compass icon.
- Select the window components that are closest to your building's design:
  - Select the type of exterior shades, if any, in the Ext Shades icon.
  - Select the window type and glass type in the Window Plane icon. When there are two images, click on each icon separately.
  - Select the interior shading type, if any, in the Int. Shade icon.
  - OR, you can specify them in a table view by clicking on the Select Window Components button:



- In the table view, you can also define several additional specifics:
    - External shades as Fixed or Operable, and Opaque or Transparent.
    - Glass type may be defined
    - Internal shades can be defined as Dark or Light
- Use the tape measure or polygon tape measure to draw the area of the skylights.
- If you wish, you may also specify the Detailed Window Design. The detailed screens will also allow you to see the values used by ES for the elements you have already selected in the simple method.

See the section, "Elevation Specifications: Windows / Skylights" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

elevation specifications: windows

Common Mistakes with Windows

- **Stack Reference Line**
  In order to calculate stack height (the distance between vertical inlets and outlets), ES needs a reference line drawn on each elevation from which to measure. This reference line should be defined in the first window specification of each elevation. When you open your first window spec box, click on the radio button for a stack ventilation inlet or outlet. You will get an instruction window. Follow the procedures in the ES manual to define the reference line. It is important that the reference line be drawn at a height which represents the same "elevation above sea level" on each elevation drawing. On a flat site, this is easy, just use the ground line. On a sloping site, it can be tricky, so be careful.
- **Daylight Zones**
  Be sure to associate each window with the appropriate Daylight Zone by clicking on the daylight zone icon in the upper left of the window spec box.
- **Opaque shades**
  Opaque Shades will do a good job at blocking solar heat gain, but they will also block out daylight. If you use opaque internal shades, you will see the electric lights come on during the hot parts of the day.
- **Night Insulation**
  If you want to specify night insulation, do NOT use the "Insulating Shades" option, as it will block daylight whenever employed and is NOT regulated by the Night Insulation Schedules. Instead, specify all the window elements, including exterior and interior shades, if desired. Then click on the "Detailed Window Design" button in the window spec box. The values shown in each of the three new spec windows represent the selections you have made already. You do not need to change them. In the spec window for the "Window Pane," you can specify an R-Value for night insulation. This done, ES will employ internal shading and night insulation *separately* as needed and per your schedules.
- **Trees and Site Obstructions.**
  Window takeoffs are the place to account for Trees and Site Obstructions. To do so, you will have to do a detailed window spec. First define all the window elements in the window spec. Then click on the "Detailed Window Spec" button. Input an external layer shading coefficient to account for trees or external obstructions from buildings, walls, etc. If your building also has external shading on the building itself, multiply the external shading device's shading coefficient by the shading coefficient that you are using to account for external obstructions. Use the product of these as an input . *Shading coefficients can be found in Appendix A of the ES Manual.* Alternatively, the percentage of glass shaded at specific sun angles can be input to define the exterior obstructions by clicking on the "Review Angles" button in the External Shades spec window.

B. DEFINING: take-offs and specifications

elevation specifications: mass

4) Create Elevation Specifications.

Now that you have defined settings and parameters to fit your building, you are ready to take off the building elements.

Click on one of the icons below for more information about creating specs and takeoffs for each element type:

Thermal Mass

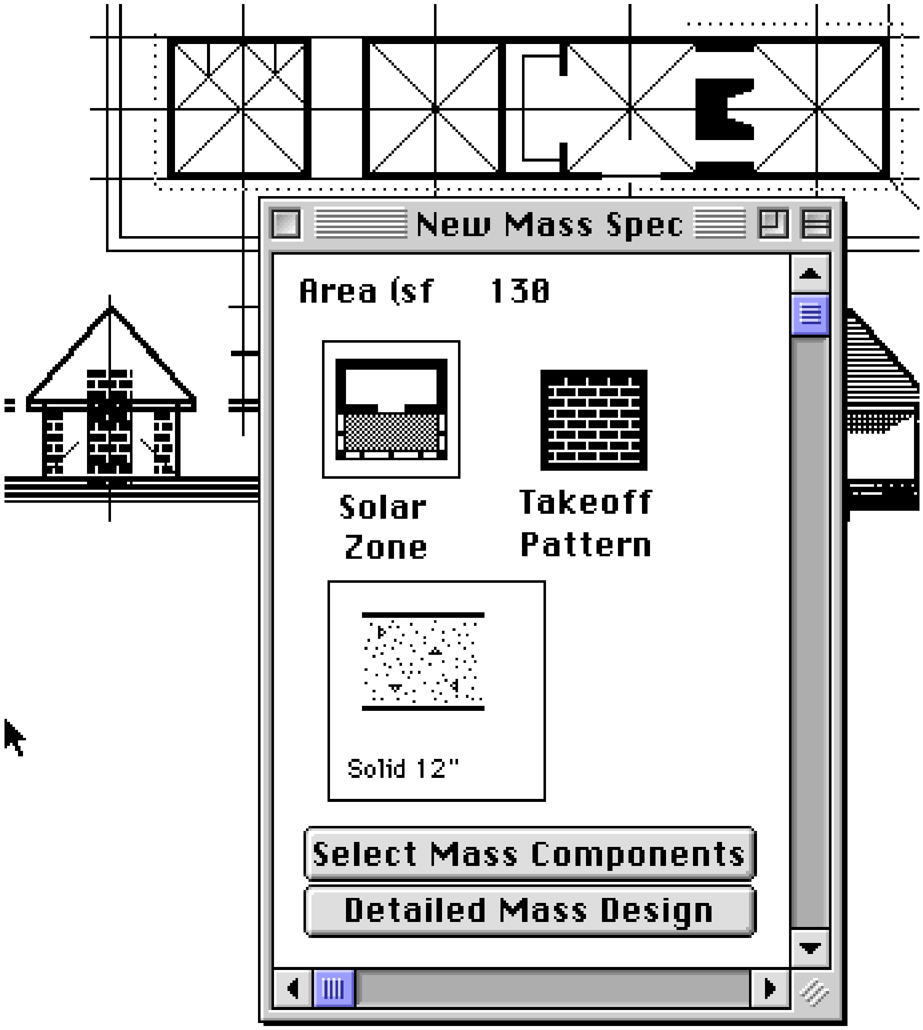
Any mass elements in the building which are NOT part of an exterior roof, wall, or floor that transfers heat conductively to the outside should be taken off using the mass icon. Take off internal mass in the PLANS if the mass is part of a HORIZONTAL surface, such as an exposed concrete intermediate floor or ceiling. VERTICALLY oriented mass, such as interior masonry bearing walls, should be taken off in the mass specification for ELEVATION drawings. Mass that is specified in wall, roof, or floor specs SHOULD NOT be specified again in the mass spec.

ES assumes that mass elements are exposed on only one side. If a mass element is exposed to room air on two sides, such as both sides of an interior masonry wall, then you should define the each side as separate specifications, using one half of the actual mass thickness for each side. Remember that exposed area is a more important factor in the mass's thermal performance than is its thickness.

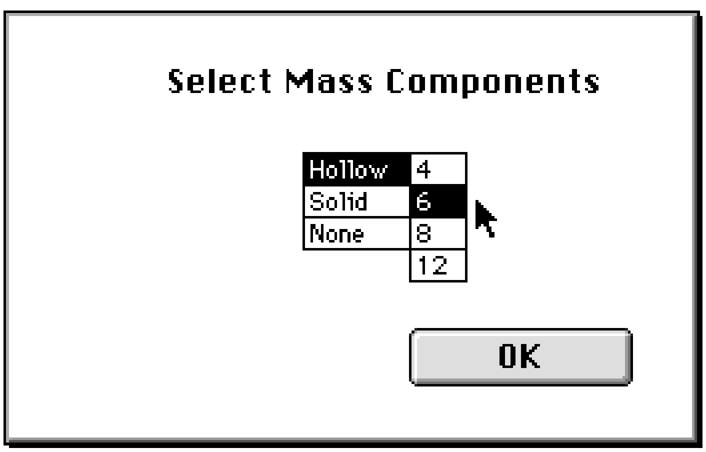
Create a different mass spec for each different type of vertical mass.

- To set up Mass Specs, double click on the Mass icon then double click on the New Mass Spec icon:

- You will get a spec window like the one below.



- Click on the Solar Zone icon to spec whether your mass is in a room with south sun or not.
- Select the type and thickness of mass that are closest to your building by clicking on the icon. You can also specify the mass in a table view by clicking on the Select Mass Components button.



- Use the tape measure or polygon tape measure to draw the area of the mass.

If you wish, you may also specify the Detailed Mass Design.

See the section, "Elevation Specifications: Mass Specification" in Chapter 5 of the ES manual for help.

SAVE and BACK-UP your work.

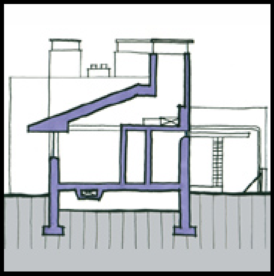
EXAMPLE PROJECT
shanley dental building, clayton, mo

harris armstrong, architect, 1936

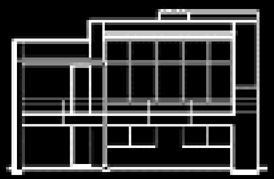
Worked Example

Re-Cycling with *Energy Scheming* exercise

Model



Final Drawings



Drawings

Site Photos

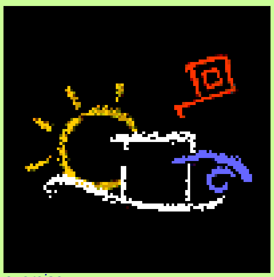
EXAMPLE PROJECT: example exercise

outline of example problem pages

exercise

A. DOCUMENTING: input your building (example)

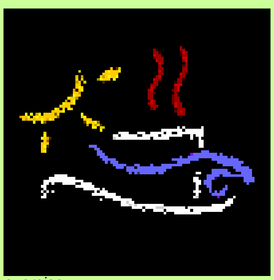
1. Assemble Schematic Plans and Elevations of Your Design
2. Identify the Building's Construction Type(s)
3. Diagram the Solar Concept
4. Determine Your Simulation Strategy
5. Diagram the Daylighting Zones
6. Get the Drawings into the Computer
7. Create a New Climate, if necessary



exercise

B. DEFINING: take-offs and specifications (example)

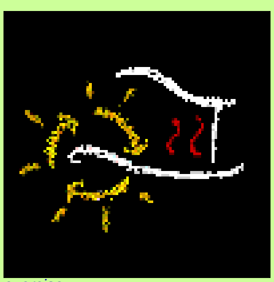
1. Tune Settings to Fit Your Building
2. Define Your Daylight Zone Icon
3. Set Performance Goals for Lighting and Heating
4. Create Plan Specifications
5. Create Elevation Specifications



exercise

C. ANALYZING: understanding energy patterns (example)

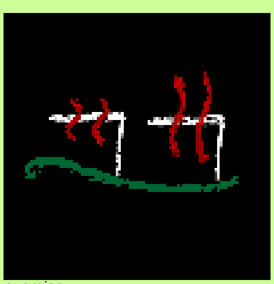
1. Use the Rule-of-Thumb Window Sizer
2. View the Graphic Report
3. Interpret and Assess the Building's Performance



exercise

D. RE-DESIGNING: generate and test cycles (example)

1. Re-Design to Meet Your Window Performance Targets
2. Re-Design to Reduce Net Flows and Peak Loads
3. Print the "Energy Performance Report"
4. Document Design Changes



exercise

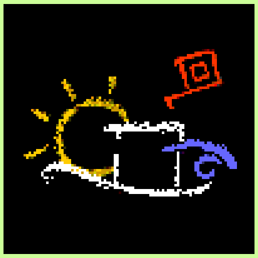
E. EVALUATING: comparing with energy codes (example)

1. Set an Energy Budget
2. Choose Reference Criteria
3. Model Your Reference Case Building
4. Compare the Performance of the Two Designs

Download the PDF version of the exercise

B. DEFINING: take-offs and specifications

settings



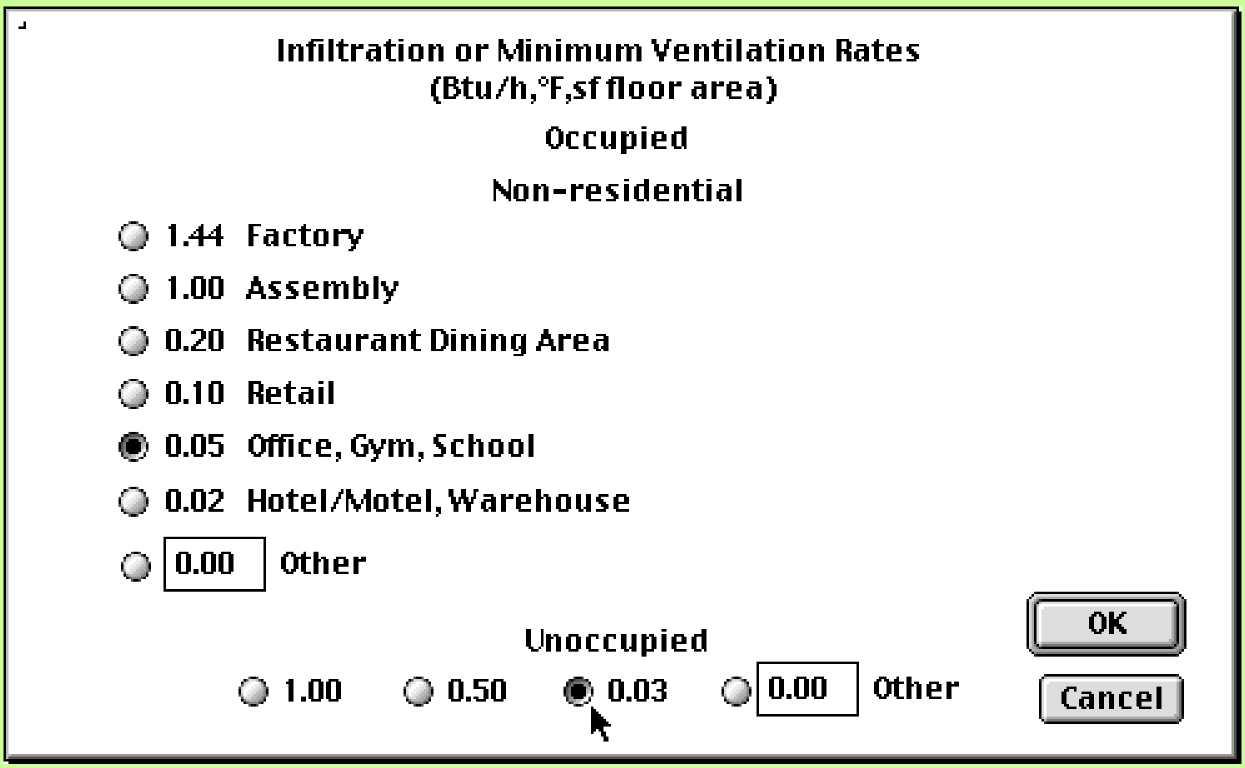
exercise

1. Tune Settings to Fit Your Building

Turn in

- A record of your settings for Ventilation / Infiltration Rate.
- A record of the evaluation days you have chosen.
- A printout of the energy performance report, done at the end of Part B, will show your settings for Schedules and Energy Strategies.

Infiltration or Minimum Ventilation Rates
Since the Shanley Building is a non-residential building, we are given ventilation options by building type. We selected "0.05 Office, Gym School." This represents a ventilation rate recommended by code. Commercial buildings are often ventilated based on an occupancy schedule. Because of this, and since fewer people are opening and closing doors and windows during unoccupied periods, we have set the unoccupied rate lower "at 0.03."



Set the "Evaluation Days"
For our four evaluation days we chose days typical of the St. Louis climate in each of four seasons: December cloudy, March cloudy, June cloudy, and September clear.

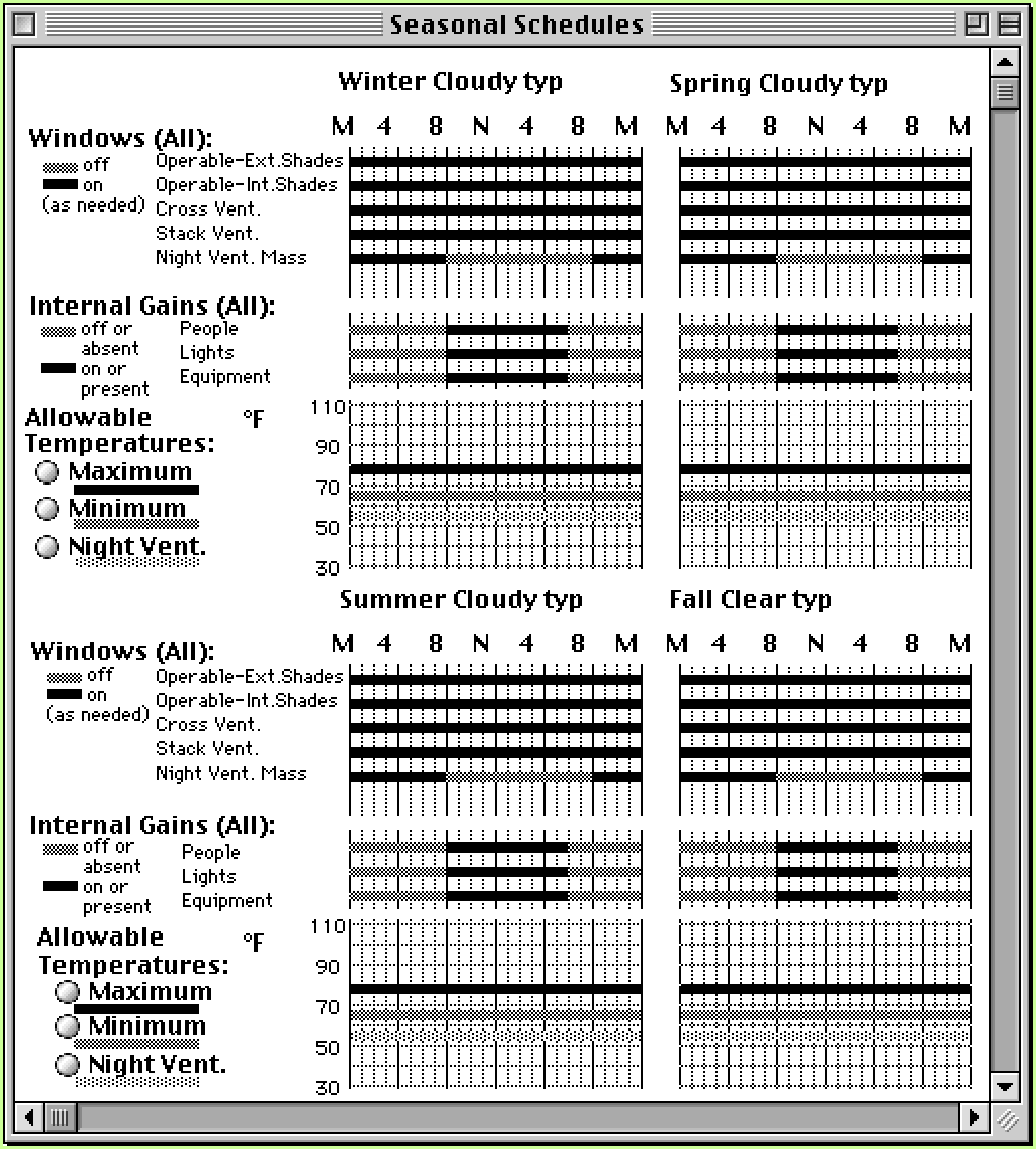
Check the Schedules

- **Shades**
  The operable shades are turned on all the time. This does not mean that they are in use all of the time; it only means that they are *available for use* all of the time.

- **Ventilation**
  Although the Shanley Building cannot take advantage of cross ventilation because it only has operable windows on one wall, we do not need to turn off "Cross Vent." because Energy Scheming will realize that there is an outlet but no inlet. We will want it on later when we redesign to improve ventilation. "Stack Vent." also does not need to be turned off.

  We turned off "Night Vent. Mass" during daytime hours of 8 AM and 8 PM so that it would not be used during occupied hours. Even though the occupied hours typically end at 6 PM, we do not want high volumes of possibly cool air in the building until we are sure people have gone home. In St. Louis, this is probably not a problem, because the outside temperature in the summer will only drop below the inside temperature later in the evening.

- **People, Lights, and Equipment**
  These are turned on from 8 AM to 6 PM because those are the expected times of occupancy.

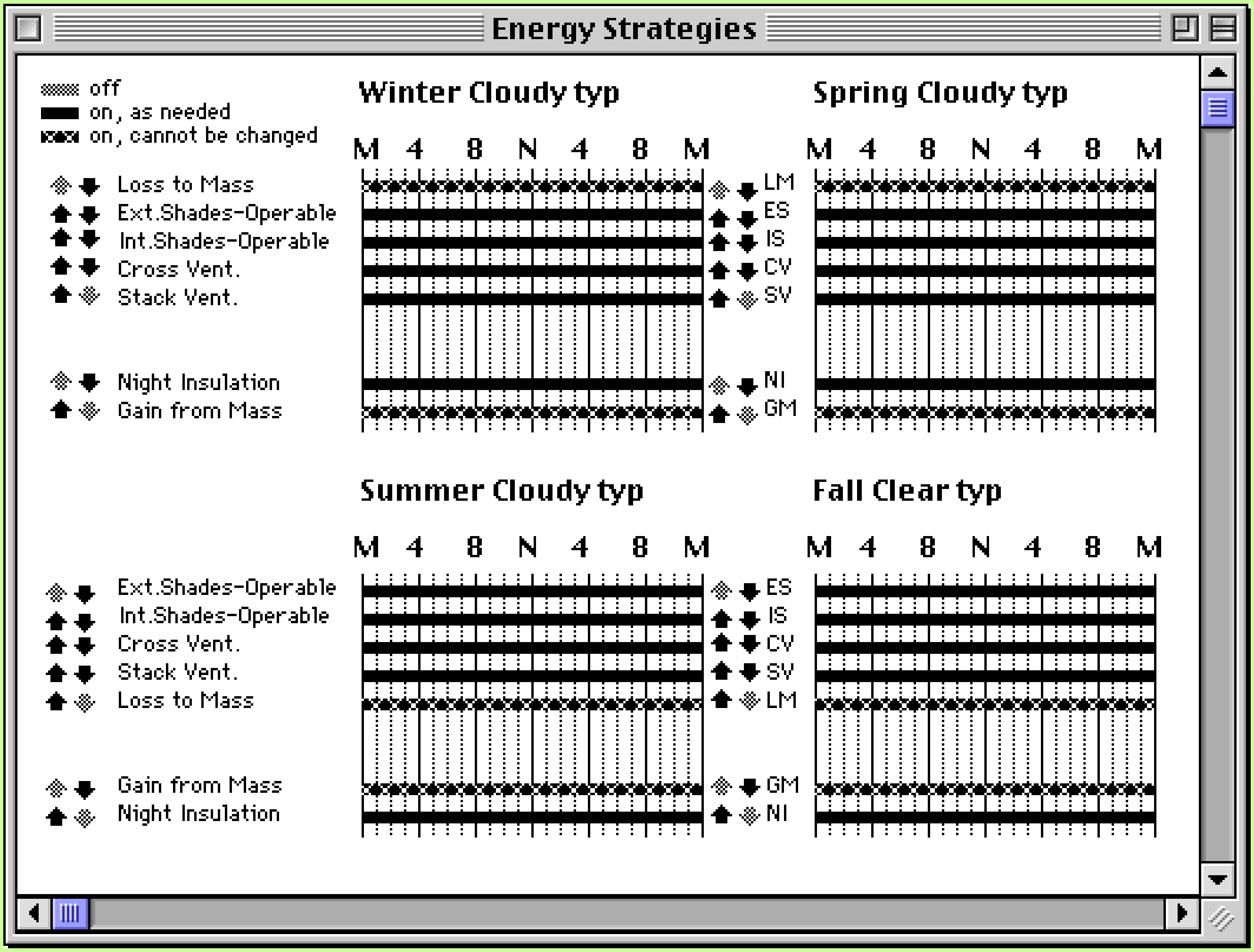


- **Check the Interior Temperature Settings**
  We used the default temperature settings of 65 F Minimum to 78 F Maximum, with a 55 F minimum for Night Ventilation.

Set the Order of Energy Strategies
In winter and spring we moved "Loss to Mass" up to the top of the list so ES will know to store excess heat before trying to remove it by passive cooling strategies. This is appropriate whenever thermal storage is necessary to store excess gains from one part of the day to be used to offset net losses during another portion of the day.

"Night Insulation" was turned off during the daylight hours of 8 AM to 6 PM because night insulation (heavy drapes in the initial design) will not be drawn during hours of operation. If it was, it would block all our daylight and views!

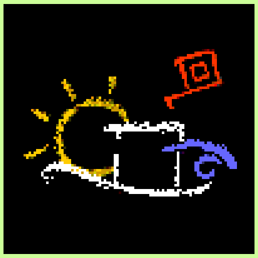
"Gain from Mass" was moved above "Night Insulation" for the summer and fall seasons (typically cooling seasons) because of the unlikeliness that night insulation will be used in the summer. NI is turned off in summer for the same reason. We leave NI on top in the Winter and Spring, because, being heating seasons, we want heat inside the building to be kept in by the NI before heat stored in the mass is used.



Jump to the next EXAMPLE section: Daylight Zone Icon

B. DEFINING: take-offs and specifications

daylight zone icon

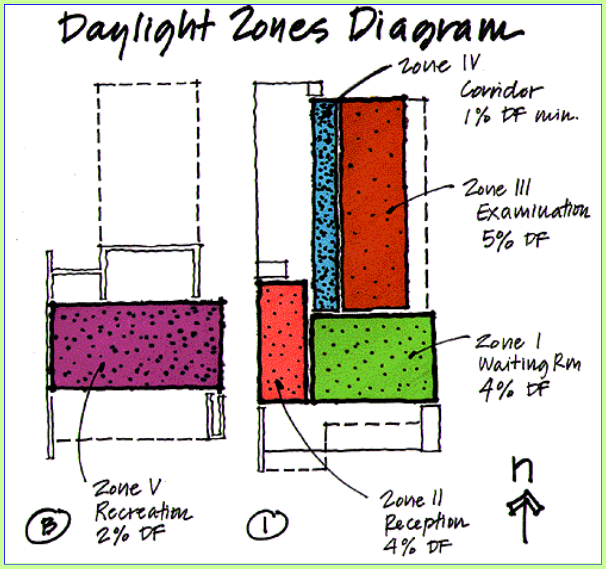


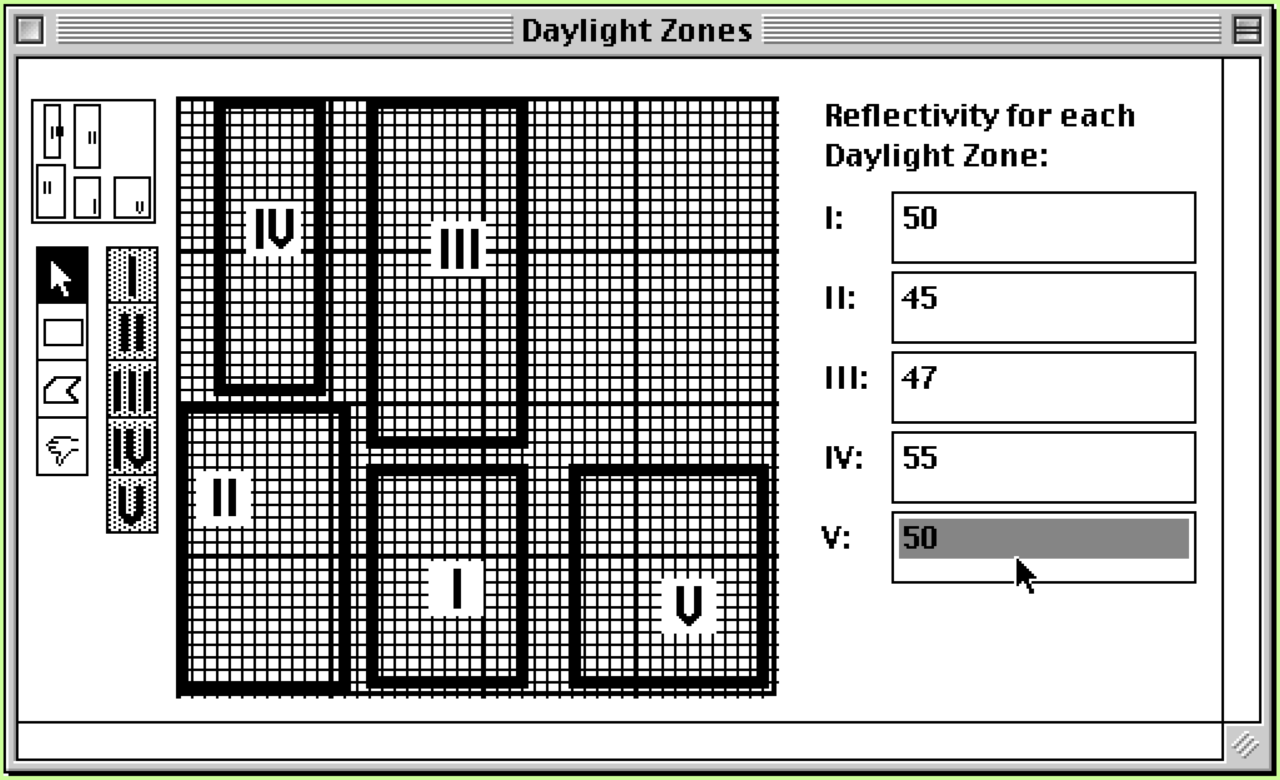
2. Define Your Daylight Zone Icon

Turn in

- A Screen capture of the daylight zone icon screen

exercise





Drawing the Icons

In section A, we explained how we chose the daylight zones. The image above shows how we diagrammed them. When drawing these zones in the dialog box, we drew the general shapes and adjacencies of the zones for our own reference, while trying to draw each zone *as large as possible*. The daylight zones will appear as small icons; if the zones are drawn too small, it will be difficult to select the appropriate zone when defining windows and electric lighting later. Referencing to the plan, daylight zone I represents the waiting room; II is the reception area; III is the series of offices; IV is the hallway and bathroom; and V is the basement recreation room. Notice we did not include the mechanical room because it is unconditioned, has no windows, and will not be occupied most of the time.

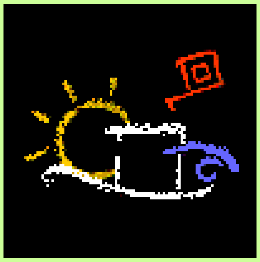
Setting Reflectivity Levels

Average reflcetivity for rooms with white walls and ceilings, with medium colored floors, will generally be in the 40-50% range. In our building, reflectivity for each zone was estimated using a weighted average of the reflectivity of the various room surfaces. For instance, in zone III which contains the offices, there are white tiled walls (70% reflectivity), dark colored floors and ceilings (15%), and a strip of windows on one wall (glass is about 15% reflective). We estimated that the dark surfaces composed about 5/12 of the surface area in the room and the white tile, the other 7/12. This averages out to a reflectance level of 47%: [(70x7) + (15x5)] / 12 = 47.

Jump to the next EXAMPLE section: Set Performance Goals

B. DEFINING: take-offs and specifications

performance goals



exercise

3. Set Performance Goals for Lighting and Heating

Turn in

- A record of your daylighting, solar heating, and ventilation goals. You will not be able to print the windows directly unless you use a screen capture technique.

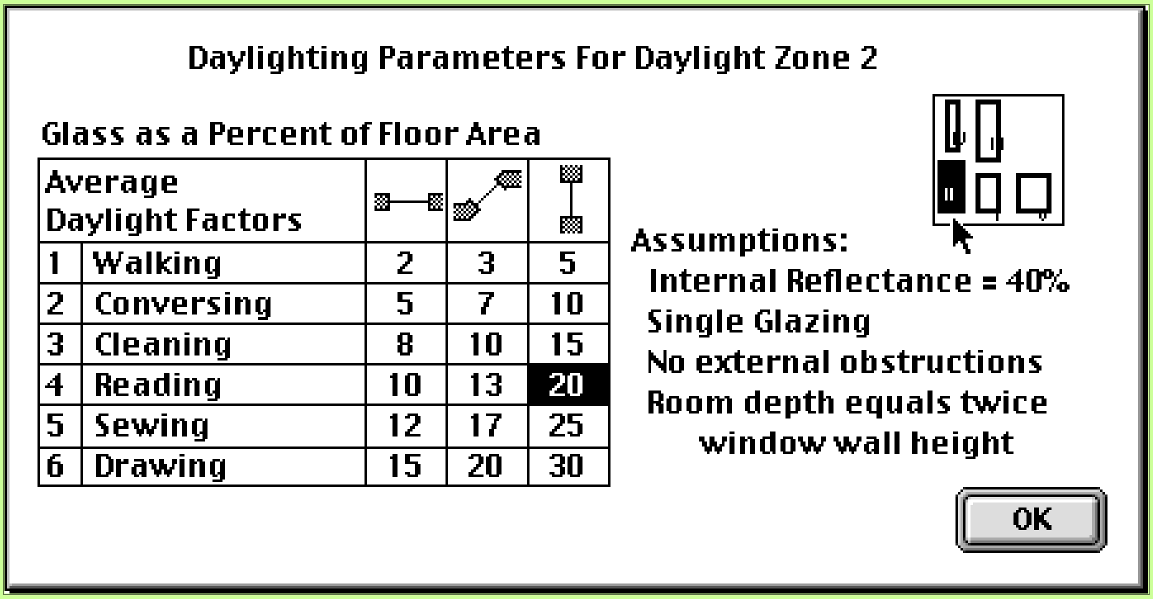
Define Daylighting Parameters

For each of the five daylighting zones, we chose a representative activity type from the list in the dialogue box. All of our glass is vertical, so all selections are made in the column below the icon for vertical glass.

- Zone I & II: The waiting room (zone I) and reception area (zone II) are best associated with "reading," for a 4% daylight factor (DF).
- Zone III: We chose a 5% DF, good for a more difficult task like "sewing," for the dental examination and laboratory rooms. We assumed that the light level would be supplemented by task lighting (you remember those intense dental lamps!) for close work performed in the orthodontic offices.
- Zone IV: The hallway is associated with "walking" and functionally requires very little light. However, given the brightness of the well lit adjacent spaces and the short adjustment time between them, we were concerned about having too much contrast. So we actually set that space to a 2% DF, "conversing."
- Zone V: Finally, we chose a 3% DF, "cleaning," for the recreation room, since play requires more light than conversing but less than reading.

NOTE: Remember to switch between daylight zones by clicking on the small daylight zone icons in the upper right corner of the dialogue box.

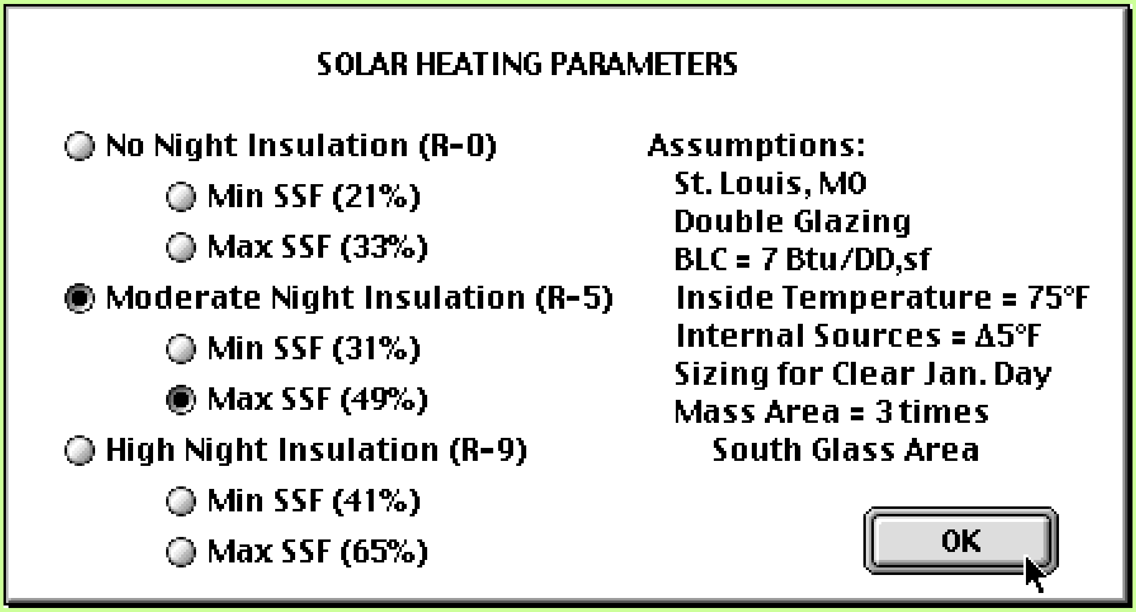
The day lighting in the building can be evaluated by using the Rule of Thumb Window Sizing Aid once the window and electric light takeoffs are complete. It will show if the windows are over- or undersized for each daylight zone, in relation to the parameters, set here.



Click on a zone in daylight zone icon of the image above to see the takeoff for daylighting parameters in each zone .

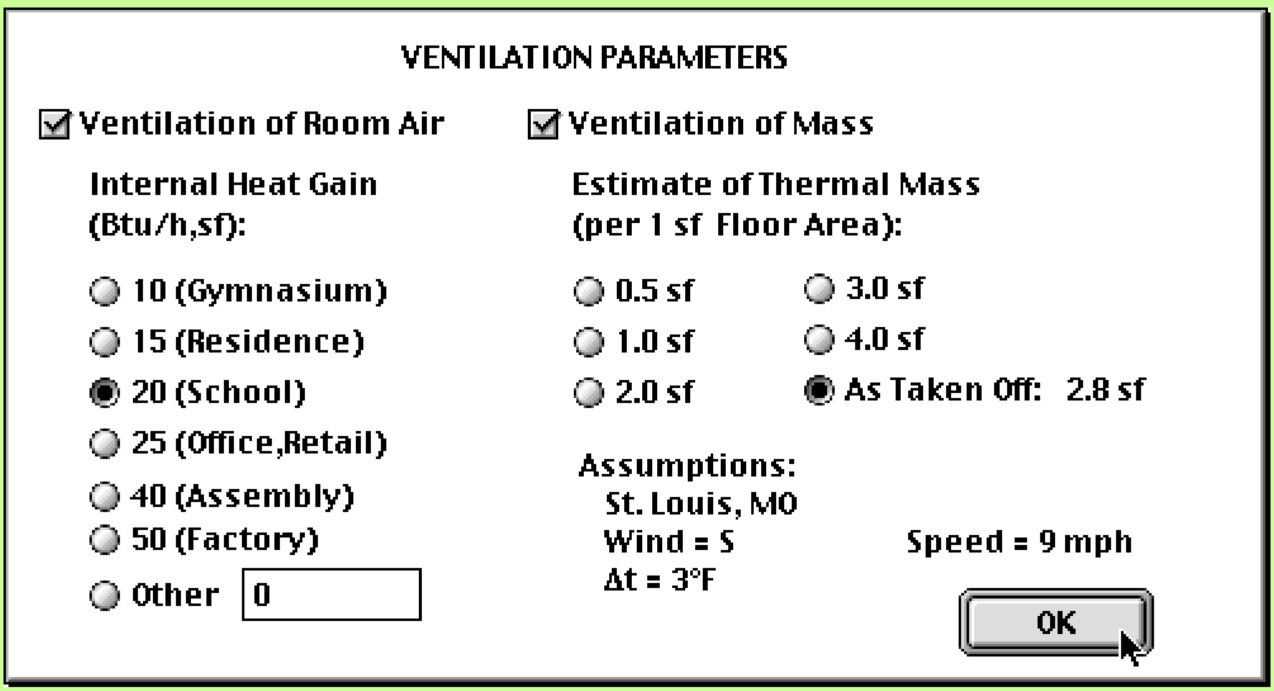
Define Solar Heating Parameters

The Shanley Building as designed does not have any significant night insulation except for some heavy drapes in the reception area. However, we plan on achieving a reasonable level of solar heating in the building through redesign. This is the place to set our target. We may add night insulation, and in all likelihood upgrade the windows to a higher performance window type. Therefore, we used the high end of the rule-of-thumb recommendation, a setting of Moderate Night Insulation (R-5) with Max SSF (49%).



Define Ventilation Parameters

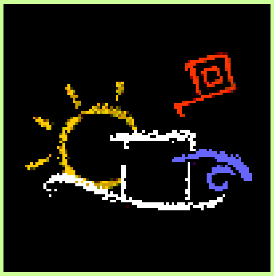
- Under Ventilation of Room Air, we selected "20 Btu's per hour per square foot (School)" because, even though this is a small office building, its occupant density and equipment are less than a typical office.
- Under Ventilation of Mass we selected "As Taken Off," because we would like to see the effect of the mass in the building as designed. If you want to work on window sizing in your elevations before defining the mass, you can make an assumption about the level of mass in the building by selecting one of the other settings. An "average mass" building might be about 1.0 sf of mass per sf of floor area; a "high mass" building, 2.0.



Jump to the next EXAMPLE section: Create Plan Specifications

B. DEFINING: take-offs and specifications

plan specifications



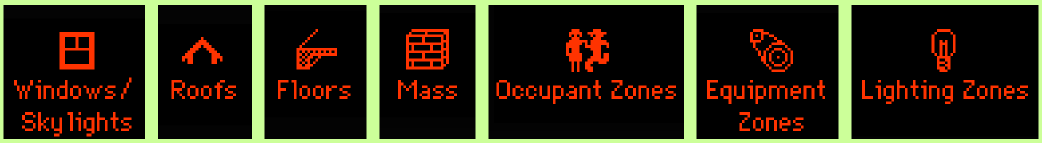
exercise

4. Create Plan Specifications

Turn in

- A screen capture of your plans showing lighting zones. Turn off all other plan takeoffs in the "VIEW / Takeoffs..." menu. You will not be able to print the takeoffs unless you use a screen capture technique.
- In the next section, Elevation Takeoffs, you will print the Energy Performance Report, which will document all your takeoffs.

Click on all icons below for specific information:



A few notes on managing takeoffs

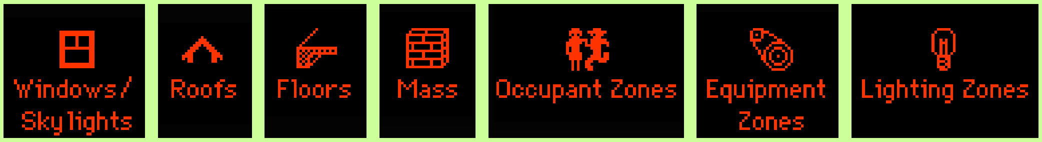
- **Renaming Icons**
  When you are doing takeoffs, you end up with a lot of icons representing various building elements. When you have many icons under one category, it sometimes helps to avoid confusion if you rename each takeoff icon with a specific name, such as "bedroom window" or "dormer roof". You can rename an icon by highlighting its name with the mouse and typing a new one in its place. This can only be done if the dialogue box associated with the icon is closed. We found this technique particularly useful when defining windows in the "Create Elevation Specifications" section.
- **Visibility of Icons**
  Another way to keep from getting too confused during the takeoff mode of *Energy Scheming* is to change the settings of the takeoffs under "VIEW/Takeoffs... " You can make visible only the takeoffs that you want to see, such as only electric lights, or only takeoffs in the open spec.

Jump to the next EXAMPLE section: 5. Create Elevation Specifications

plan specifications: skylights

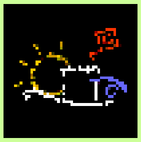
worked example

Click on all icons below for specific information:



HORIZONTAL SKYLIGHTS

There are no horizontal skylights in the Shanley Building.

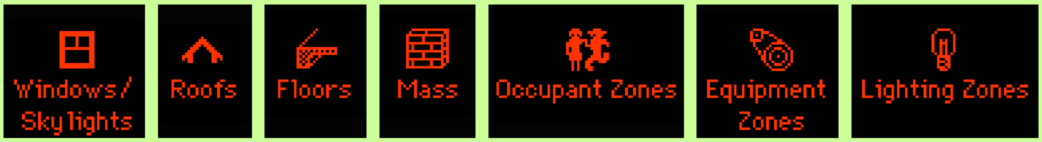


Back to **plan specifications**

worked example

plan specifications: roofs

Click on all icons below for specific information:

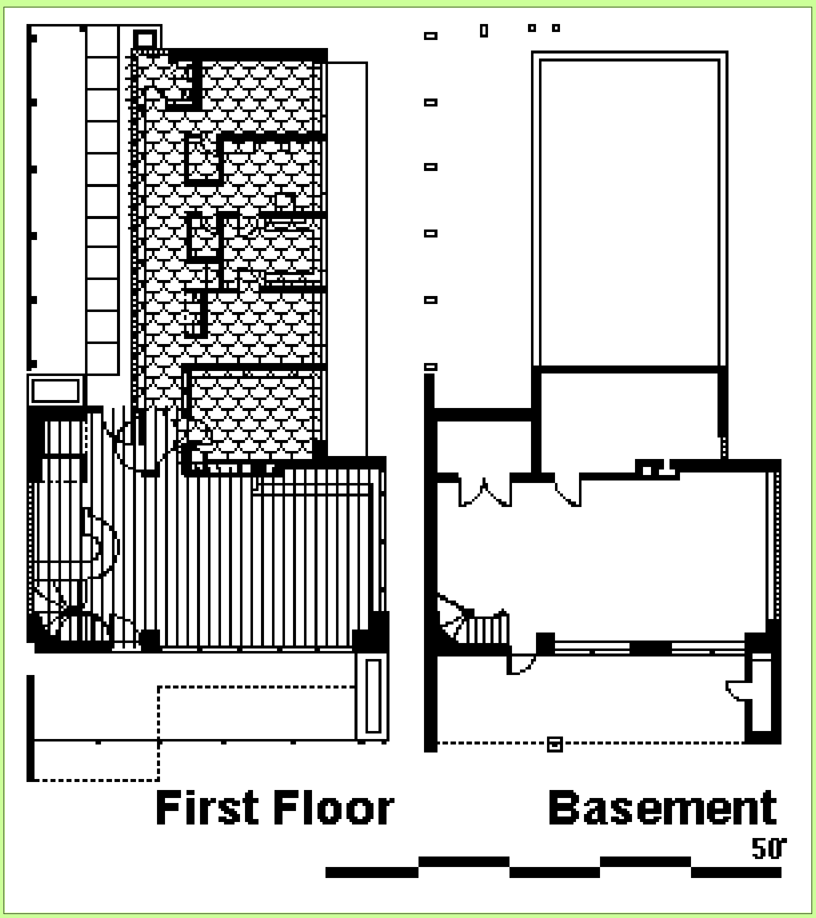


ROOFS

Roofs for our building are taken off in plan view because they have a very low slope. Sloped roofs can also be taken off in the elevations. We took off two different roof areas:

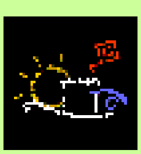
- one over the office wing, sloping East
- one over the waiting room/reception area, sloping South

The construction of the roof is discussed in Part A: DOCUMENTING



Click on one of the Roof takeoffs in the above plan to see its associated specifications

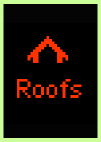
---



Back to **plan specifications**

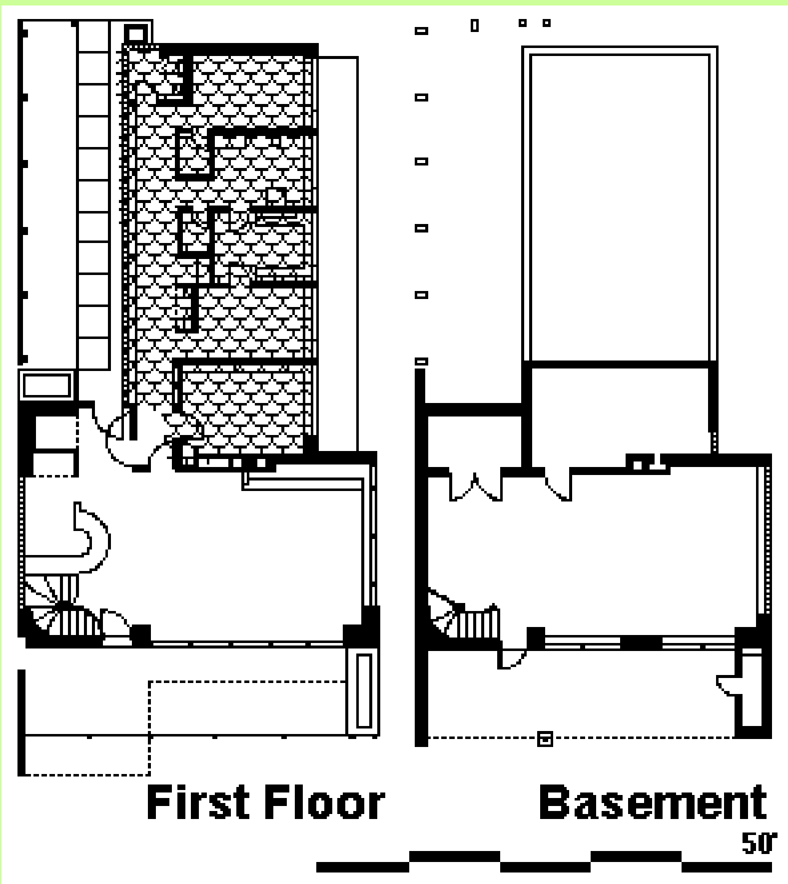
worked example

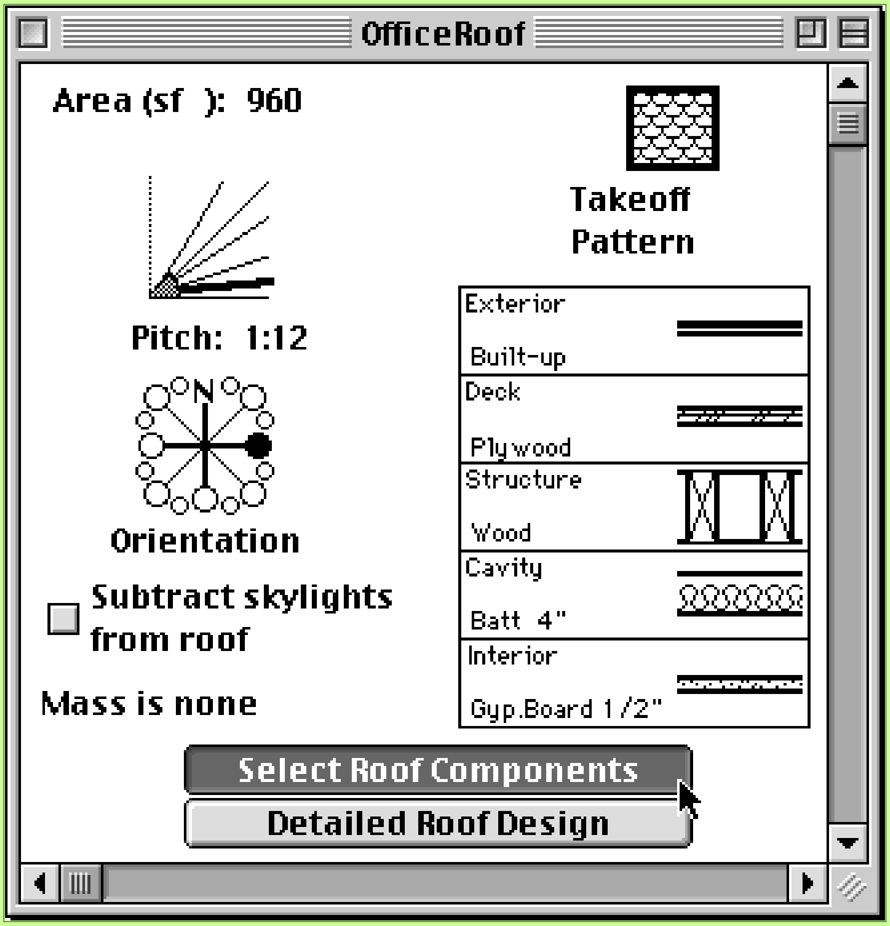
plan specifications: roofs



ROOF OVER OFFICE WING

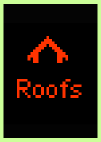
The office wing roof has a 1:12 pitch to the East. Under "Select Roof Components" we selected the elements: built-up roofing, plywood decking, wood structure, 4" batt insulation (a good equivalent for the 3" of 1930's rigid insulation), and 1/2" interior gypsum board. We represented the exterior aluminum roof paint by selecting "light" exterior color. There is no roof mass and it is in a non-solar zone.




OfficeRoof
Area (sf): 960
Takeoff
Pattern
Pitch: 1:12
N
Orientation
Subtract skylights from roof
Mass is none
Exterior
Built-up
Deck
Plywood
Structure
Wood
Cavity
Batt 4"
Interior
Gyp.Board 1/2"
Select Roof Components
Detailed Roof Design

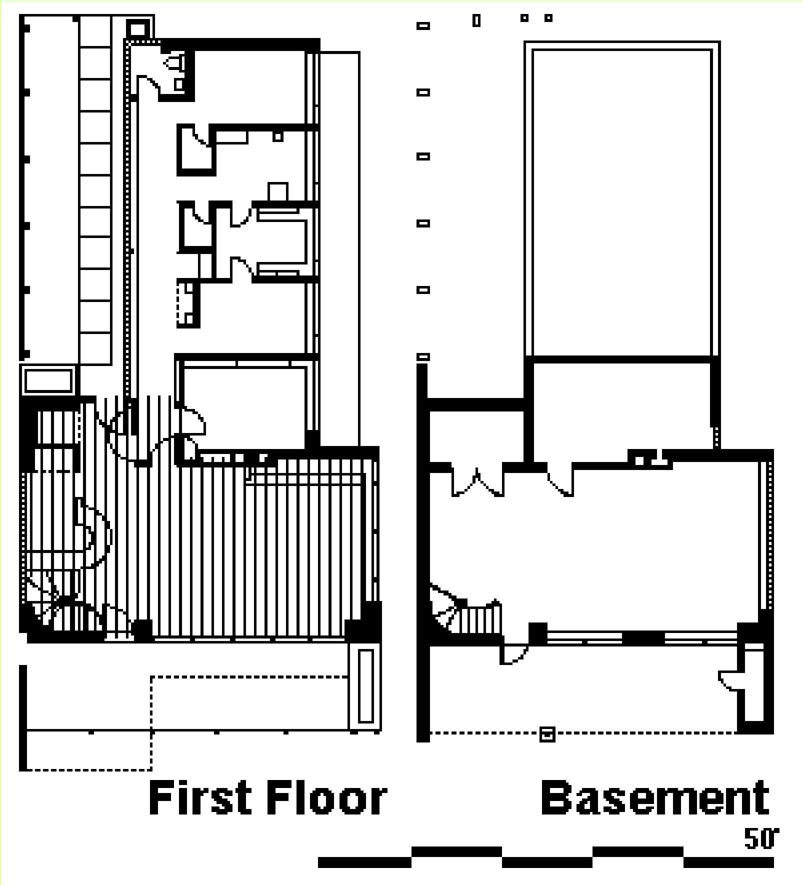
worked example

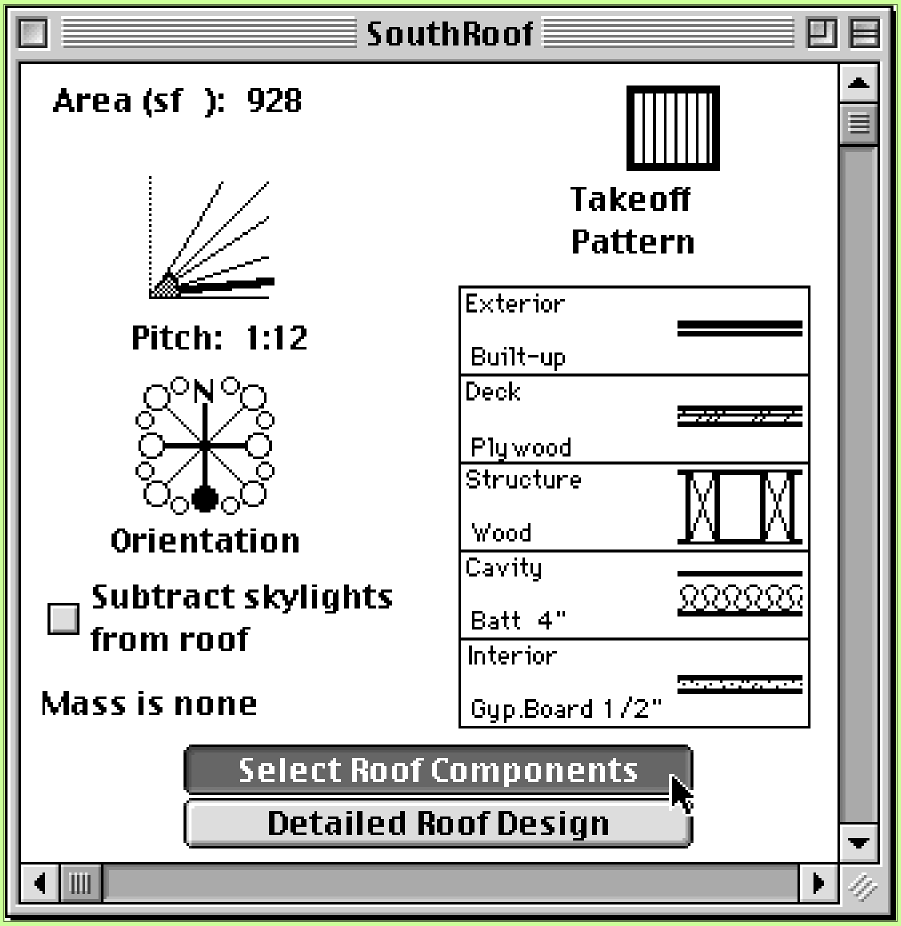
plan specifications: roofs



ROOF OVER THE WAITING ROOM/RECEPTION AREA

The roof over the waiting room/reception area was specified as having a 1:12 pitch to the south. It is made of the same materials as the other roof spec, but it is in a solar zone. Under "Select Roof Components" we selected the elements: built-up roofing, plywood decking, wood structure, 4" batt insulation (a good equivalent for the 3" of 1930's rigid insulation), and 1/2" interior gypsum board. We represented the exterior aluminum roof paint by selecting "light" exterior color. There is no roof mass.



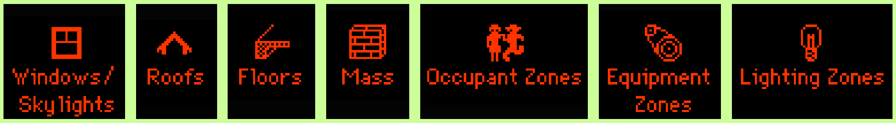


SouthRoof
Area (sf): 928
Takeoff Pattern
Pitch: 1:12
N
Orientation
Exterior
Built-up
Deck
Ply wood
Structure
Wood
Cavity
Batt 4"
Interior
Gyp.Board 1/2"
Subtract skylights from roof
Mass is none
Select Roof Components
Detailed Roof Design

worked example

plan specifications: floors

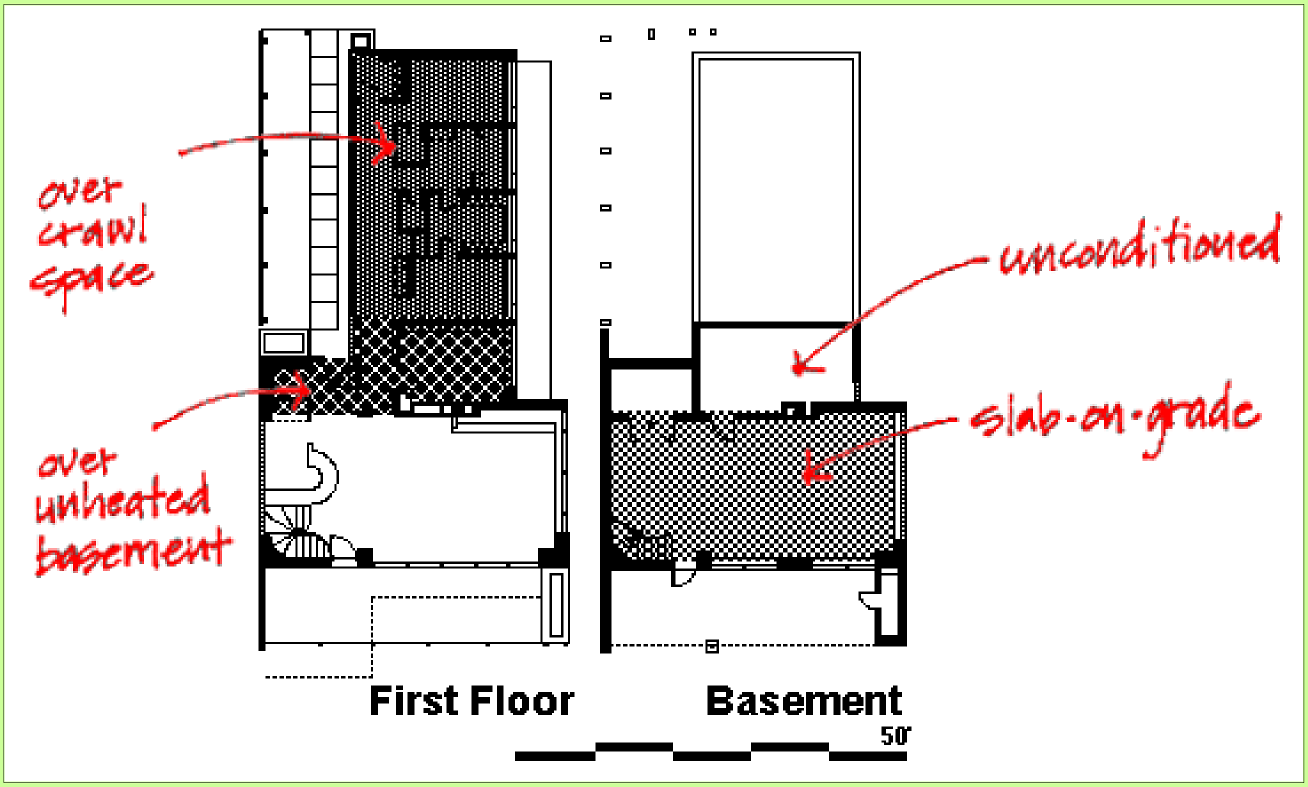
Click on all icons below for specific information:



FLOORS

The only portions of the floors which should be taken off are those which are exposed to the outdoors. There are three floor areas that satisfy this requirement:

1. The floor of the office wing where it is over a crawl space,
2. The floor of the office wing where it is over the unheated mechanical room (over unheated basement), and
3. The floor of the basement rec room which is a slab-on-grade.



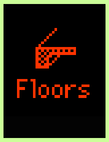
Click on one of the Floor takeoffs in the above plan to see its associated specifications

The mechanical room floor is ignored because it is not a heated or cooled space. The waiting room/reception area floor is also ignored because it is over a heated space, and therefore no heat transfers across it. We do not specify the waiting room/reception area floor anywhere in *Energy Scheming* because it is not massive. If it were a thermally massive floor we would define it under "Thermal Mass," not "Floors".

Back to **plan specifications**

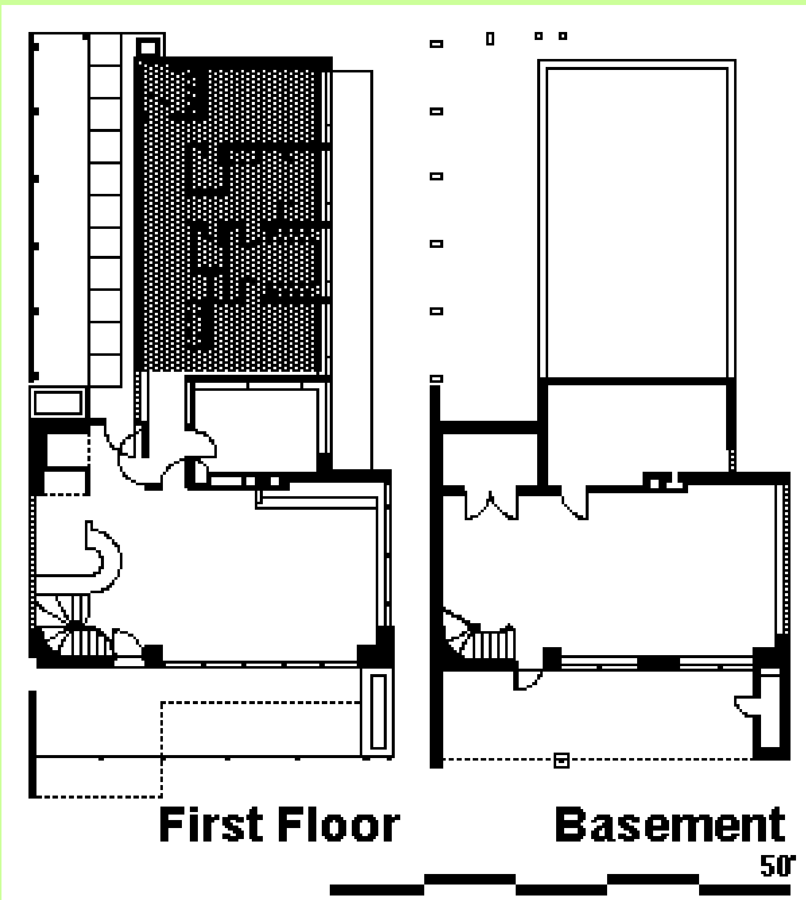
worked example

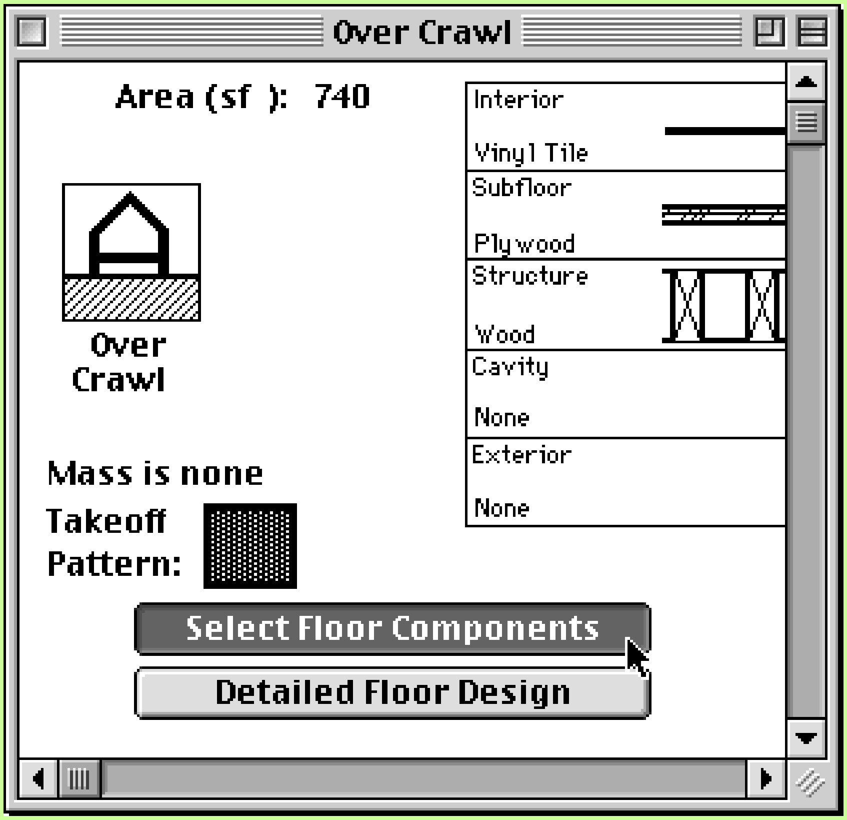
plan specifications: floors



FLOORS OVER A CRAWL SPACE

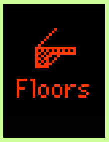
The office wing floor is linoleum on wood frame over an uninsulated crawl space. We selected "Over Crawl" and under "Select Floor Components," we highlighted vinyl tile, 3/4" plywood subfloor, wood structure, no cavity insulation, no exterior material, no mass, non-solar zone.




Over Crawl
Area (sf): 740
Over
Crawl
Mass is none
Takeoff
Pattern:
Interior
Vinyl Tile
Subfloor
Plywood
Structure
Wood
Cavity
None
Exterior
None
Select Floor Components
Detailed Floor Design

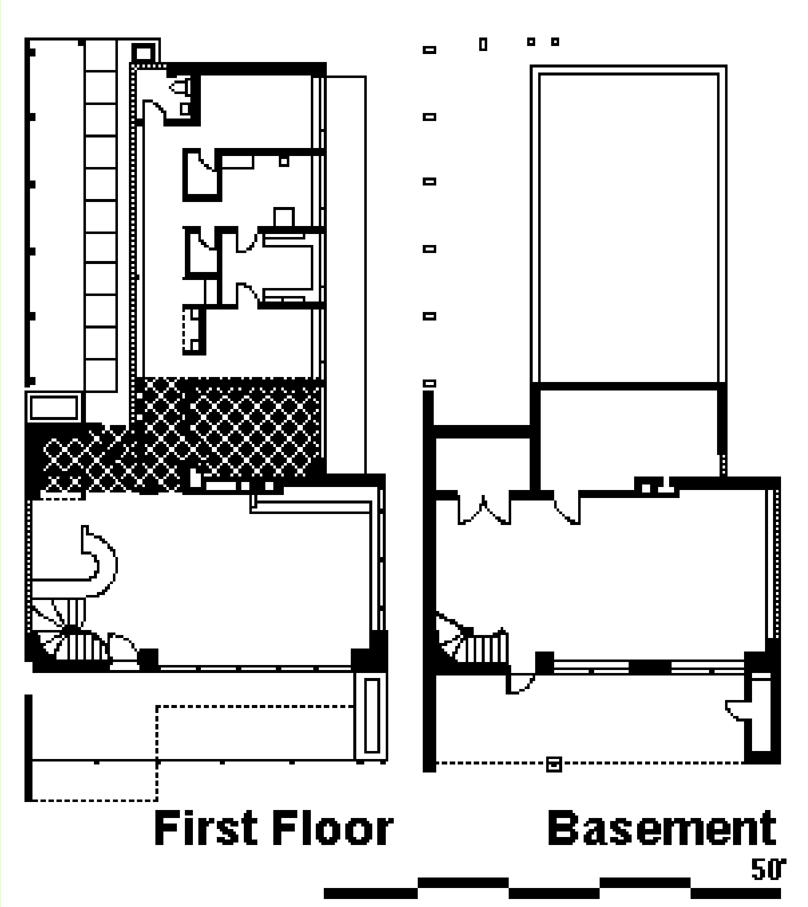
worked example

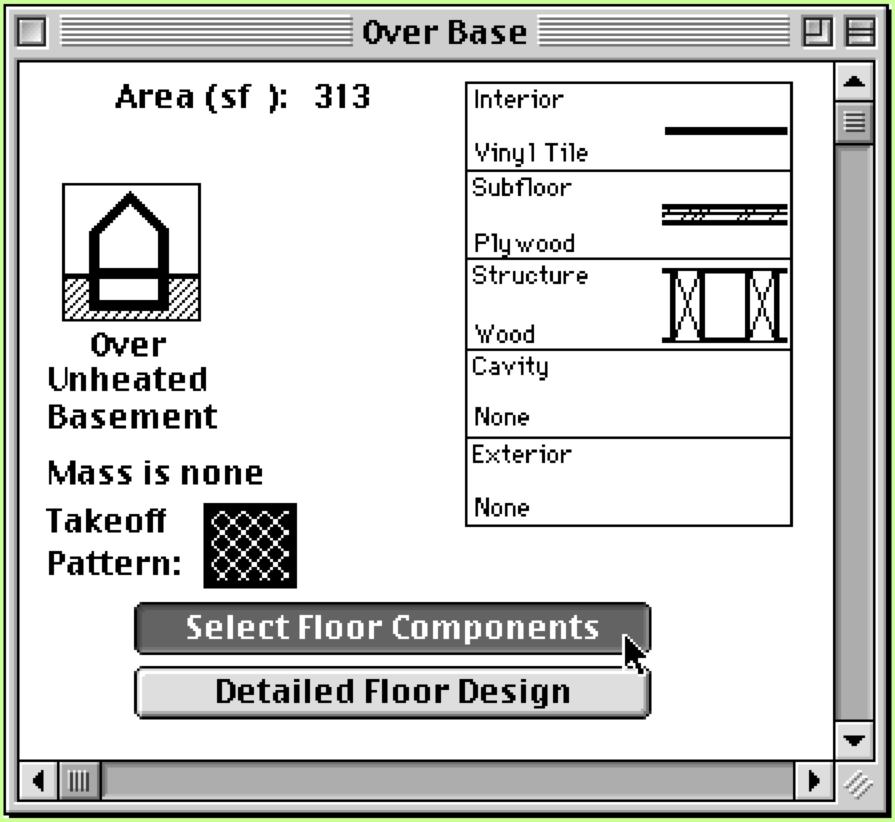
plan specifications: floors



FLOORS OVER AN UNHEATED BASEMENT

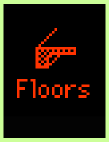
There is a small floor section over the unheated storage and mechanical rooms. We spec it as "Over Unheated Basement," with the same floor construction as the offices floor.




Over Base
Area (sf): 313
Over Unheated Basement
Mass is none
Takeoff Pattern:
Interior
Vinyl Tile
Subfloor
Plywood
Structure
Wood
Cavity
None
Exterior
None
Select Floor Components
Detailed Floor Design

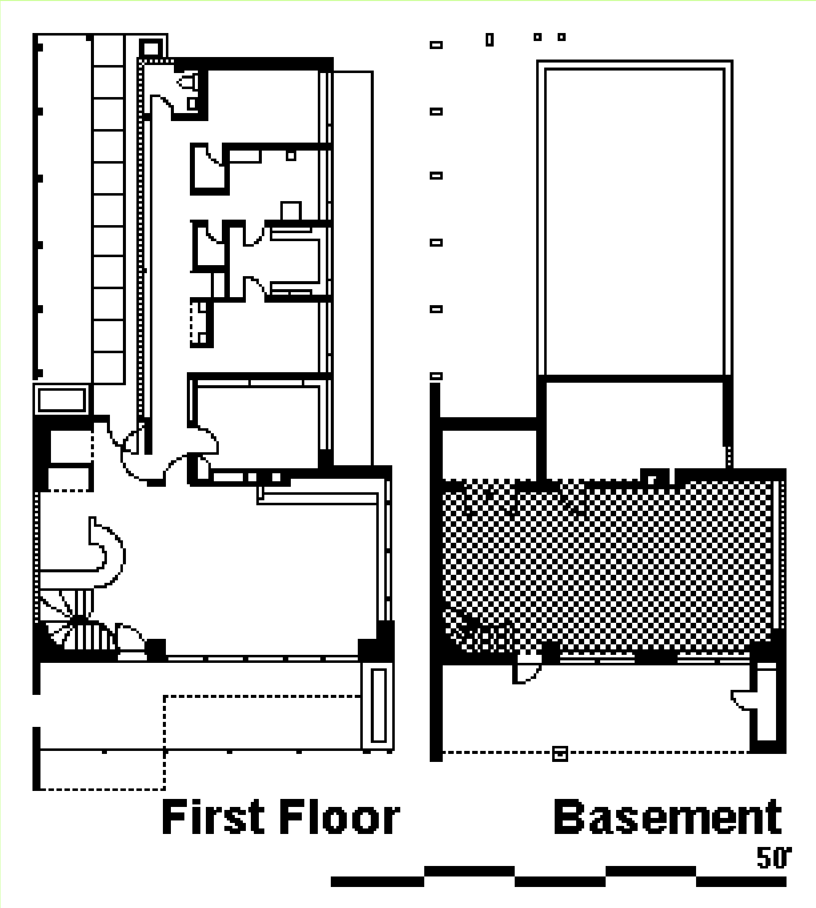
worked example

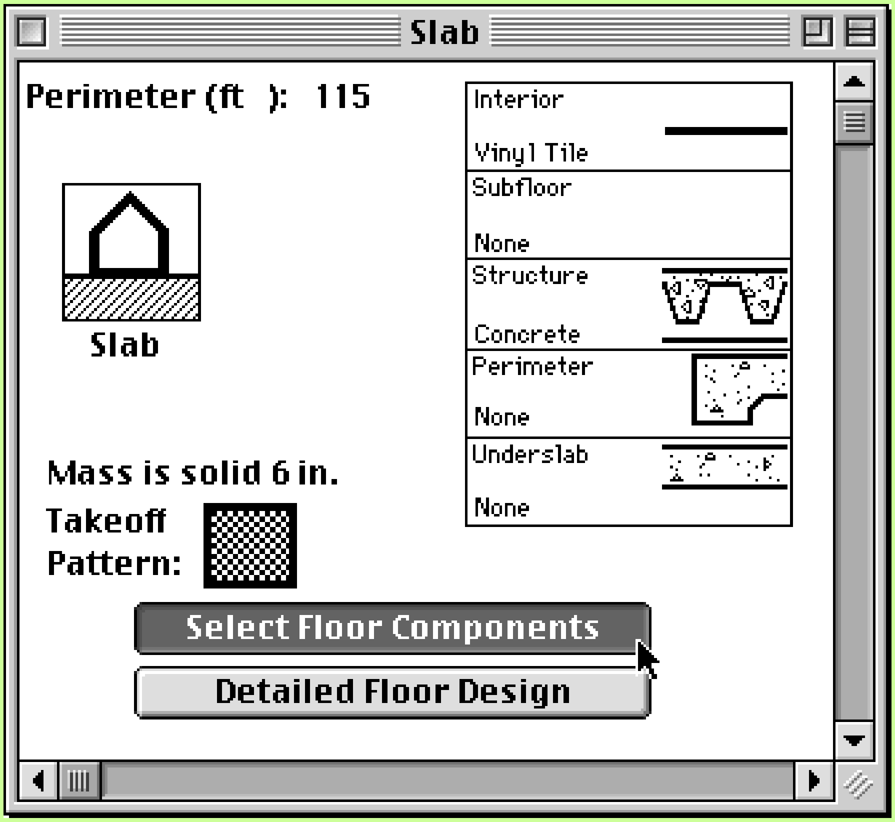
plan specifications: floors



SLAB-ON-GRADE FLOOR

The recreation room floor is an uninsulated, linoleum-covered slab-on-grade. Since it is a slab, we used the polygon tape measure; this is so ES can calculate the linear footage of slab edge that it needs to estimate heat flow from the slab. We selected the elements as follows: vinyl tile, no subfloor, concrete 6", no perimeter or under slab insulation. Under "Mass" we entered: solid 6," occupying a solar zone, because the floor is in a room with sun-collecting south glass.

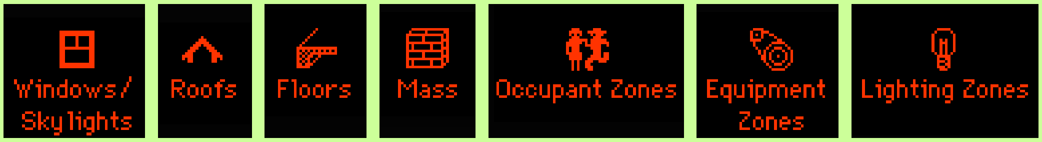



Slab
Perimeter (ft): 115
Slab
Mass is solid 6 in.
Takeoff Pattern:
Interior
Vinyl Tile
Subfloor
None
Structure
Concrete
Perimeter
None
Underslab
None
Select Floor Components
Detailed Floor Design

worked example

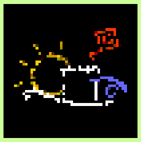
plan specifications: mass

Click on all icons below for specific information:



THERMAL MASS

The only thermal mass in a horizontal orientation is the floor of the rec room. Since the floor of the rec room was defined in the floor take-off as having mass, it does NOT need to be taken off again. Vertically oriented mass is specified in the elevation specifications.

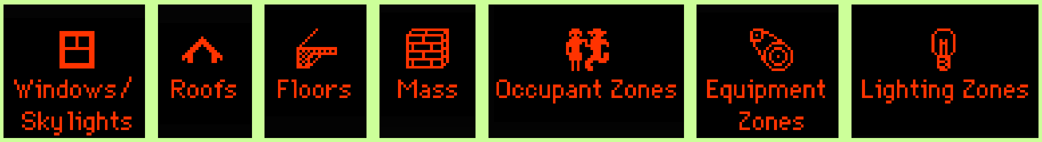


Back to **plan specifications**

worked example

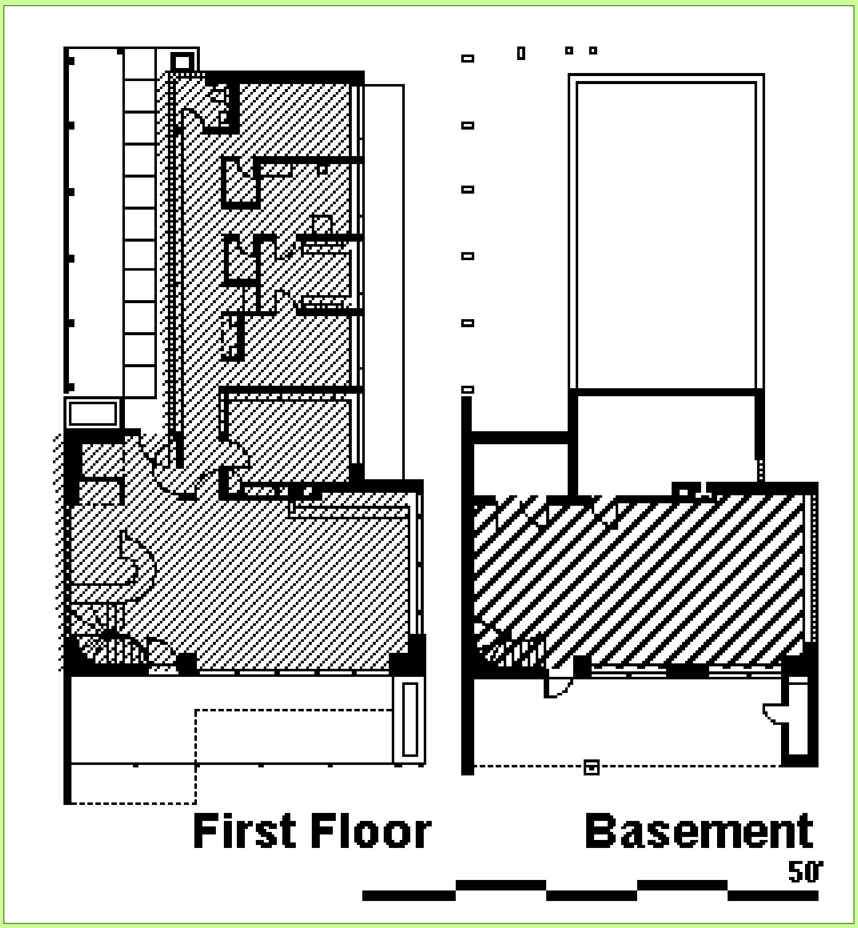
plan specifications: occupants

Click on all icons below for specific information:



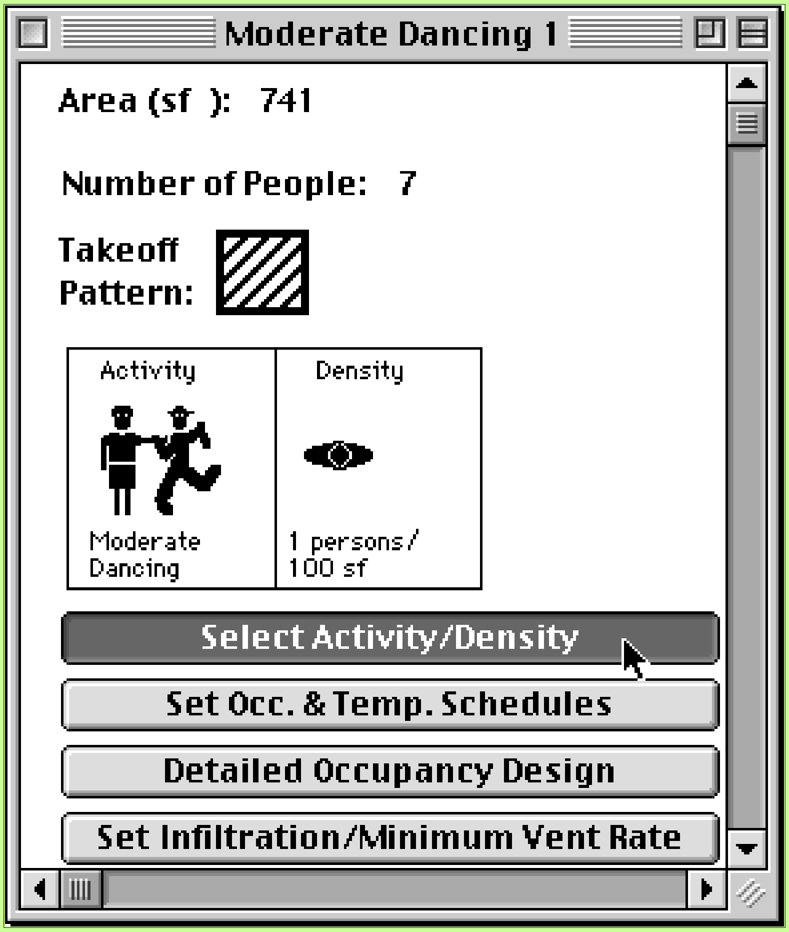
OCCUPANT ZONES

In the Shanley building, the occupant zones were very simple because we figured that "light work" bests described the entire first floor's typical activity with an approximate density of one person per 100 square feet (office). This was all done in one takeoff.

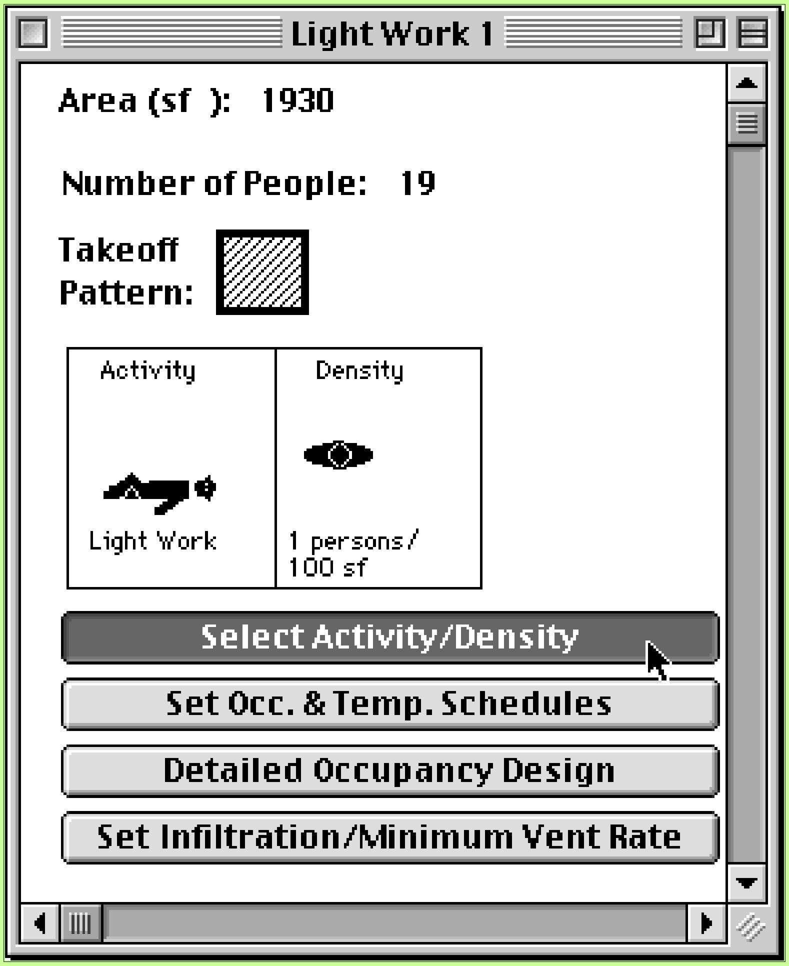


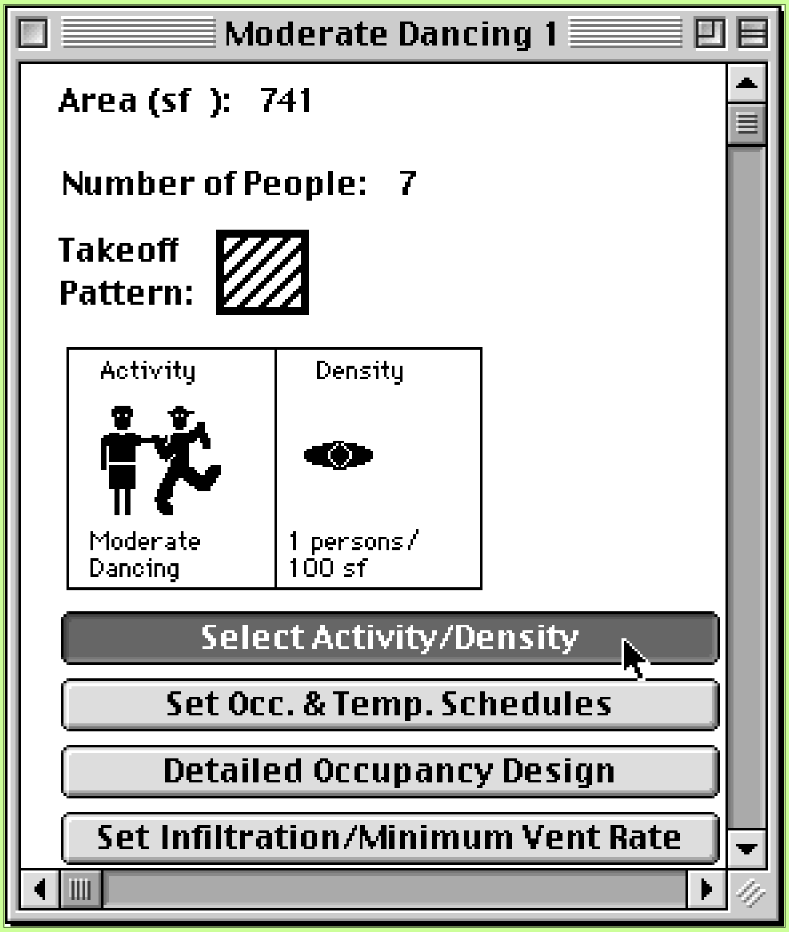
Click on one of the occupant zone takeoffs in the above plan to see its associated spec window.

The basement contains a children's rec room, so we specified it as "moderate dancing" at the density of one person per 100 square feet.



Back to **plan specifications**

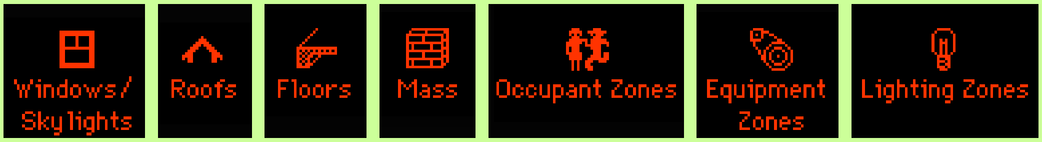

Light Work 1
Area (sf): 1930
Number of People: 19
Takeoff
Pattern:
Activity
Density
Light Work
1 persons/
100 sf
Select Activity/Density
Set Occ. & Temp. Schedules
Detailed Occupancy Design
Set Infiltration/Minimum Vent Rate


Moderate Dancing 1
Area (sf): 741
Number of People: 7
Takeoff Pattern:
Activity
Density
Moderate Dancing
1 persons/ 100 sf
Select Activity/Density
Set Occ. & Temp. Schedules
Detailed Occupancy Design
Set Infiltration/Minimum Vent Rate

worked example

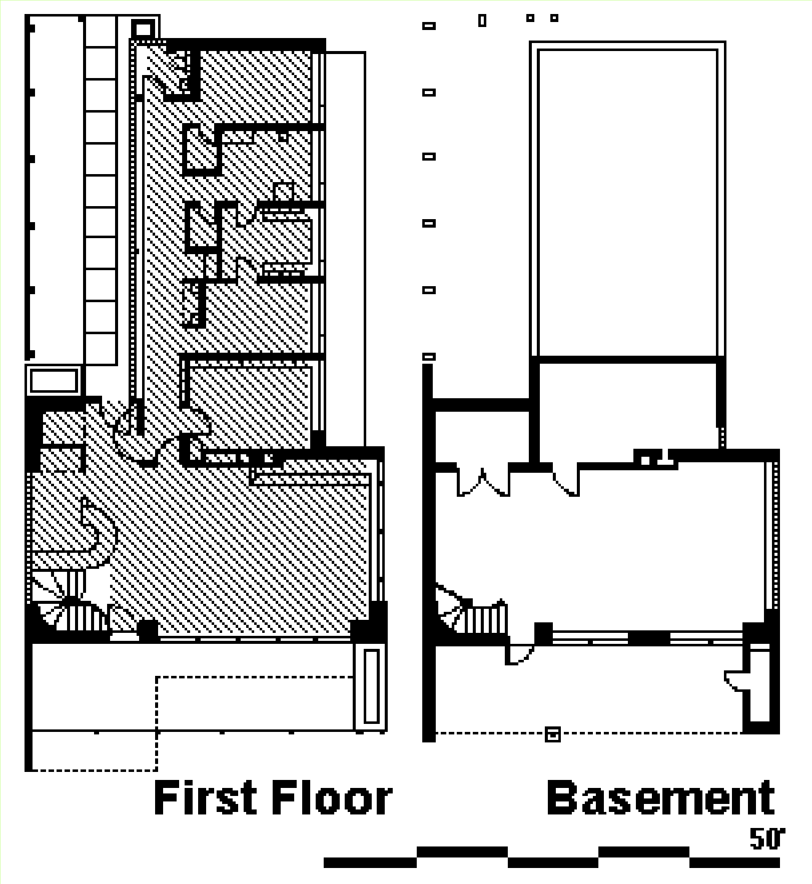
plan specifications: equipment

Click on all icons below for specific information:

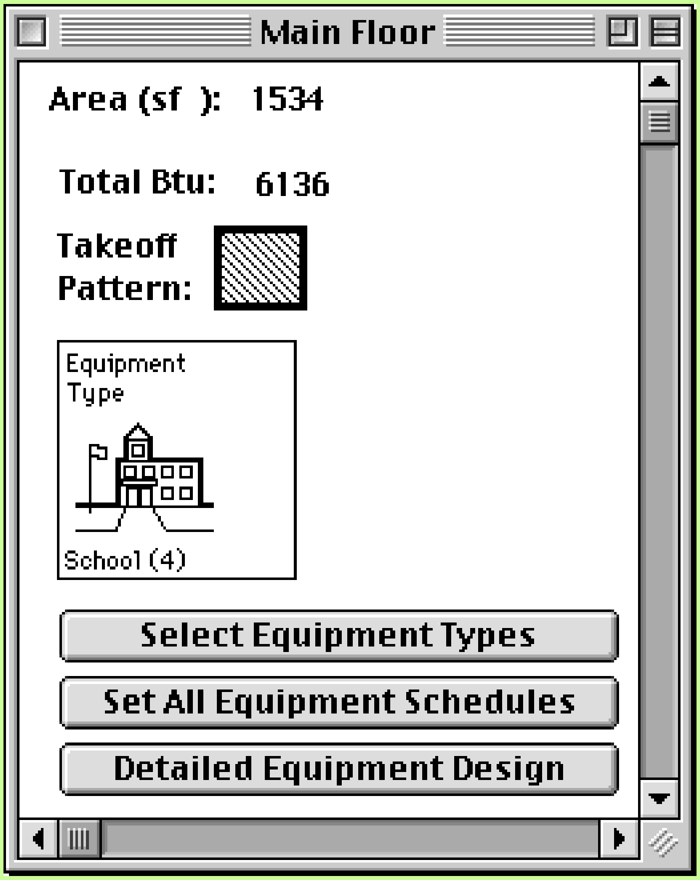


EQUIPMENT ZONES

Heat gain rates from equipment are based on gross square footage, so we took off the entire floor area of the main floor, even though some areas will have little or no equipment.



Since the building has significantly less equipment than a typical office building, we chose a heat gain rate for "school." The image below shows the equipment zone takeoff.



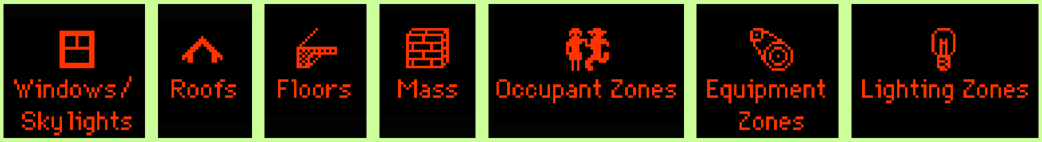
We did *not* specify any equipment zones for the basement level, because there is no equipment in the recreation room. Even though the mechanical room has a hot water heater and HVAC equipment that will generate excess waste heat, the room is ventilated separately and will not be heated or air conditioned. Therefore, it will not contribute to the heating and cooling loads of the building. So, we have *not* taken off an equipment zone for the mechanical room.

Back to **plan specifications**

worked example

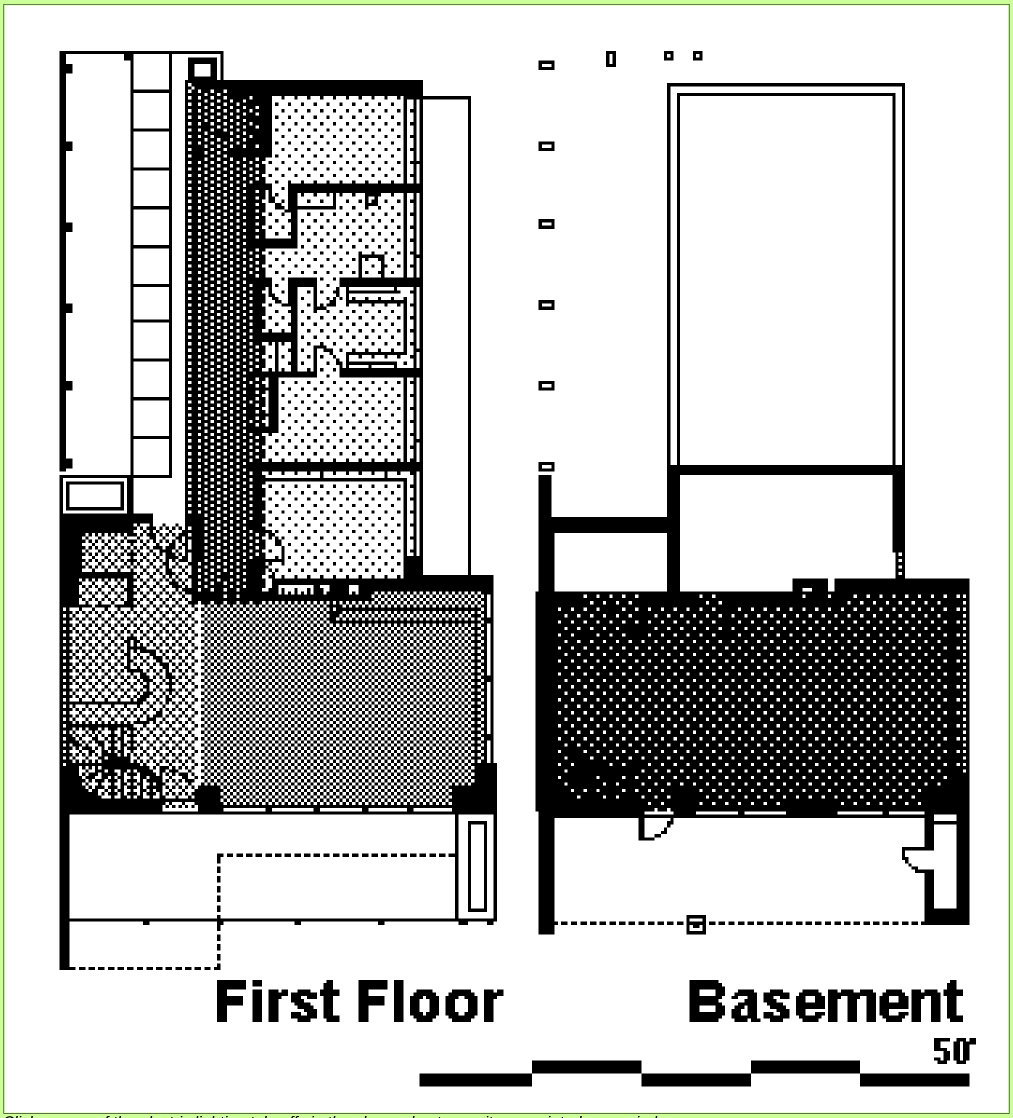
plan specifications: electric lighting

Click on all icons below for specific information:



ELECTRIC LIGHTING ZONES

We defined five different electric lighting zones, which correlate exactly with the size and area of the daylight zones. The plans below show how these takeoffs appear in *Energy Scheming.*



Click on one of the electric lighting takeoffs in the above plan to see its associated spec window.

Lighting Types

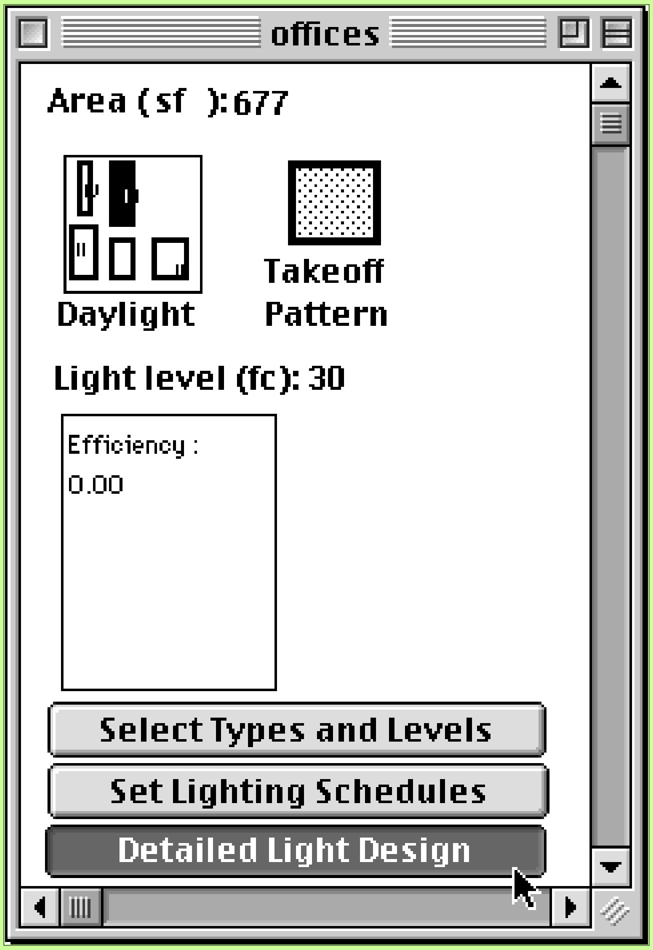
The original lighting in the building was primarily ceiling mounted, general diffuse luminaries. There was some indirect, cove type, electric lighting in the waiting room, in addition to general diffuse, but only one lighting type per zone can be specified. Therefore, all five zones were assigned the same lighting type: incandescent general diffuse. ES 2.5 has an option for General Diffuse, but ES 3.0 has eliminated that option, in favor of more contemporary lighting choices. We took the lighting efficiency for General Diffuse Incandescent from ES 2.5; it has a value of 0.59 Btu/h, per square foot of floor area, per foot-candle of interior illuminance (Btu/h,sf,fc). Values for some older lighting types that have been eliminated from ES 3.0 can be found in the Table of Lighting Efficiencies.

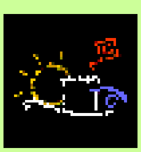
Visual Task Levels

Each takeoff can have its own visual task level, measured in foot-candles or Lux. Each zone or area within a zone can have its own lighting takeoff. If there is more than one lighting level in a zone, you can take off each area separately. We chose lighting levels appropriate for the activities in each zone and the subjective brightness levels desired, as follows:

- ZONE I, waiting room --30 fc for reading
- ZONE II, reception area --40 fc for general office type work
- ZONE III, dental examination and laboratory rooms --50 fc, averaged across the zone, for detailed work, to be supplemented by high intensity localized task light as required.
- ZONE IV, corridor --20 fc
- ZONE V, recreation --30 fc

The images below shows the Spec Window for Zone III. To see Spec Windows for other zones, click on one of the electric lighting takeoffs in the above plan.



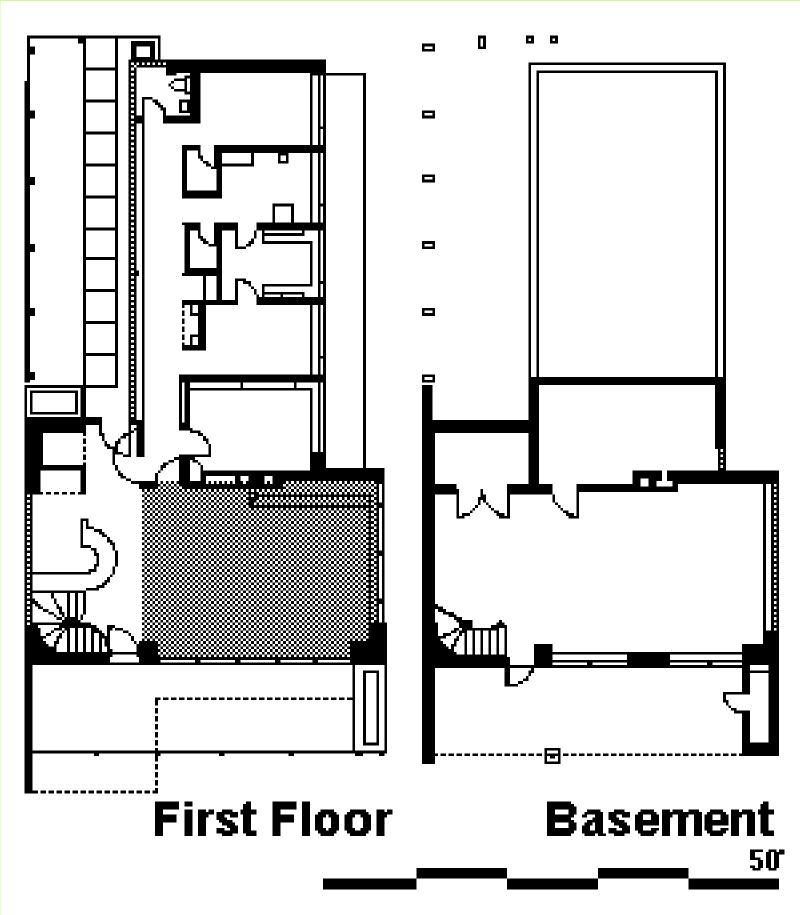


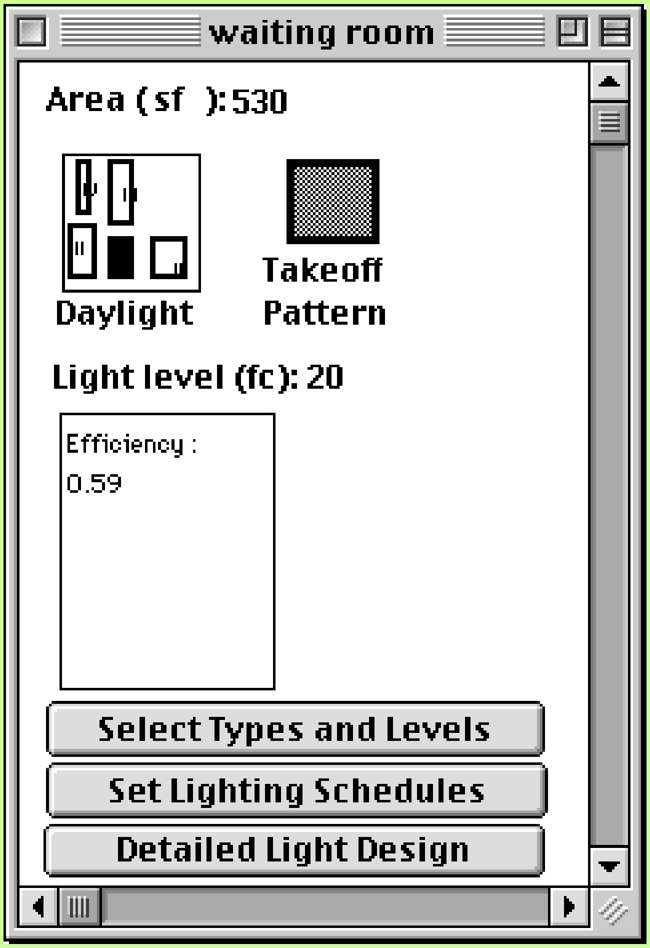
Back to **plan specifications**

worked example

plan specifications: electric lighting

ELECTRIC LIGHTING ZONE I

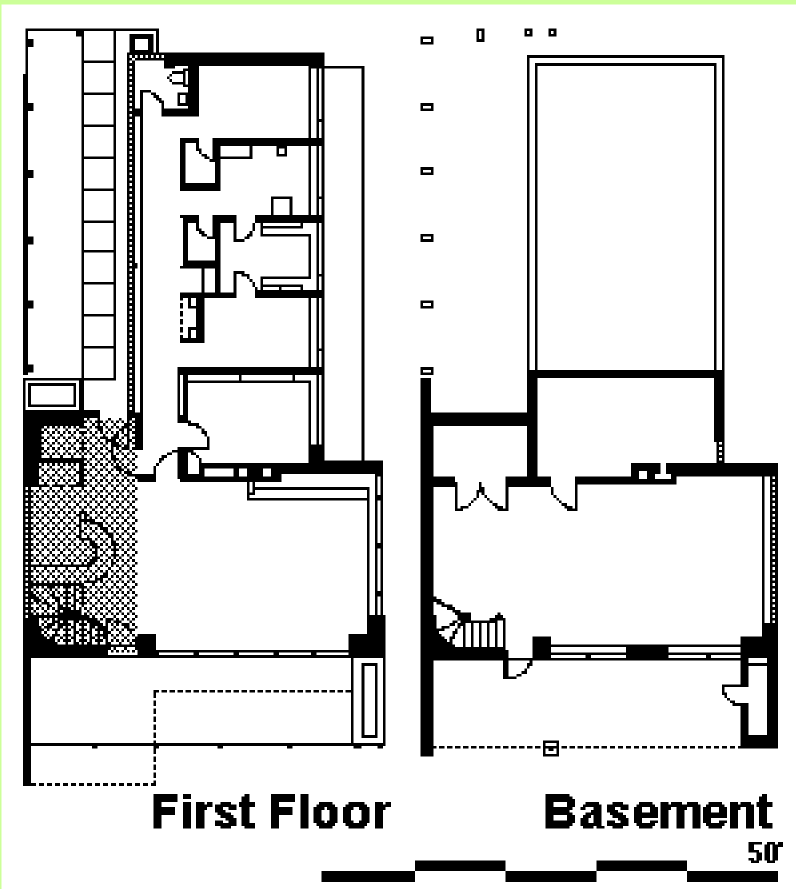


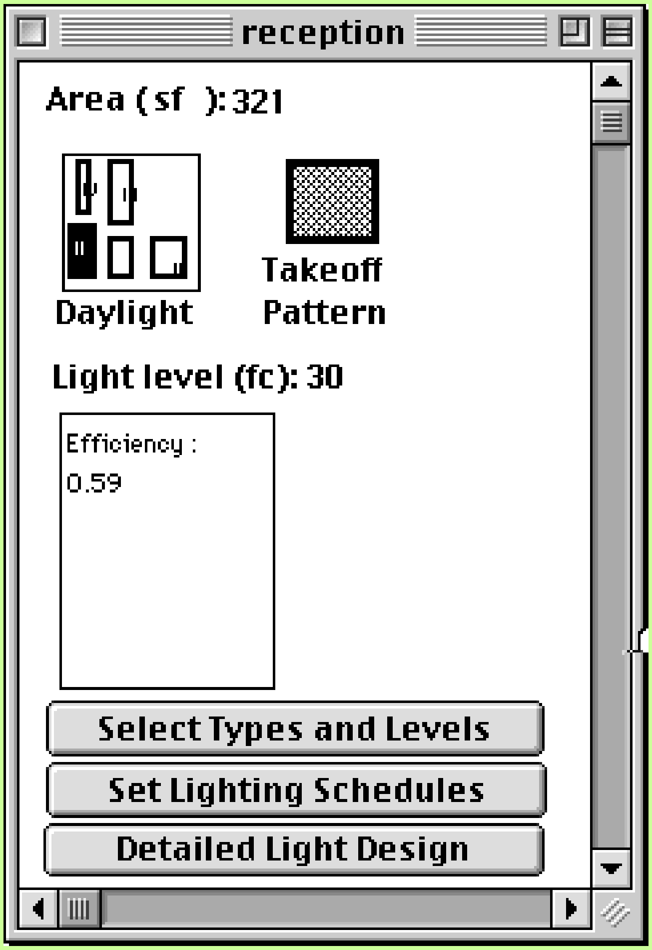

waiting room
Area (sf): 530
Daylight
Takeoff
Pattern
Light level (fc): 20
Efficiency :
0.59
Select Types and Levels
Set Lighting Schedules
Detailed Light Design

worked example

plan specifications: electric lighting

ELECTRIC LIGHTING ZONE II

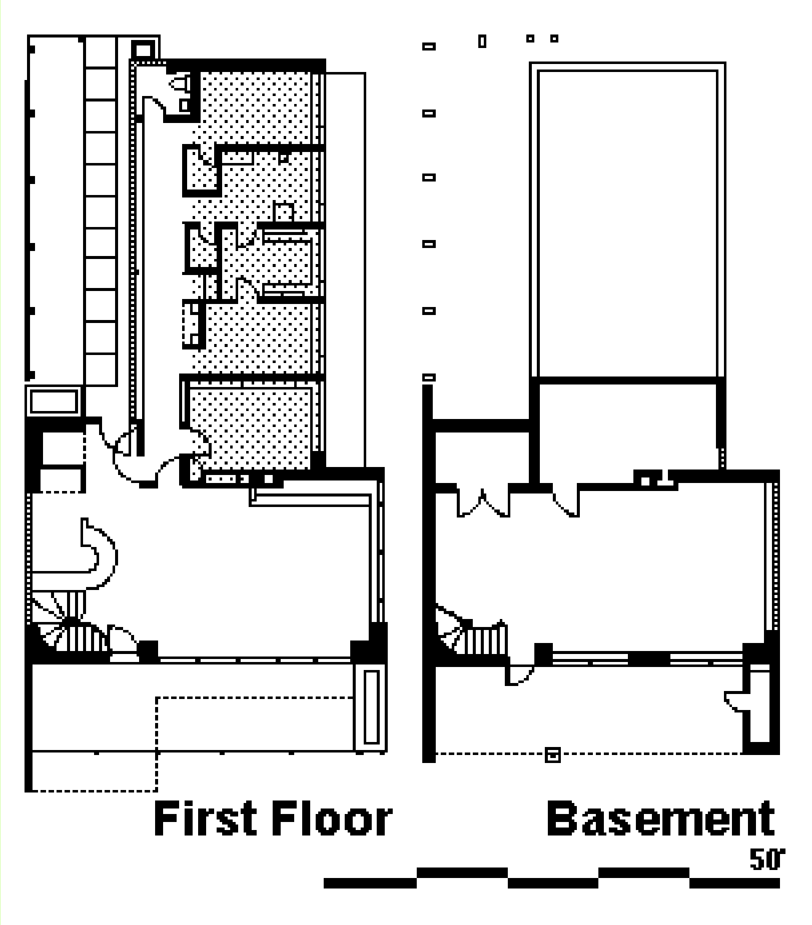


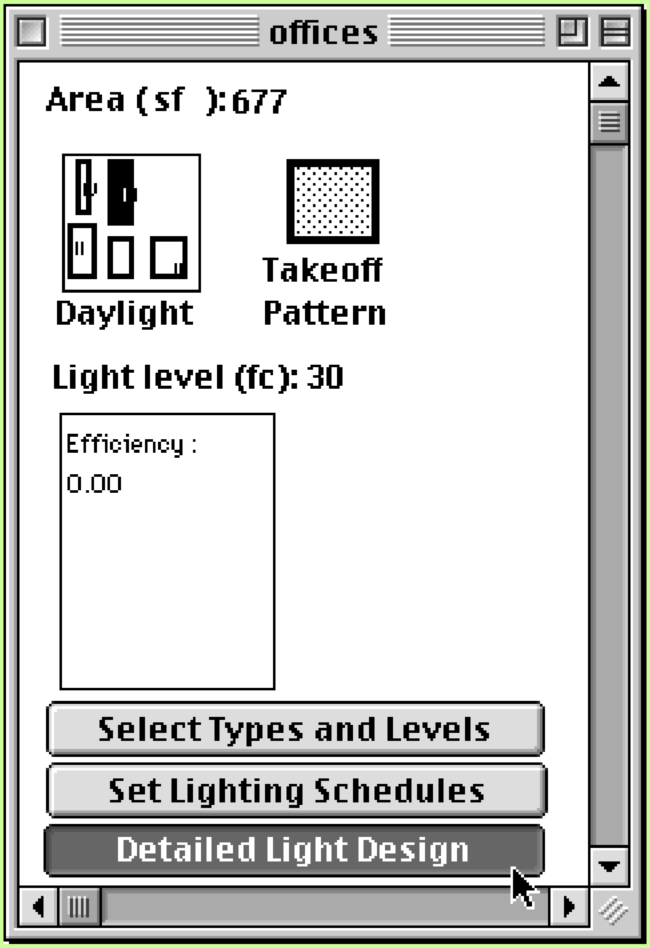

reception
Area (sf): 321
Daylight
Takeoff
Pattern
Light level (fc): 30
Efficiency :
0.59
Select Types and Levels
Set Lighting Schedules
Detailed Light Design

worked example

plan specifications: electric lighting

ELECTRIC LIGHTING ZONE III



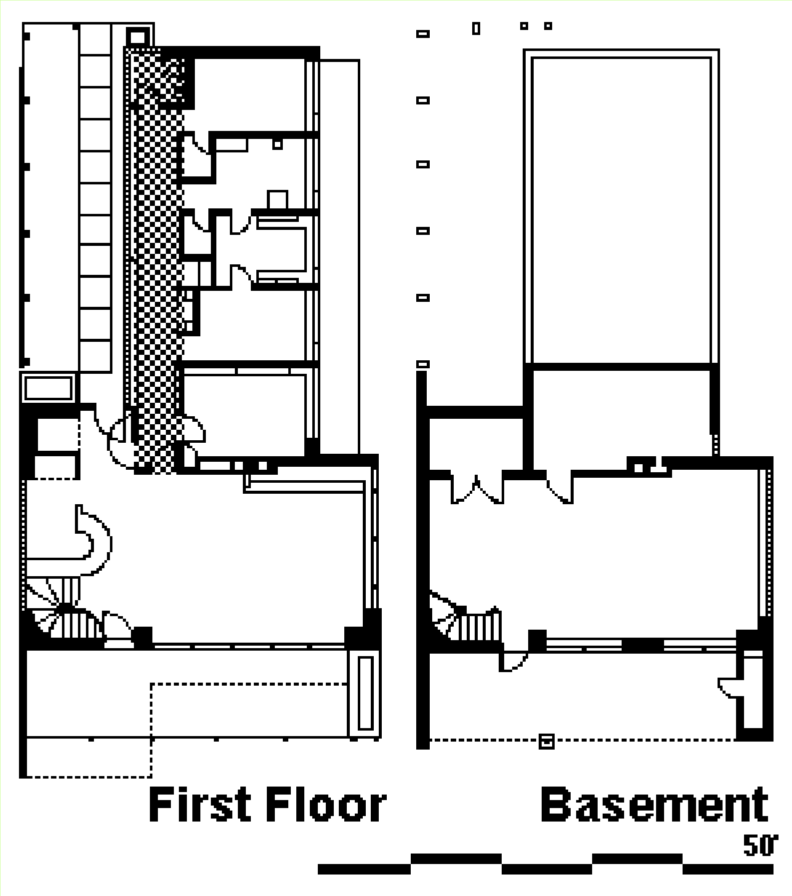

offices
Area (sf): 677
Daylight
Takeoff
Pattern
Light level (fc): 30
Efficiency :
0.00
Select Types and Levels
Set Lighting Schedules
Detailed Light Design

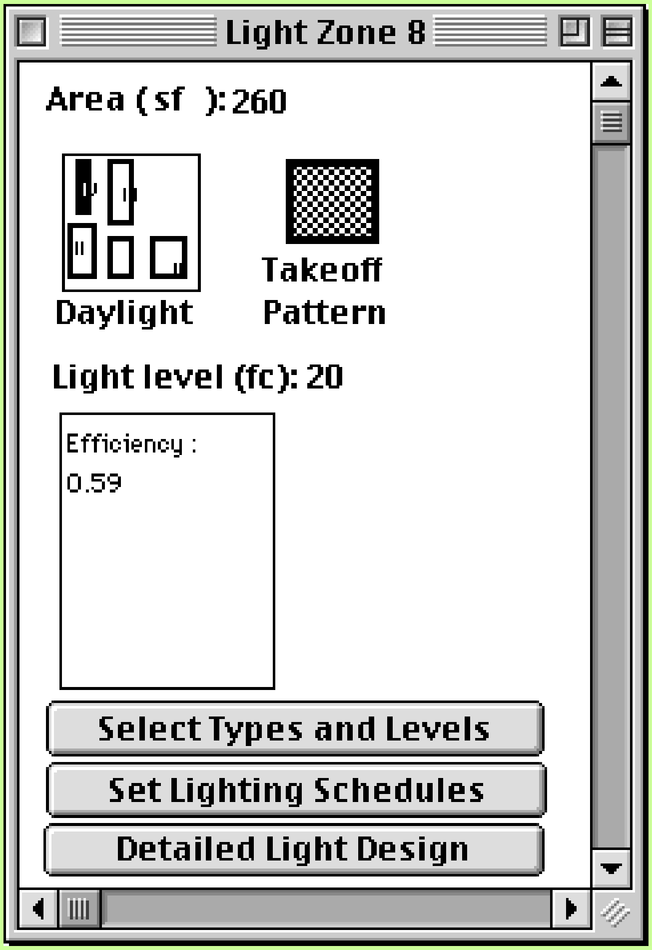
worked example

plan specifications: electric lighting

Lighting Zones

ELECTRIC LIGHTING ZONE IV

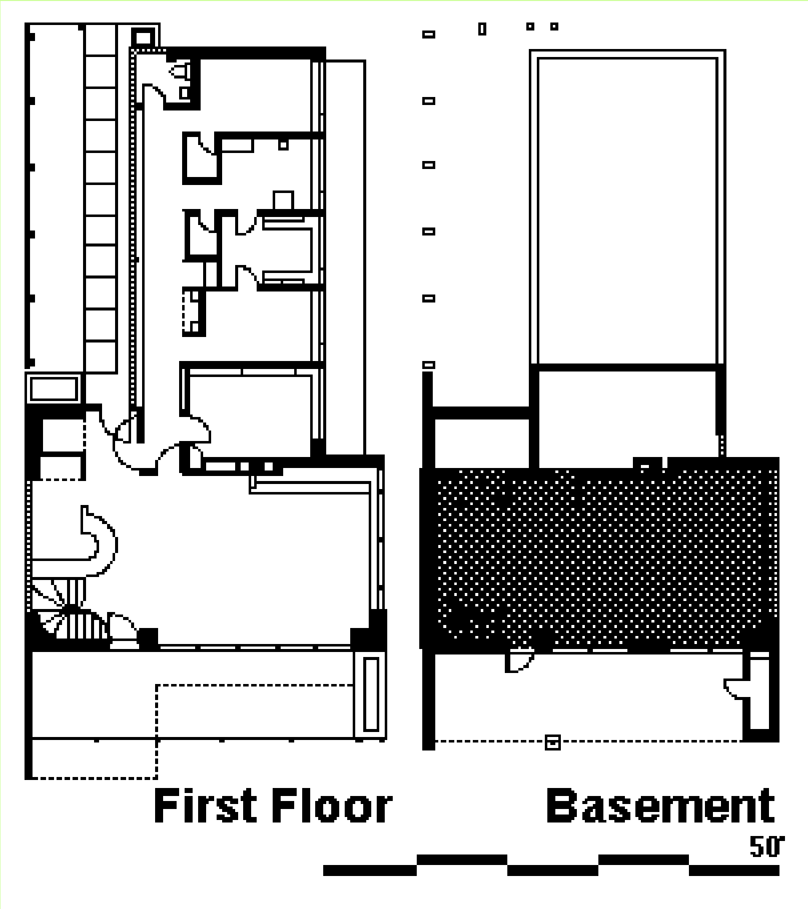


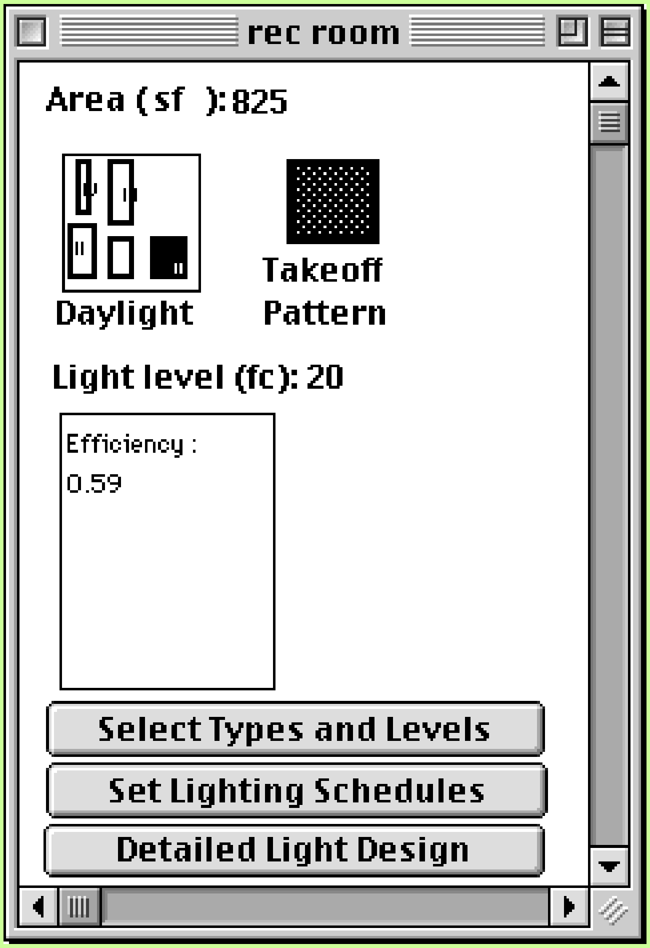

Light Zone 8
Area (sf): 260
Daylight
Takeoff
Pattern
Light level (fc): 20
Efficiency :
0.59
Select Types and Levels
Set Lighting Schedules
Detailed Light Design

worked example

plan specifications: electric lighting

ELECTRIC LIGTHING ZONE V

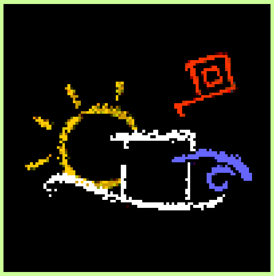



rec room
Area (sf): 825
Daylight
Takeoff
Pattern
Light level (fc): 20
Efficiency :
0.59
Select Types and Levels
Set Lighting Schedules
Detailed Light Design

RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

B. DEFINING: take-offs and specifications

elevation specifications



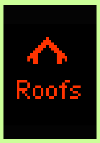
exercise

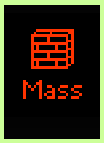
5. Create Elevation Specifications

Turn in

- A screen capture of your Elevations, showing walls, roofs, and windows.
- A printout of the energy performance report

Click on all icons below for specific information





A few notes on managing takeoffs

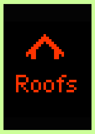
- **Renaming Icons**
  When you are doing takeoffs, you end up with a lot of icons representing various building elements. When you have many icons under one category, it sometimes helps to avoid confusion if you rename each takeoff icon with a specific name, such as "bedroom window" or "dormer roof." You can rename an icon by highlighting its name with the mouse and typing a new one in its place. This can only be done if the dialogue box associated with the icon is closed. We found this technique particularly useful when defining windows in the Create Elevation Specifications section.
- **Visibility of Icons**
  Another way to keep from getting too confused during the takeoff mode of Energy Scheming is to change the settings of the takeoffs under "VIEW/Takeoffs... " You can make visible only the takeoffs that you want to see, such as only electric lights, or only takeoffs in the open spec.

Return to the EXAMPLE OUTLINE

worked example

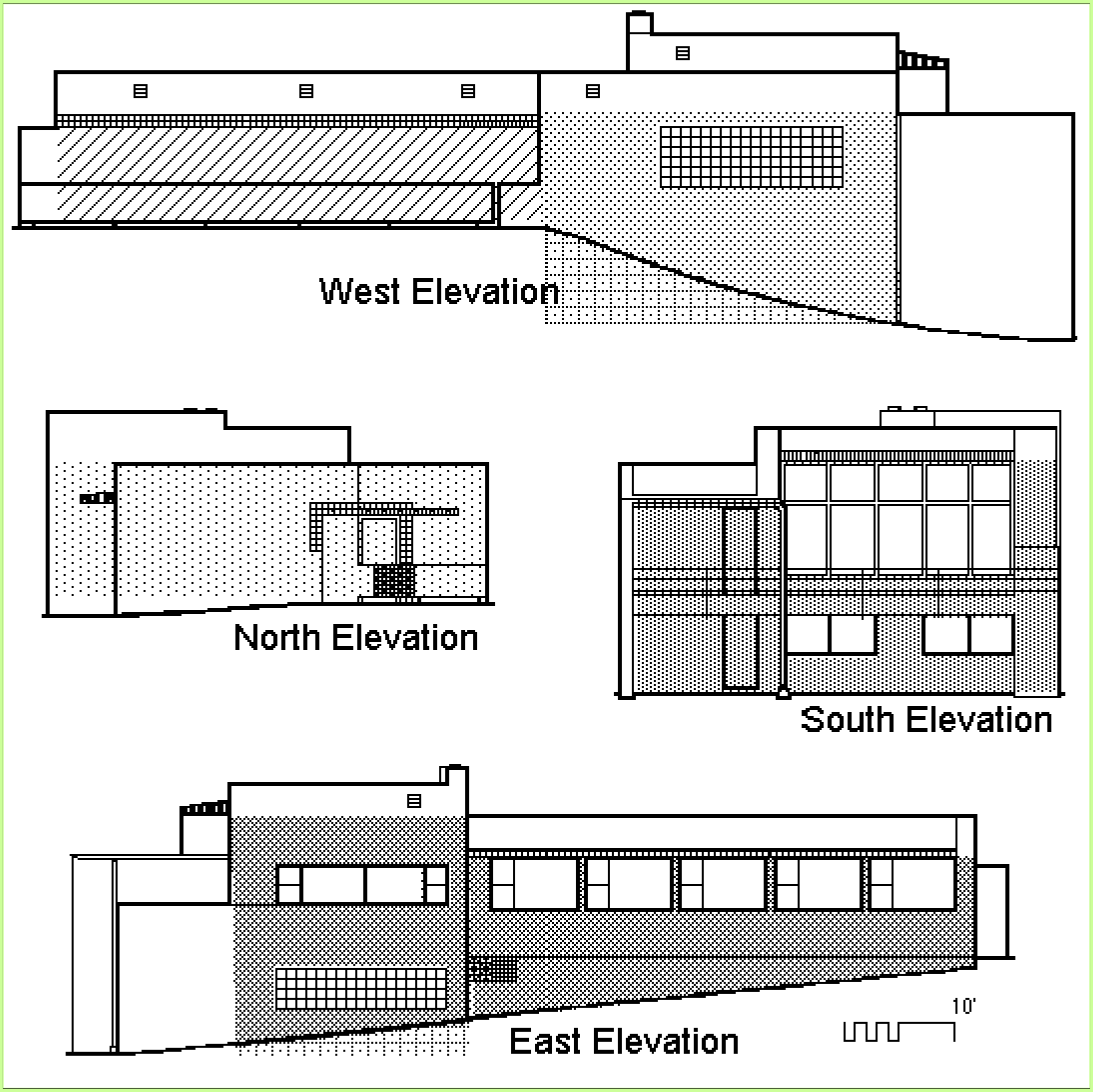
elevation specifications: walls

Click on all icons below for specific information:



WALLS

We only took off the portions of the elevations which had heated space behind them, making sure that the "Subtract window area" box was checked, so that wall takeoffs would be simpler. All exterior walls were defined as massive because they are of masonry.

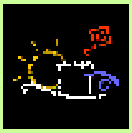


Click on one of the Elevations to see the wall specs for that elevation.

There are three types of walls in the Shanley Building:

- The east wall, south wall, north wall, and the reception area portion of the west wall are composed of uninsulated 6" concrete block, with plaster inside and stucco outside.
- The portion of the west exterior wall next to the hallway is similar, but made of 12" solid masonry.
- Portions of walls on the east and west sides of the recreation room are partially below grade.

Important Note: We also made sure each of the takeoff patterns were different from one another because, in the analysis, one of the options available is to look at heat gain/loss through just walls. The gains and losses are shown by a graph that uses the takeoff patterns we choose to represent each wall type in the graph. A little planning now will pay off later!

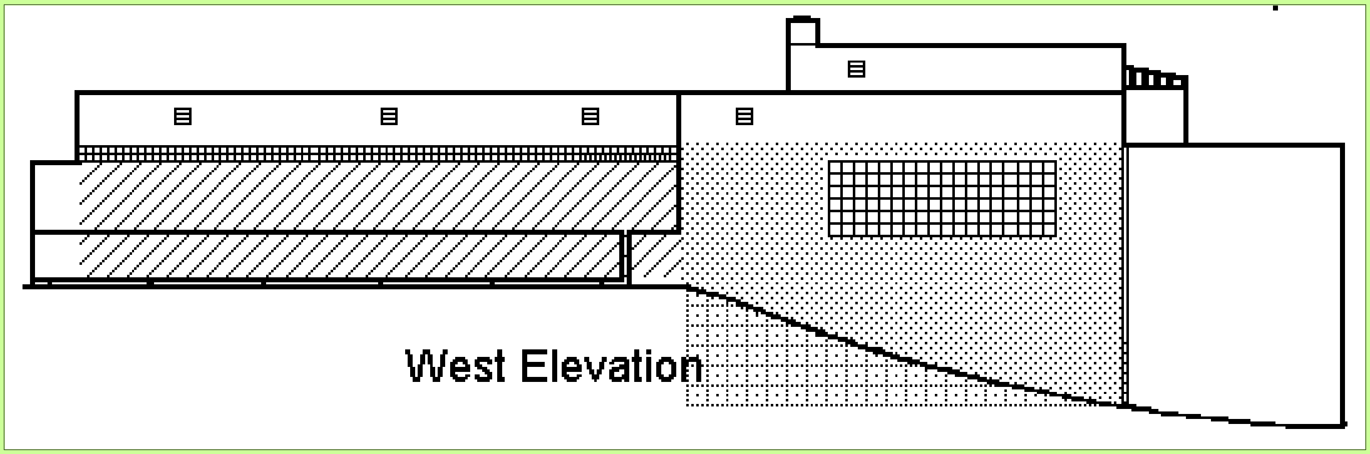


Back to **elevation specifications**

worked example

elevation specifications: walls

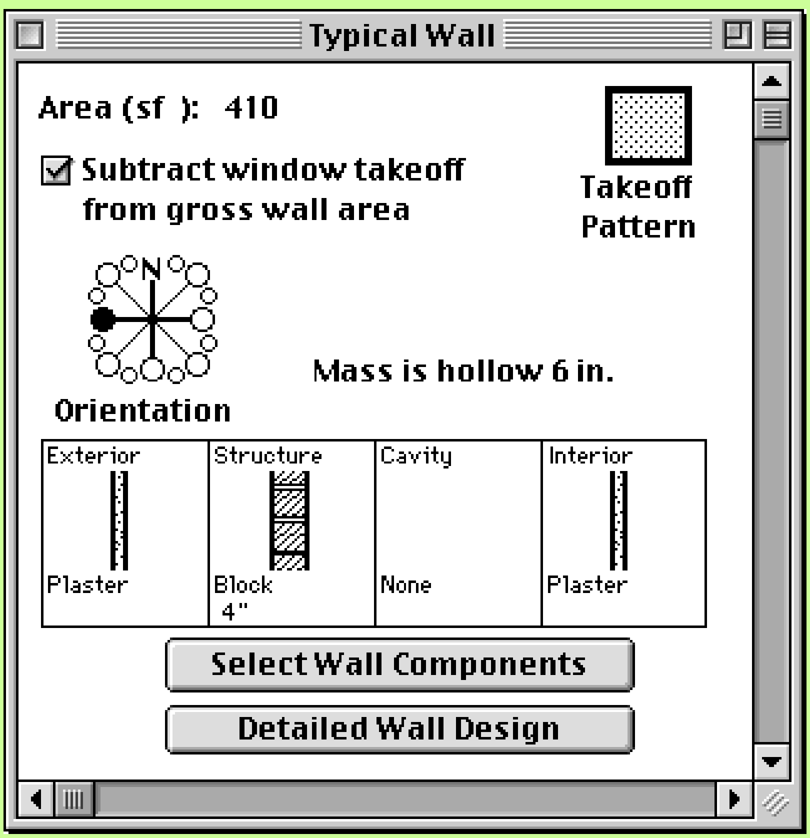
WEST WALLS

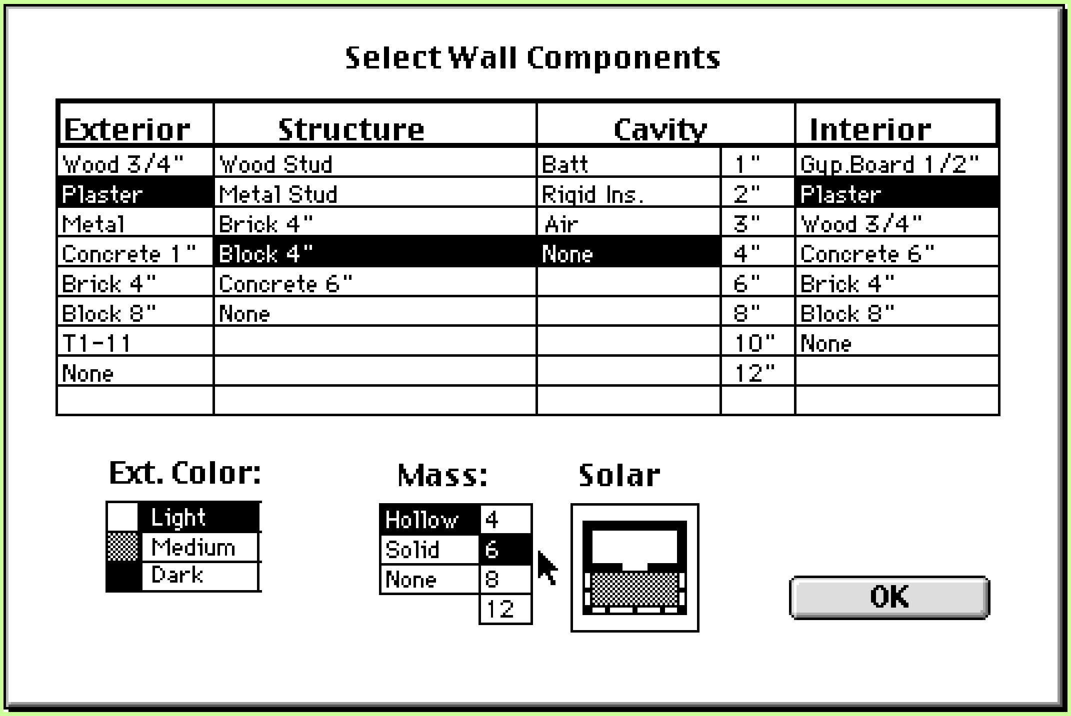


There are three types of wall construction on the west wall. Click on the wall takeoff to see the wall specs for that area.

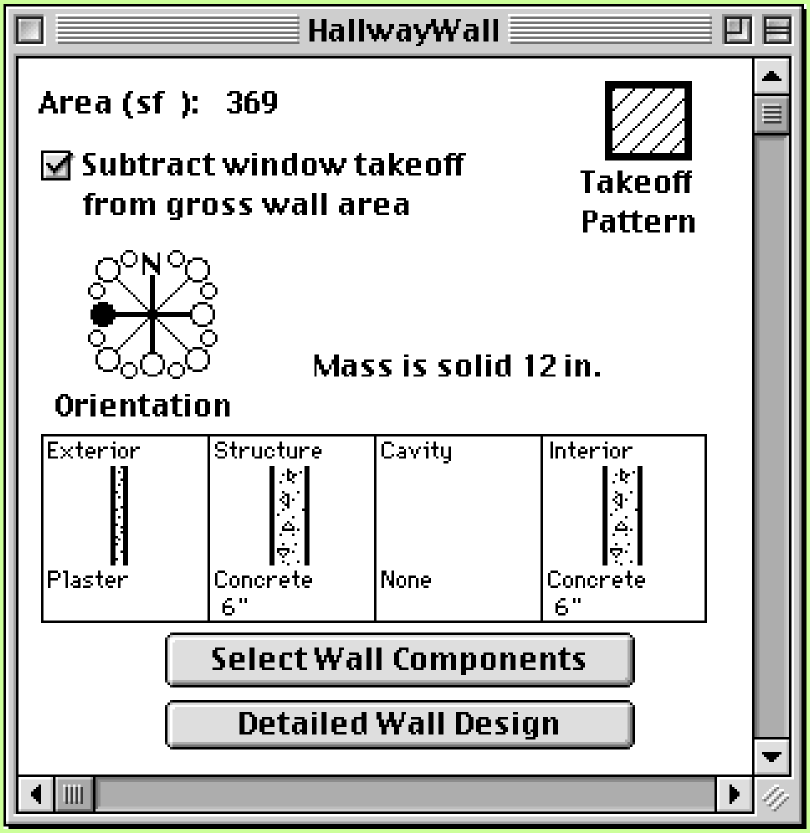
1. West Typical Above Grade Wall

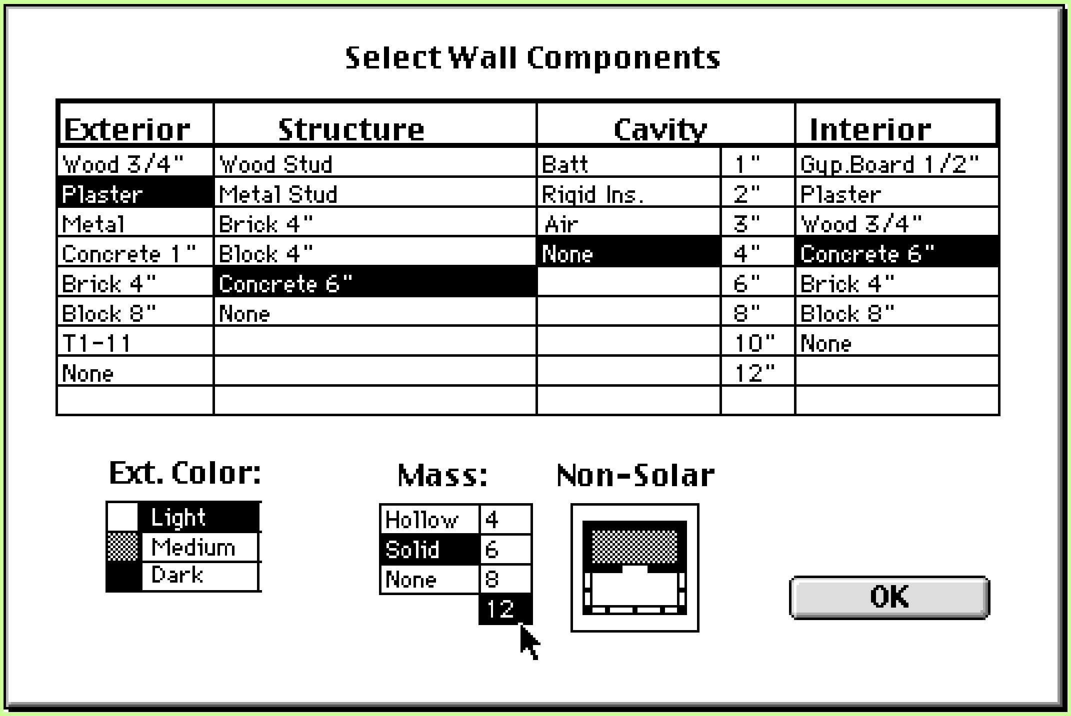
The reception area portion of the west wall is the typical wall construction for the building: uninsulated 6" concrete block, with plaster inside and stucco outside. There is no 6" Concrete Block option, so we chose 4" block, but in the mass section, we specified the mass as Hollow, 6". The interior is plaster,which we selected; the exterior, cement stucco, so we selected plaster. There is no insulating cavity. This gave a very close thermal representation of the actual wall construction for each of the walls.





2. West Hallway Wall
The portion of the west exterior wall next to the hallway is of a slightly different construction. It is similar to the typical wall, but 12" thick instead of 8" -- and solid masonry.

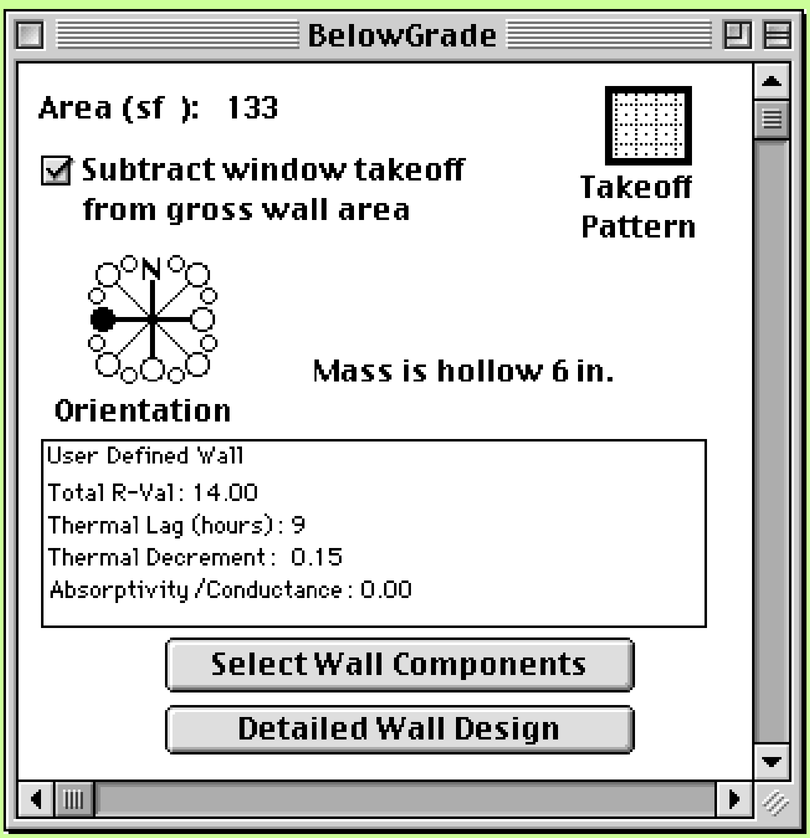


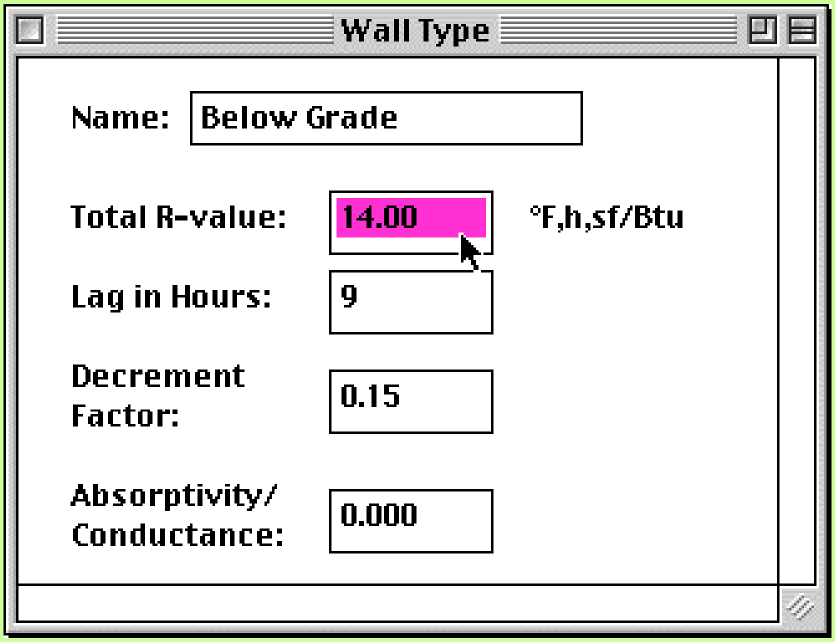


3. West Below Grade Wall

The area below grade has the same construction as the wall above ground, but we do a detailed wall spec to account for the insulating value of the earth. The takeoff area shows a triangular wall section below grade. The average depth below grade is only about four feet. From Sun, Wind, and Light: architectural design strategies (G. Z. Brown, 1984), pp. 86-87, we can estimate that at a two foot depth, in damp, medium weight soil, we can expect an added R-value of the earth of about R-12.

We first specified the wall as usual, the same as the wall above grade. Then, in the detailed spec, noted the R-value from the wall without the earth, and then added R-12, to give us an R-14 wall. We also set the lag to 9 hours and decrement factor to 0.15 (see ES Manual Appendix, p. 45, for Hollow, Insulated, Massive walls). Adding the earth changed the wall from uninsulated to insulated. We also set the Absorptivity/Conductance to zero, since the below grade wall will not absorb any solar energy.

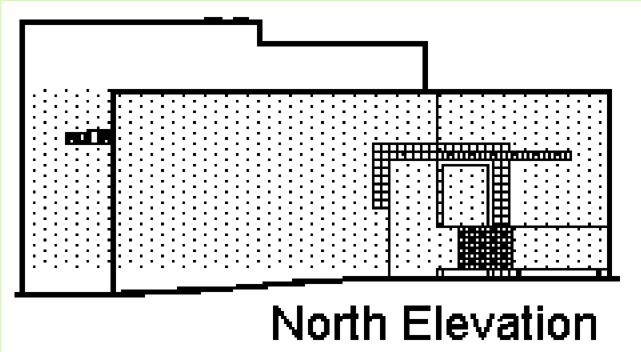



Wall Type
Name: Below Grade
Total R-value: 14.00 °F,h,sf/Btu
Lag in Hours: 9
Decrement Factor: 0.15
Absorptivity/ Conductance: 0.000

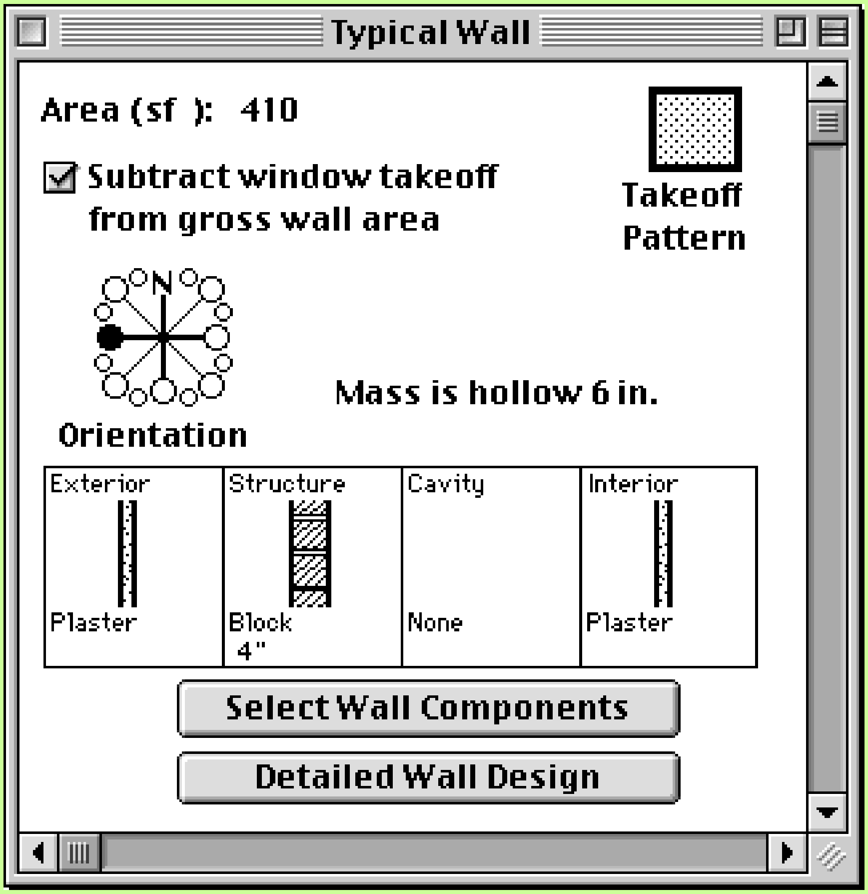
worked example

elevation specifications: walls

NORTH WALLS



The north wall is composed of uninsulated 6" concrete block, with plaster inside and stucco outside. There is no 6" Concrete Block option, so we chose 4" block, but in the mass section, we specified the mass as Hollow, 6". The interior is plaster,which we selected; the exterior, cement stucco, so we selected plaster. There is no insulating cavity. This gave a very close thermal representation of the actual wall construction.



Select Wall Components

Exterior	Structure	Cavity		Interior
Wood 3/4"	Wood Stud	Batt	1"	Gyp.Board 1/2"
Plaster	Metal Stud	Rigid Ins.	2"	Plaster
Metal	Brick 4"	Air	3"	Wood 3/4"
Concrete 1"	Block 4"	None	4"	Concrete 6"
Brick 4"	Concrete 6"		6"	Brick 4"
Block 8"	None		8"	Block 8"
T1-11			10"	None
None			12"	

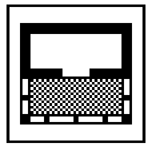
Ext. Color:

	Light
	Medium
	Dark

Mass:

Hollow	4
Solid	6
None	8
	12

Solar

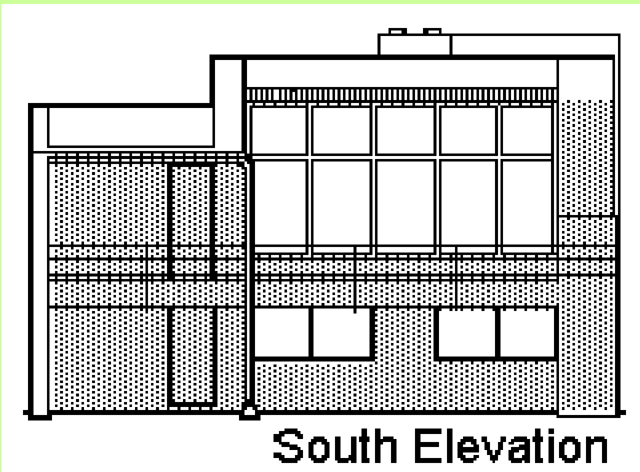


OK

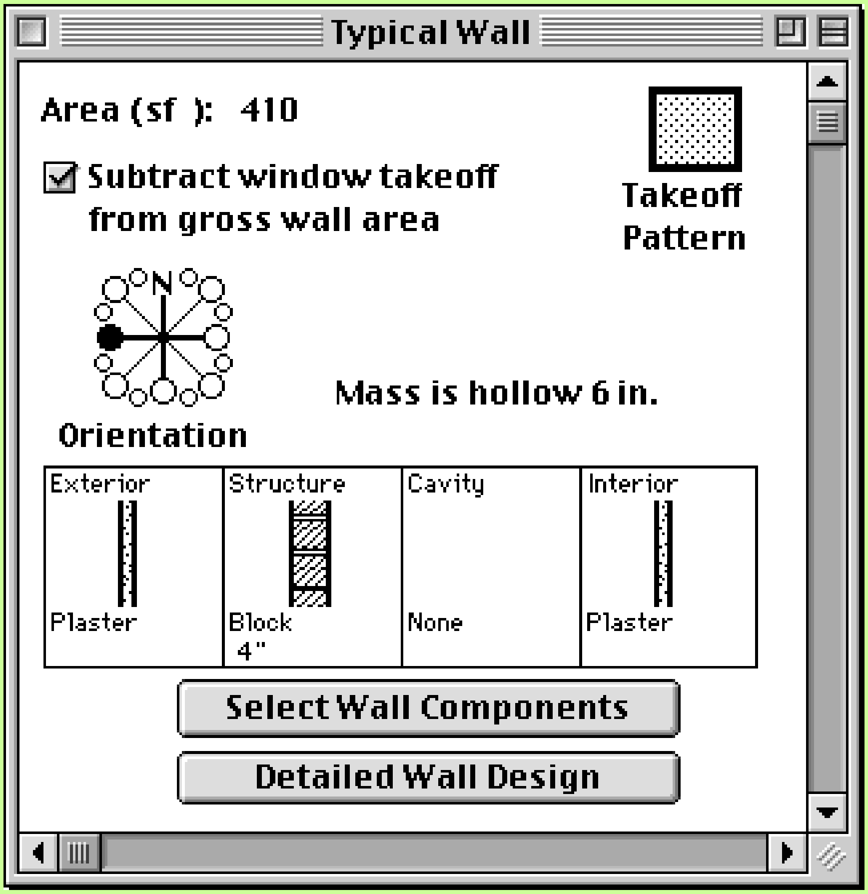
worked example

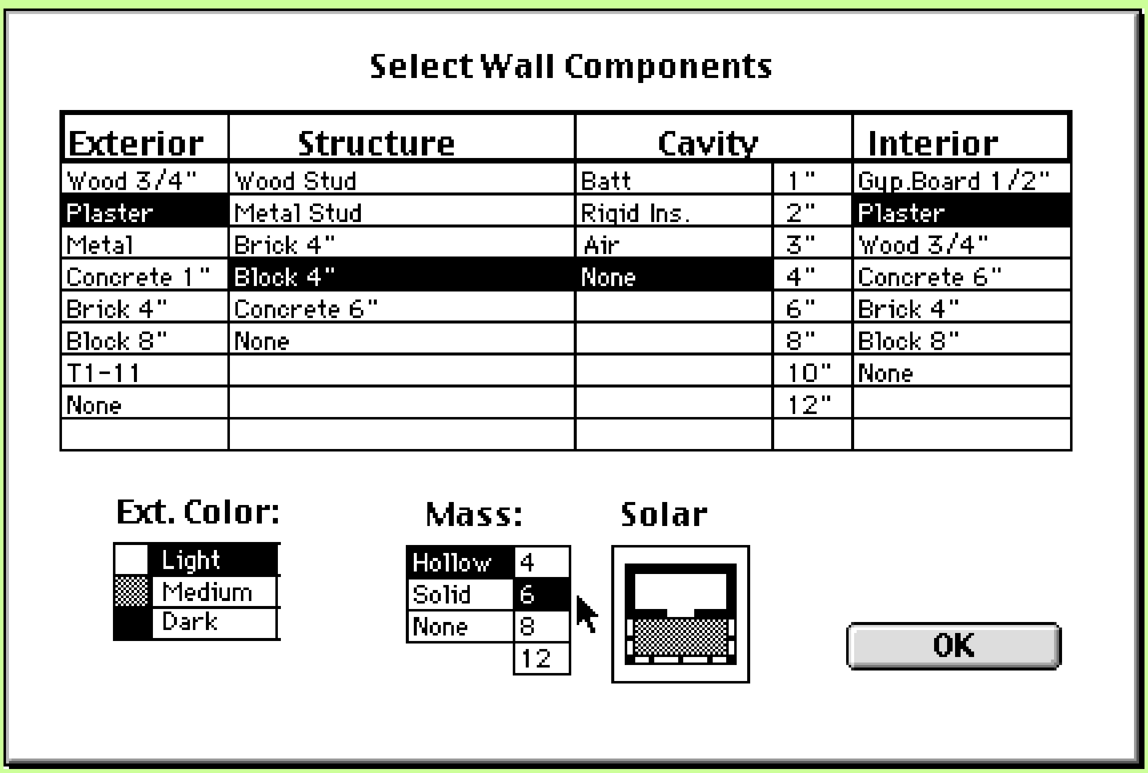
elevation specifications: walls

SOUTH WALLS



The south wall is composed of uninsulated 6" concrete block, with plaster inside and stucco outside. There is no 6" Concrete Block option, so we chose 4" block, but in the mass section, we specified the mass as Hollow, 6". The interior is plaster,which we selected; the exterior, cement stucco, so we selected plaster. There is no insulating cavity. This gave a very close thermal representation of the actual wall construction.

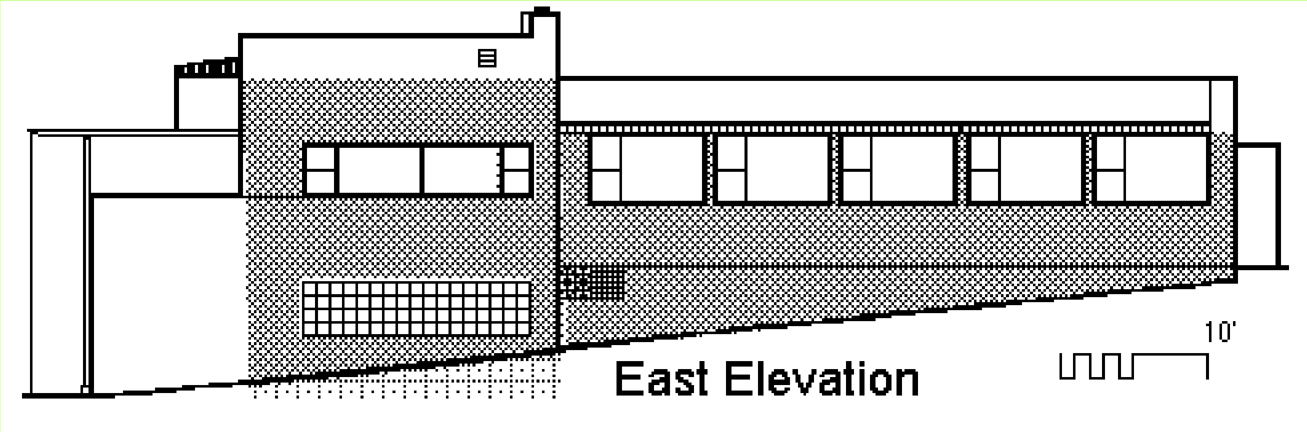

Typical Wall
Area (sf): 410
Subtract window takeoff
from gross wall area
Takeoff
Pattern
N
Orientation
Mass is hollow 6 in.
Exterior
Structure
Cavity
Interior
Plaster
Block
4"
None
Plaster
Select Wall Components
Detailed Wall Design


Select Wall Components
Exterior
Structure
Cavity
Interior
Wood 3/4"
Wood Stud
Batt
1"
Gyp.Board 1/2"
Plaster
Metal Stud
Rigid Ins.
2"
Plaster
Metal
Brick 4"
Air
3"
Wood 3/4"
Concrete 1"
Block 4"
None
4"
Concrete 6"
Brick 4"
Concrete 6"
6"
Brick 4"
Block 8"
None
8"
Block 8"
T1-11
10"
None
None
12"
Ext. Color:
Light
Medium
Dark
Mass:
Hollow
Solid
None
4
6
8
12
Solar
OK

elevation specifications: walls

worked example

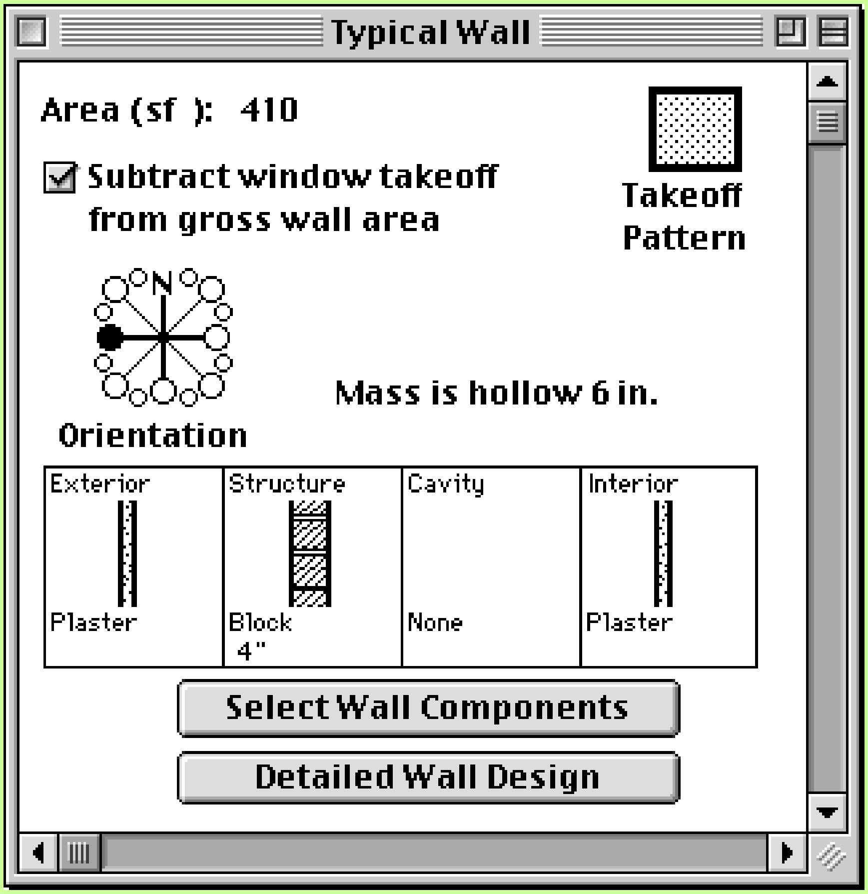
EAST WALLS

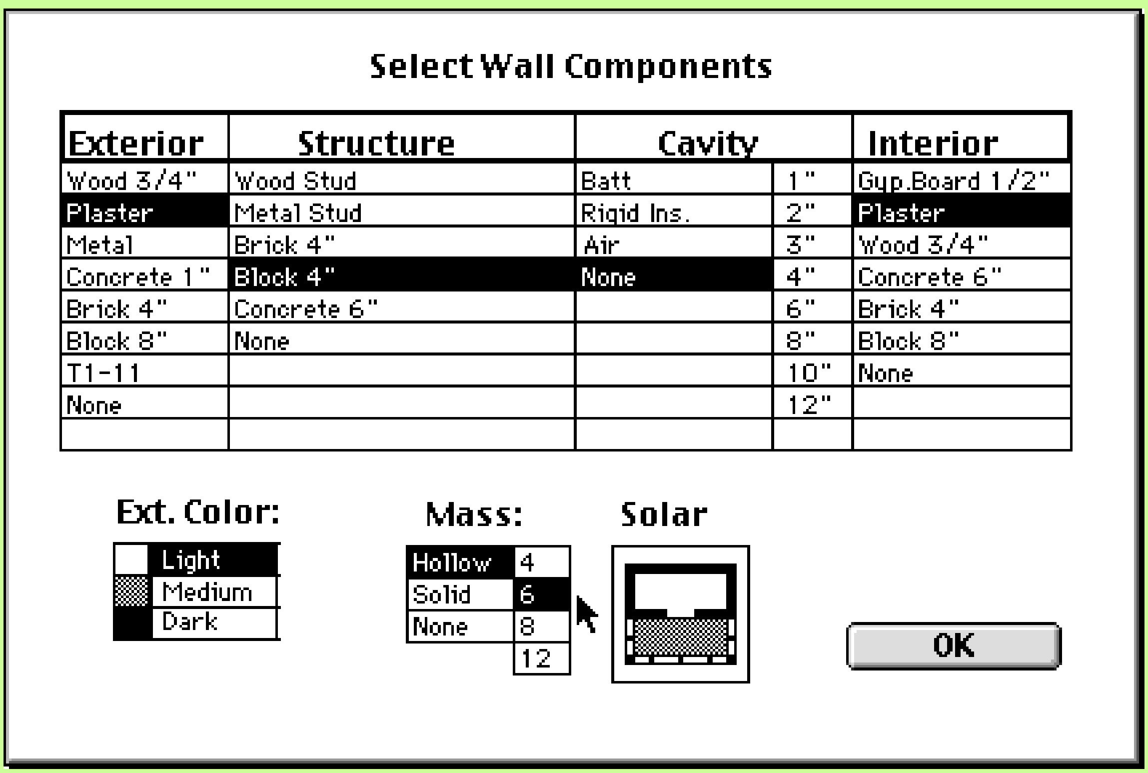


There are two types of wall construction on the west wall. Click on the wall takeoff to see the wall specs for that area.

1. Above Grade Wall

Most of the east wall is composed of uninsulated 6" concrete block, with plaster inside and stucco outside. There is no 6" Concrete Block option, so we chose 4" block, but in the mass section, we specified the mass as Hollow, 6". The interior is plaster,which we selected; the exterior, cement stucco, so we selected plaster. There is no insulating cavity. This gave a very close thermal representation of the actual wall construction.

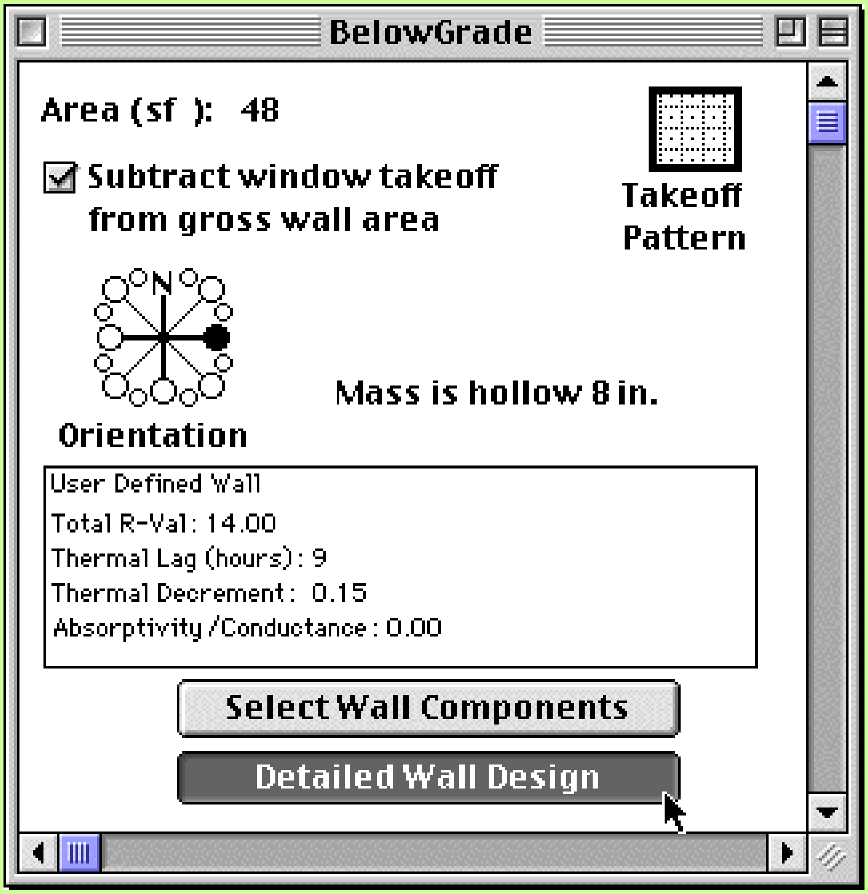


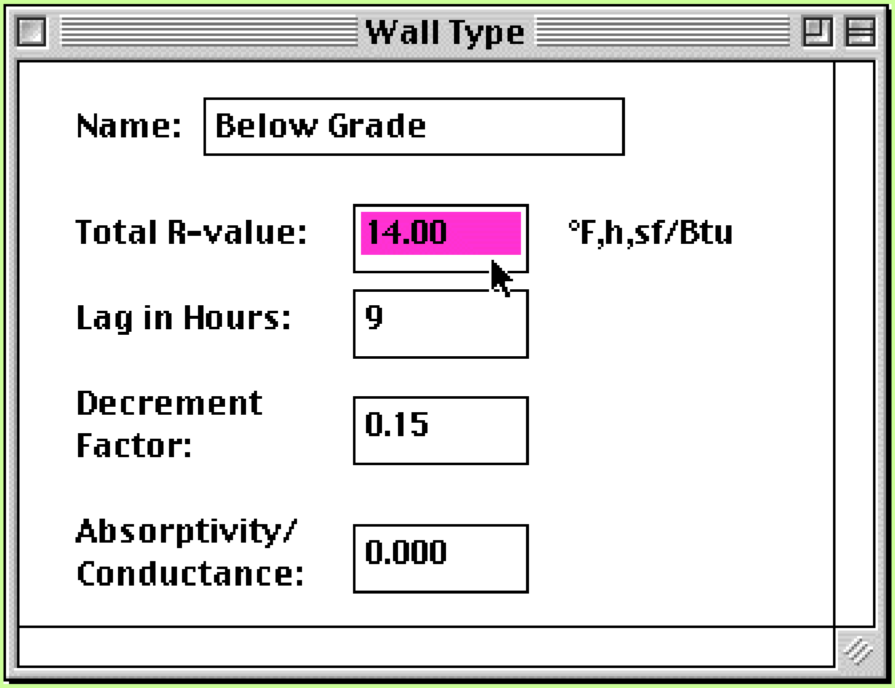


2. Below Grade Wall

The area below grade has the same construction as the wall above ground, but we do a detailed wall spec to account for the insulating value of the earth. The takeoff area shows a triangular wall section below grade. The average depth below grade is only about two feet. From Sun, Wind, and Light: architectural design strategies (G. Z. Brown, 1984), pp. 86-87, we can estimate that at a two foot depth, in damp, medium weight soil, we can expect an added R-value of the earth of about R-5.

We first specified the wall as usual, the same as the wall above grade. Then, in the detailed spec, noted the R-value from the wall without the earth, and then added R-5, to give us an R-7 wall. We also set the lag to 9 hours and decrement factor to 0.15 (see ES Manual Appendix, p. 45, for Hollow, Insulated, Massive walls). Adding the earth changed the wall from uninsulated to insulated. We also set the Absorptivity/Conductance to zero, since the below grade wall will not absorb any solar energy.





worked example

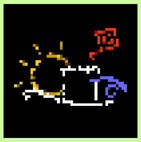
elevation specifications: roof

5) Create Elevation Specifications.

Click on all icons below for specific information:

ROOFS

There are no significantly sloped roofs, thus we specified all roofs in the plan takeoffs. (roof plan takeoffs)



Back to **elevation specifications**

worked example

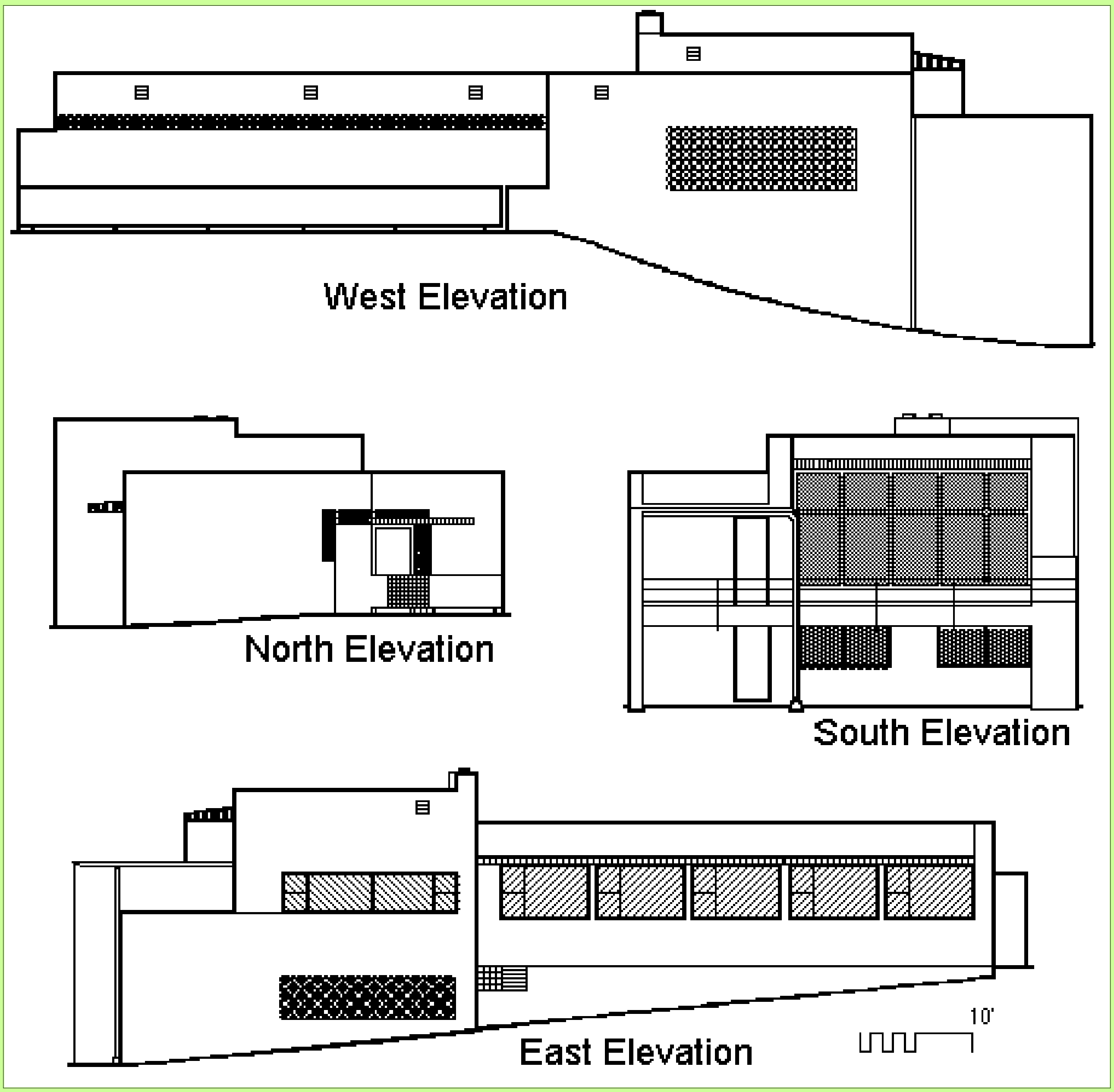
elevation specifications: windows and skylights

Click on all icons below for specific information:

WINDOWS

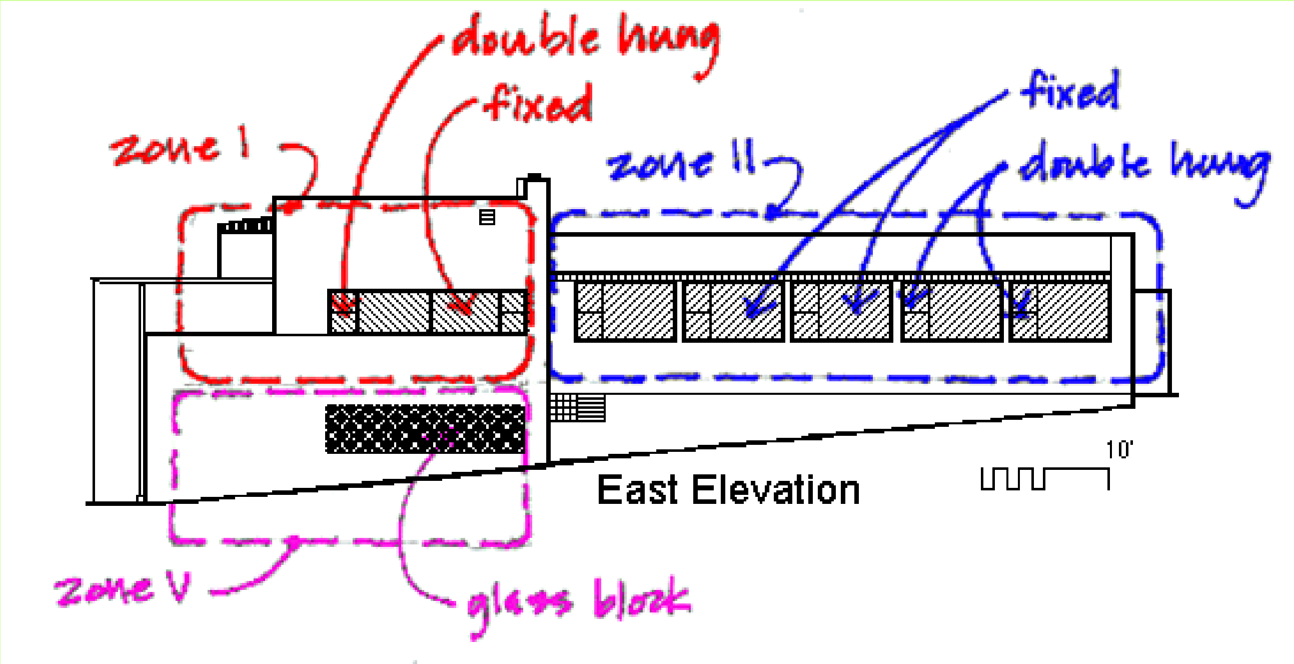
The Shanley building has three different kinds of windows:

- glass block
- fixed, double glazed windows
- double hung, double glazed windows

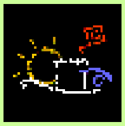


Click on one of the Elevations to see the Window Specs for that elevation.

We created a different takeoff for each window type in *each daylight zone* (remember windows have to be associated with a particular daylight zone.) For example, the east facade (East windows page) has all three window types and three daylight zones. Both fixed and double hung windows are located in daylight zones I and III, thus we created four different takeoffs for those windows. We created a fifth takeoff for the glass block window in daylight zone 5. We then renamed the window spec icons to avoid confusion, since there were so many of them.



As with walls, we used different takeoff patterns for different window types. Windows show up in the graphic report by orientation and spec. We made different window takeoff patterns for each different shading condition. These will be used later by *Energy Scheming* to represent a graphic analysis of heat gain and loss through the windows.

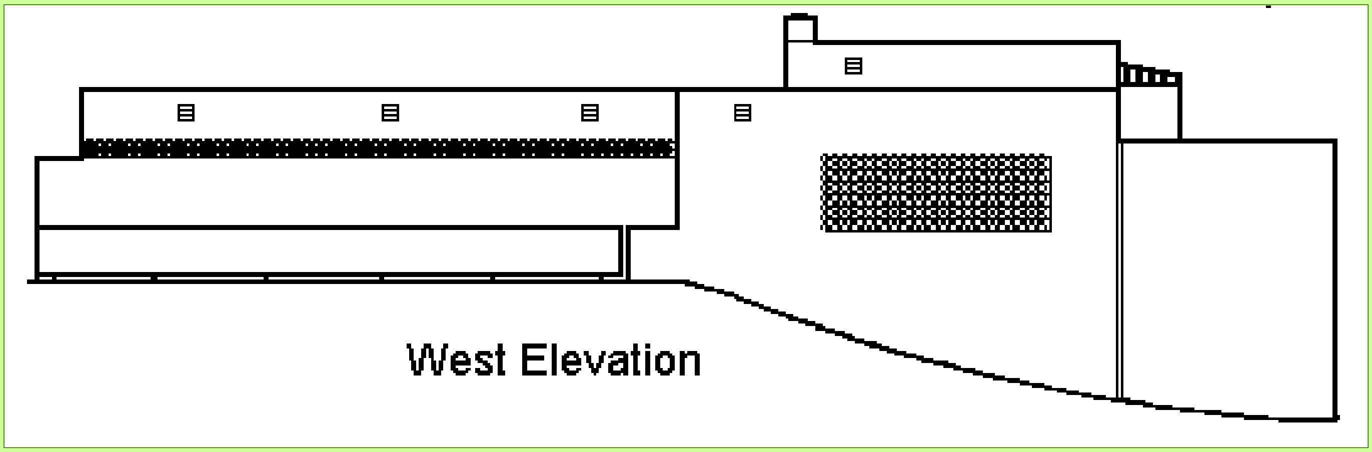


Back to **elevation specifications**

worked example

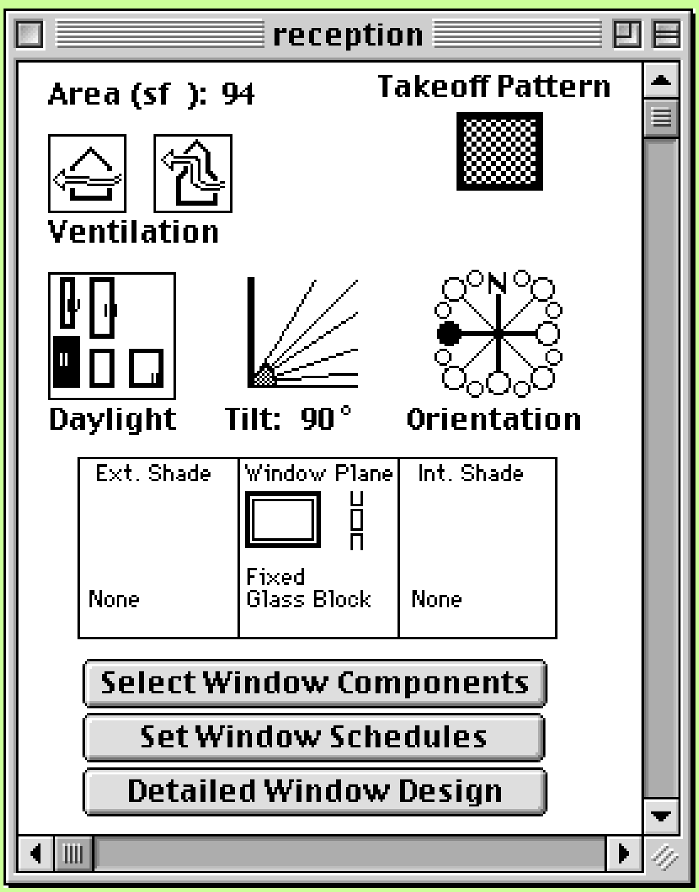
elevation specifications: windows and skylights

WEST WINDOWS



Click on the Window takeoff to see the Window Specs for that area.

Reception Area Windows (main floor)

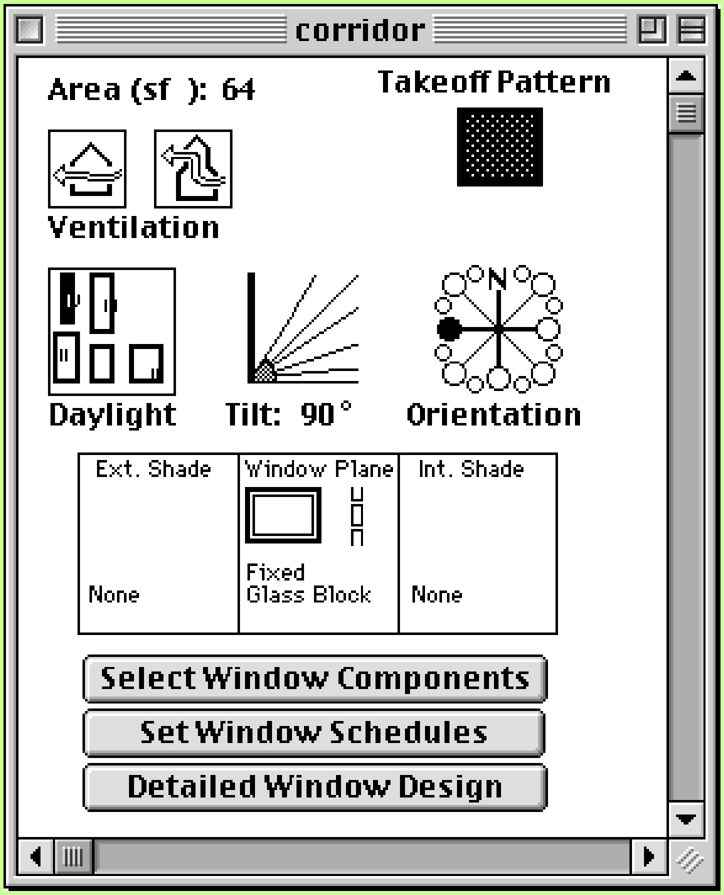


The reception area is lit with a single large unshaded glass block window.

It is specified as:

- No ventilation
- Daylight zone II
- Vertical tilt
- West orientation
- No exterior shades
- Fixed glass block
- No interior shades

Corridor Window (main floor)



There is a thin high strip glass block window along the entire length of the corridor.

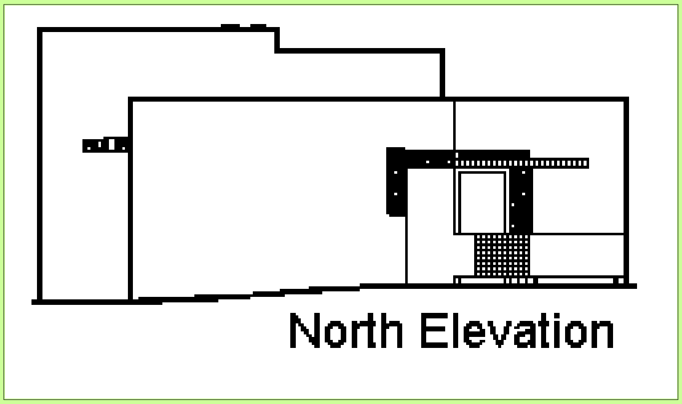
It is specified as:

- No ventilation
- Daylight zone IV
- Vertical tilt
- West orientation
- No exterior shades
- Fixed glass block
- No interior shades

worked example

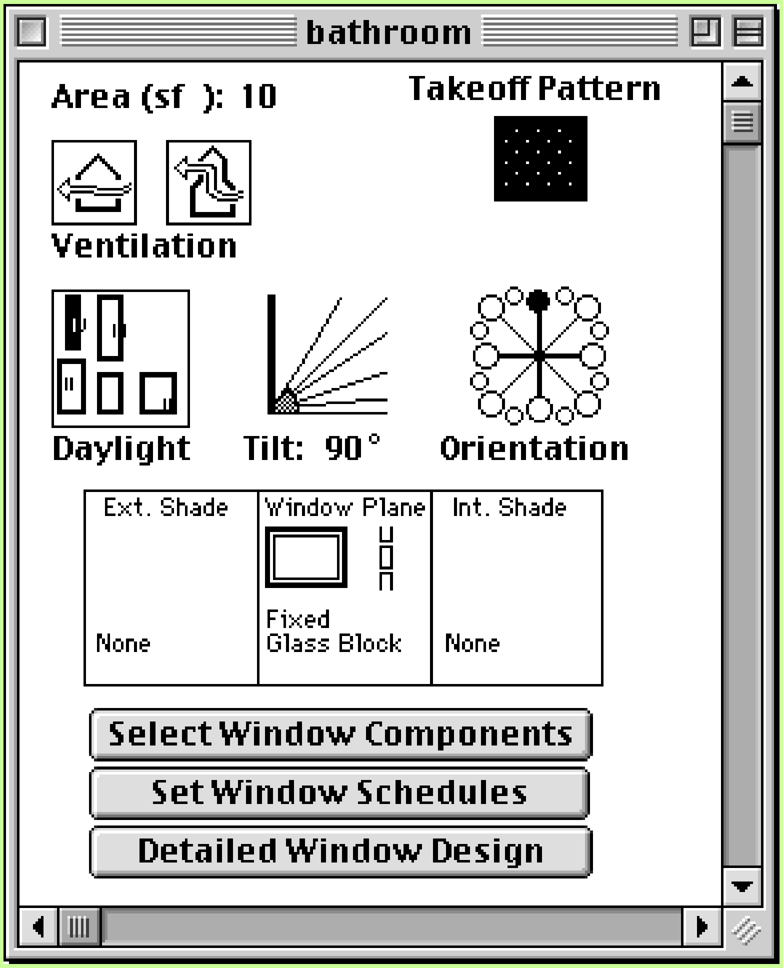
elevation specifications: windows and skylights

NORTH WINDOWS



North windows are thin strips of glass block in two locations: the bath room at the end of the corridor and around and over the entry.

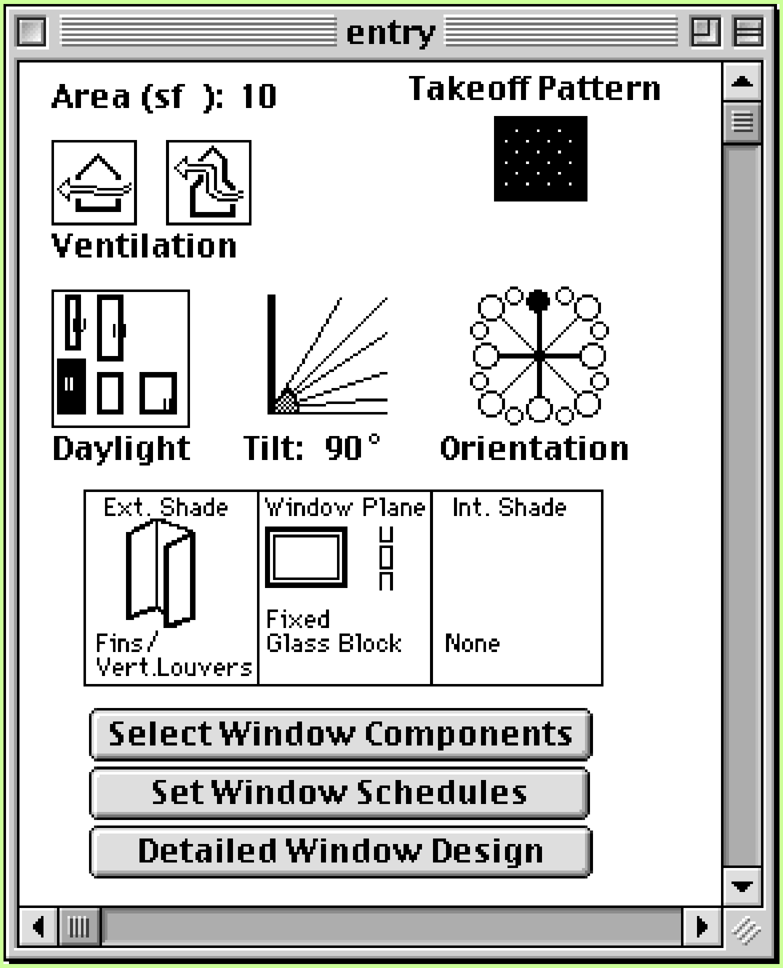
Bathroom Windows (main floor)



It is specified as:

- No ventilation
- Daylight zone IV
- Vertical tilt
- North orientation
- No exterior shades
- Fixed glass block
- No interior shades

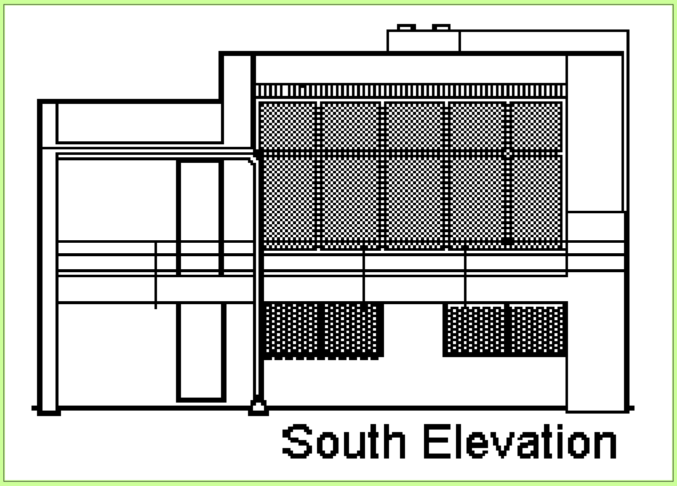
Entry glass block windows have the same spec, except they are in daylight zone II


entry
Area (sf): 10
Takeoff Pattern
Ventilation
Daylight
Tilt: 90°
Orientation
Ext. Shade
Fins/
Vert.Louvers
Window Plane
Fixed
Glass Block
Int. Shade
None
Select Window Components
Set Window Schedules
Detailed Window Design

worked example

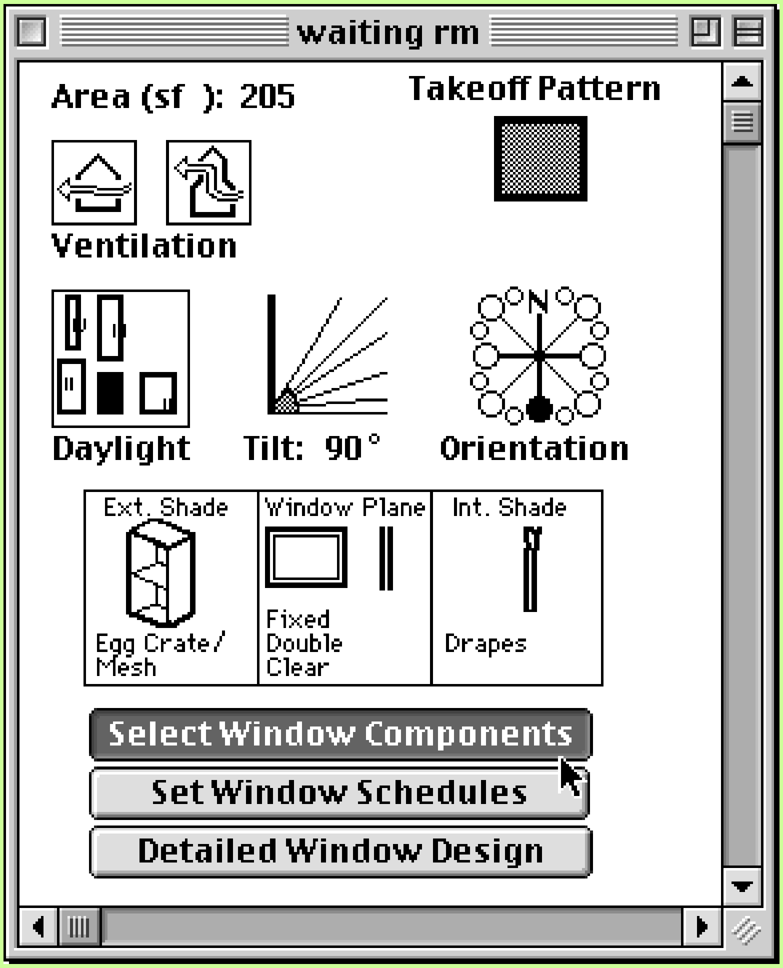
elevation specifications: windows and skylights

SOUTH WINDOWS



Click on the Window takeoff to see the Window Specs for that area.

Waiting Room Windows (main floor)



The south elevation has fixed double glazed windows in the Waiting Room. The unique design uses an early desiccant system between the two panes (detail drawing). We picked Fixed, Double, Clear glass.

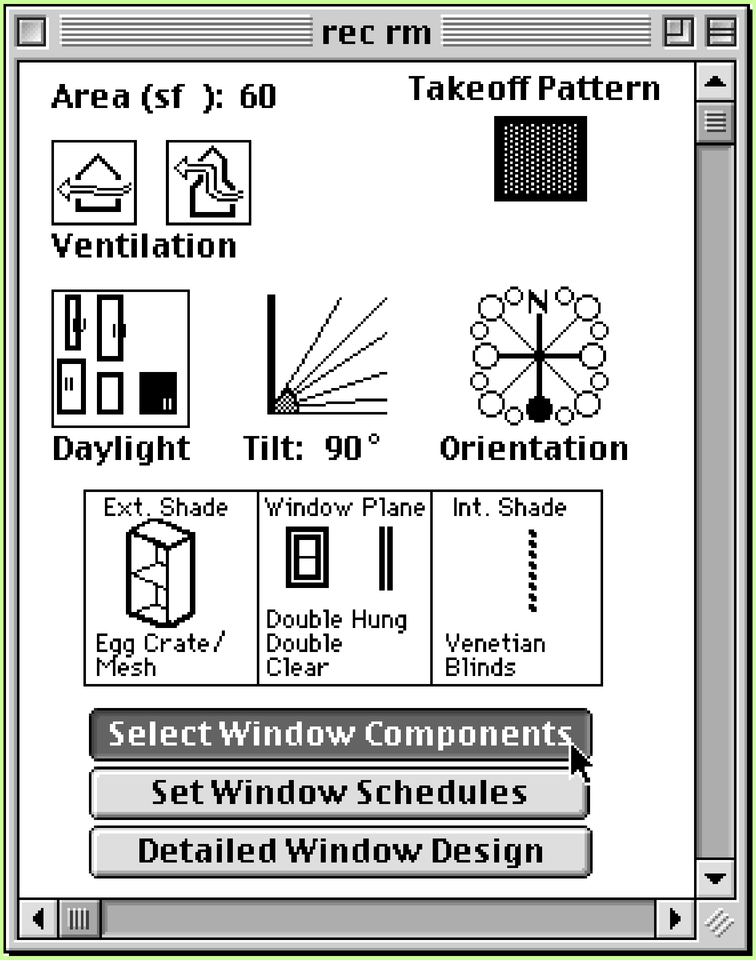
The windows are protected by three forms of external shading, a large projecting overhang, a projecting fin wall on the west side, and an operable roll-down canvas shade that drops on guide wires from the overhang. (drawings of shades)

Additionally, there are drapes inside. When specifying window components, you can specify *only one type* of exterior shading that must approximate the combined effect of all three. We had to decide which exterior shading element to include -- the overhangs, fin, or the roll-down shades? Since exterior shades are manually operable, they may be deployed when needed (or may not!), whereas the overhangs are always in place. Therefore, it seemed to make the most sense to specify the exterior overhang on the south. However, the fin wall makes the fixed system more like an egg-crate. If we assumed perfectly attuned occupants, we would use the roll-down shade; we compromised with the egg-crate outside and interior drapes inside, still a very good shading scheme.

We also defined the other options as:

- Windows are fixed, so neither ventilation icon is selected.
- Daylight zone 1
- Vertical tilt
- South orientation

Recreation Room Windows (basement level)



On the south side, the basement level has double glazed slider windows in the Recreation Room daylight zone V. The windows are shaded by both the main floor balcony above, and by large projecting fins on each side. The combination of vertical and horizontal shading functions like one large egg-crate shading element.

Even though the windows are operable, and the wind in summer comes from the south, there are no outlets on this floor. To keep ES from showing some cross ventilation effect that would not occur because of the lack of internal air path (some East windows are also operable), we turned off the ventilation icons.

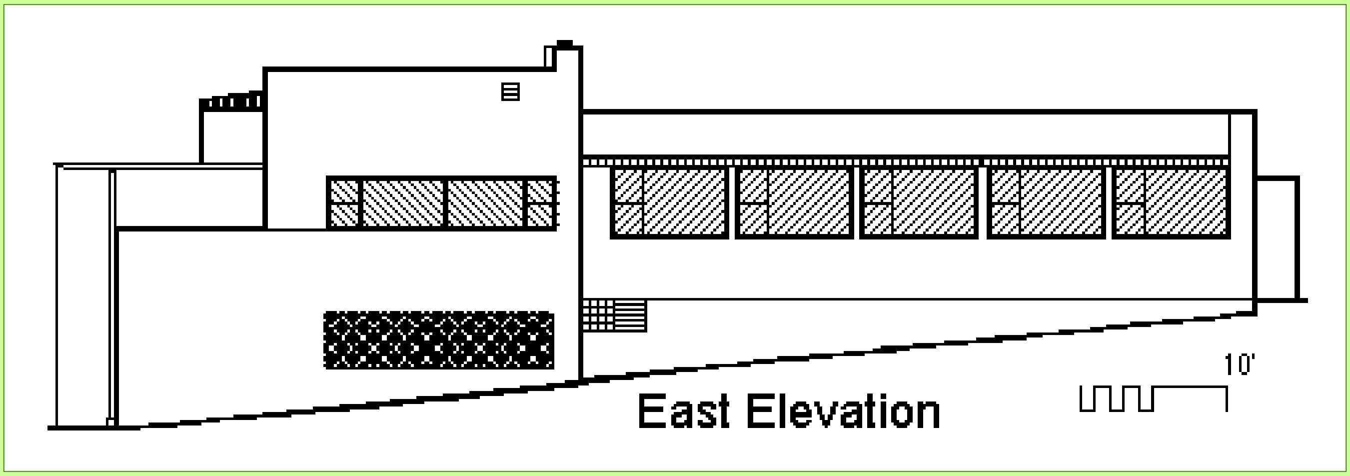
We defined these windows as:

- No ventilation
- Daylight zone V
- Vertical tilt
- South orientation
- Egg-crate exterior shades
- Double-hung (same operable area as slider), double, clear windows
- Interior venetian blinds, light

worked example

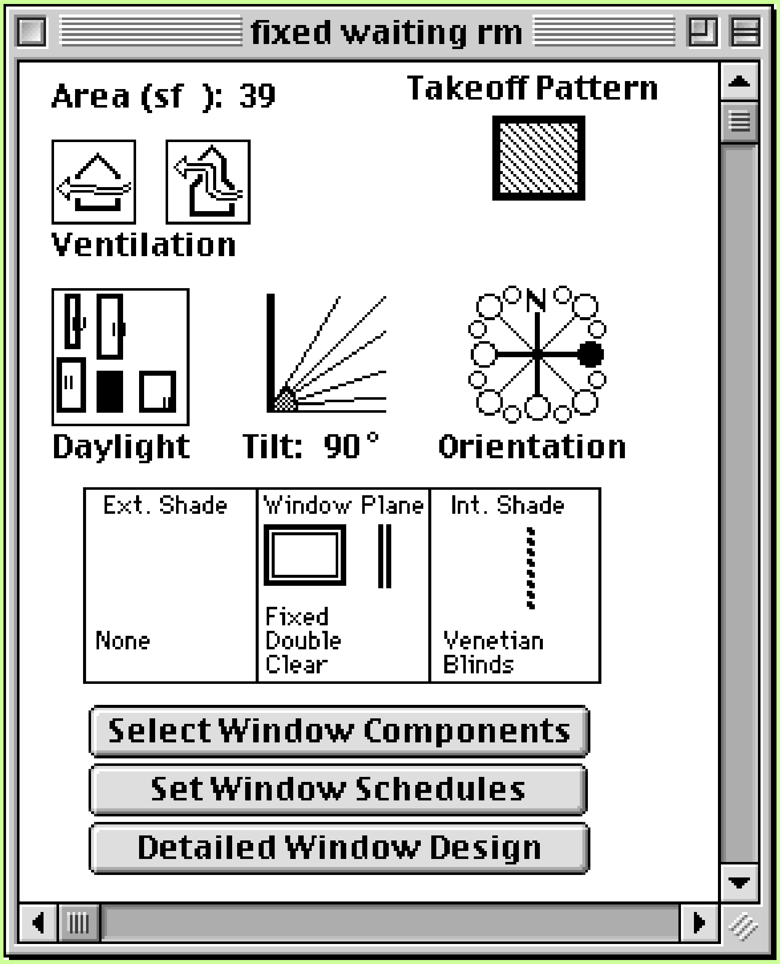
elevation specifications: windows and skylights

EAST WINDOWS



Click on the Window takeoff to see the Window Specs for that area.

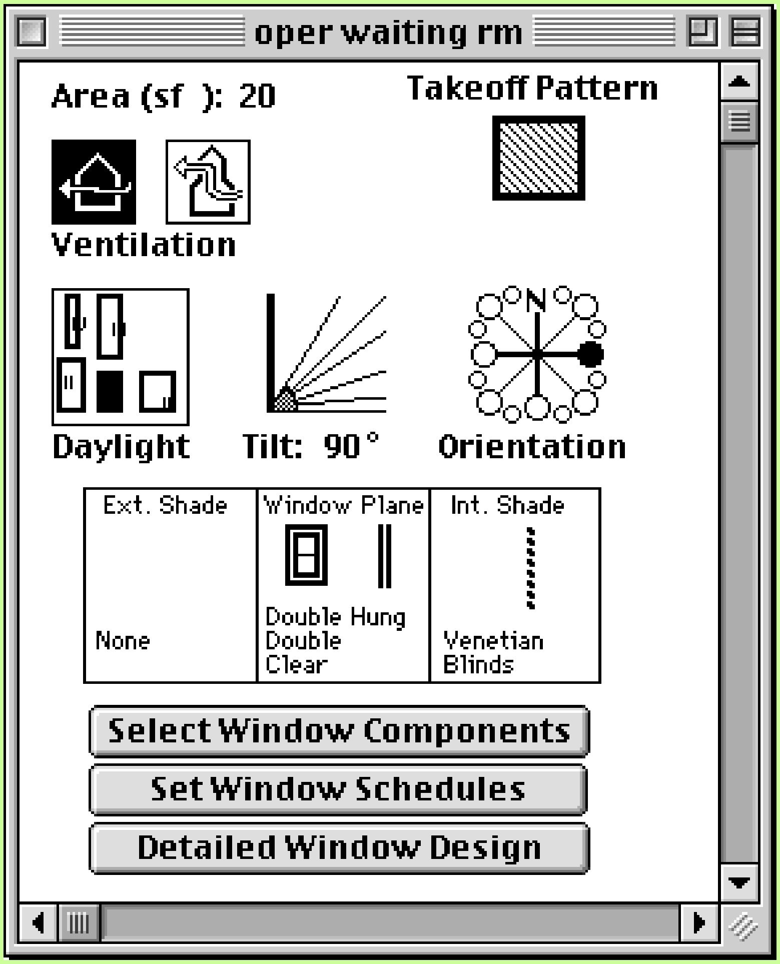
Waiting Room Window (main floor)



Waiting room windows are fixed double glazed windows set between narrow double glazed double hung windows.

Fixed, center windows are specified as:

- No ventilation
- Daylight zone I
- Vertical tilt
- East orientation
- No exterior shades
- Fixed, double, clear windows
- Interior venetian blinds, light



Operable, outer windows are specified as:

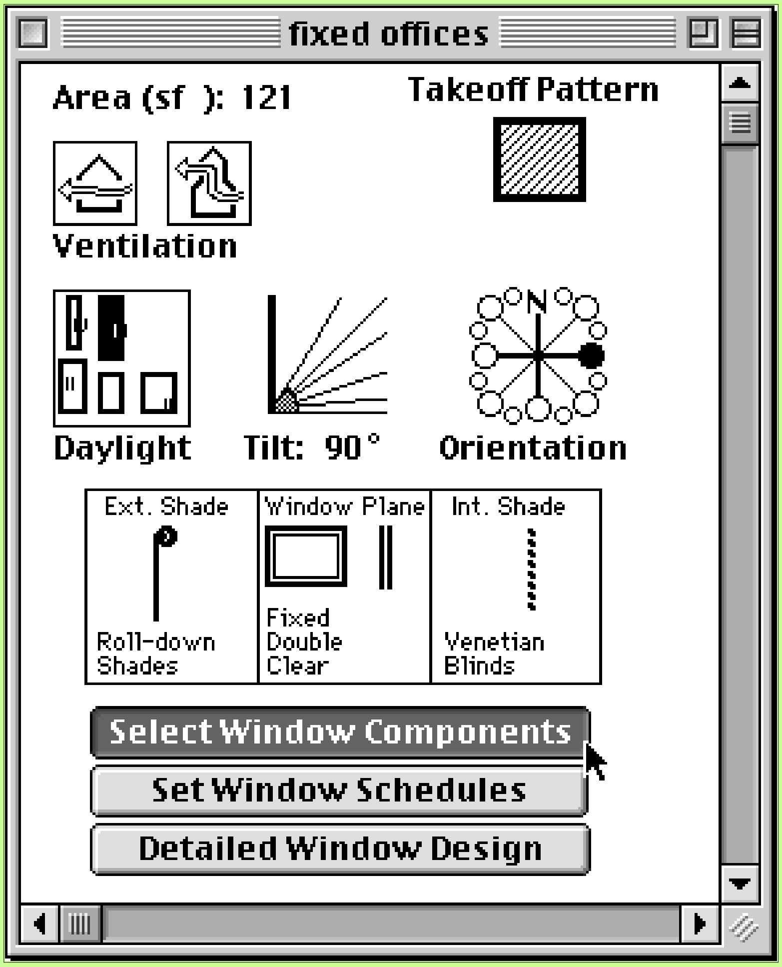
- Cross ventilation
- Daylight zone I
- Vertical tilt
- East orientation
- No exterior shades
- Fixed, double, clear windows
- Interior venetian blinds, light

Office Windows (main floor)

Windows in the office wing are also a combination of fixed double glazed windows alternating between narrow double glazed double hung windows.

These windows are shaded by a horizontal overhang, perforated with daylight openings, and by an exterior operable canvas roll-down shade (drawings of shades) , suspended from the overhang and run on cables. Additionally, there are interior venetian blinds. When specifying window components, you can specify *only one type* of exterior shading. We had to decide which exterior shading element to include -- the overhangs or the roll-down shades?

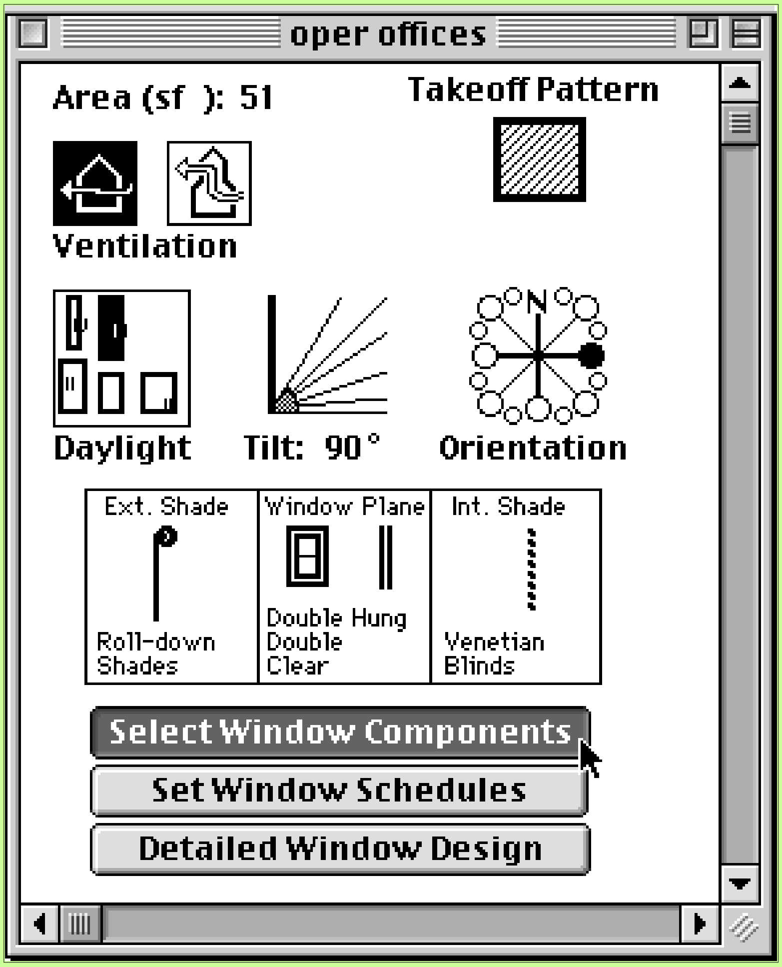
Since an overhang will not be very effective on the east elevation, because the sun is at a very low altitude in the morning when it shines from the East, and because the overhang is perforated, we chose to use the roll-down shade and ignore the overhang on the east elevation.



Waiting room windows are fixed double glazed windows set between narrow double glazed double hung windows.

Fixed windows are specified as:

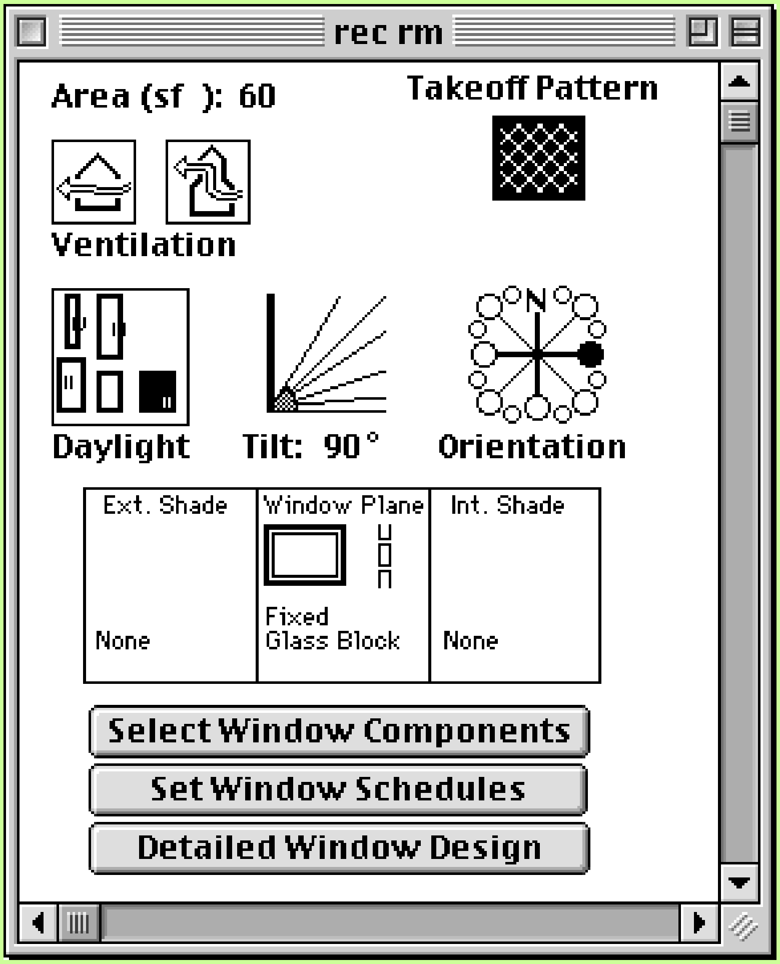
- No ventilation
- Daylight zone III
- Vertical tilt
- East orientation
- Exterior roll-down shade, translucent
- Fixed, double, clear windows
- Interior venetian blinds, light



Operable windows are specified as:

- Cross ventilation
- Daylight zone III
- Vertical tilt
- East orientation
- Exterior roll-down shade, translucent
- Fixed, double, clear windows
- Interior venetian blinds, light

Recreation Room Windows (Basement)



The basement level on the east side is lit with a single large glass block window.

It is specified as:

- No ventilation
- Daylight zone V
- Vertical tilt
- East Orientation
- No exterior shades
- Fixed glass block
- No interior shades

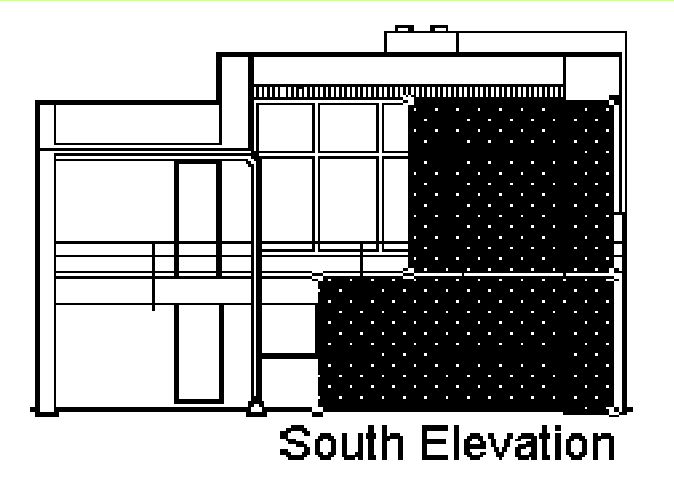
worked example

elevation specifications: mass

Now that you have defined settings and parameters to fit your building, you are ready to take off the building elements.

Click on all icons below for specific information:

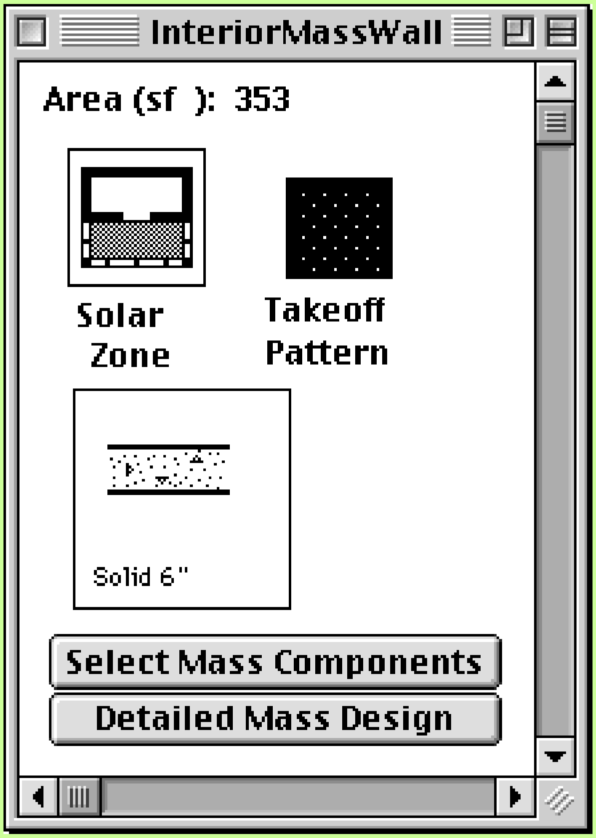
MASS



The exterior walls were all specified as massive when they were taken off under "walls" so they already have their massive characteristics registered under thermal mass automatically. If you have already defined some exterior walls with mass, then when you open the mass icon, there will be one or more predefined mass elements. These can not be changed in the mass specs, only in the wall specs that created them. If you open one, it looks like this: Mass Associated

There is one other thermally massive vertical element in the Shanley building, however. The chimney and the concrete interior wall it is located in are exposed to the south facing waiting room. We took off the chimney and wall on the south elevation under the [interior] mass icon.

It was specified as solid 6" mass in a solar zone.



Back to **elevation specifications**

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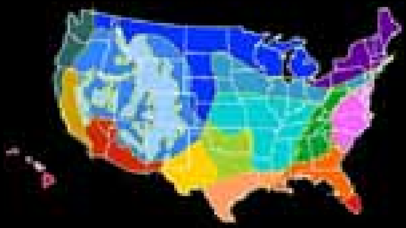
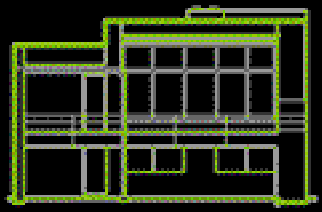
Students

Welcome to the Teaching Architecture + Energy project at Washington University. This site is part of a collaborative network of energy technology teachers in architecture schools, sponsored in part by the U.S. Dept. of Education . Our goal is to make it easier for architecture students to understand energy concepts and to design energy efficient buildings. The curricula developed here and at other universities is centered around Energy Scheming, a energy simulation tool that helps the student think about energy as an integral part of building design.



Climate:
context for design

Exercises:
"recycling with energy scheming"

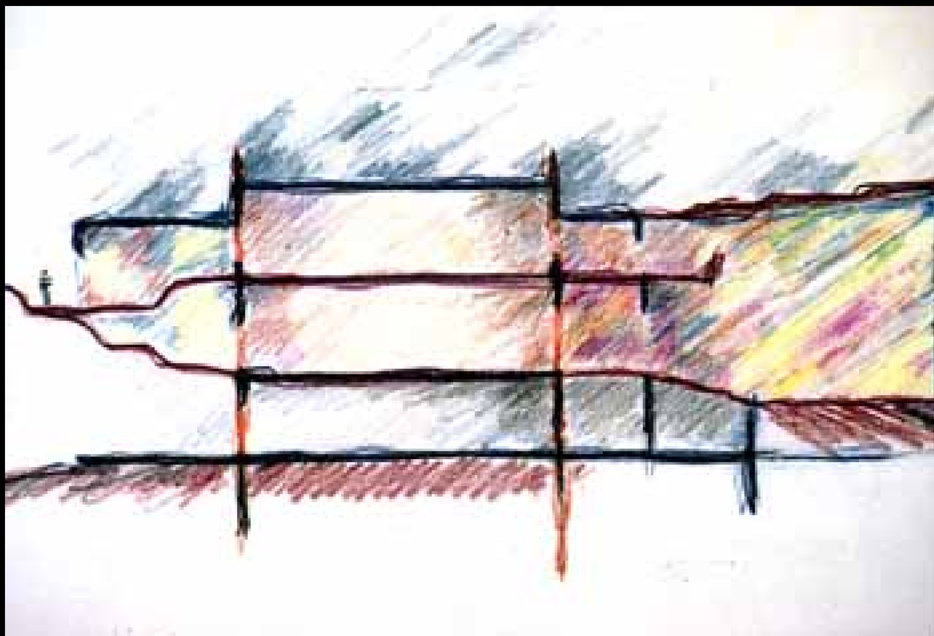


Example:
shanley building

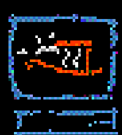
Student Work

Legal Disclaimer

RECYCLING WITH *ENERGY SCHEMING*: Schematic Design & Performance



TERRAIN MAP: outline of exercise

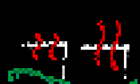


A. DOCUMENTING: input your building

B. DEFINING: take-offs and specifications

C. ANALYZING: understanding energy patterns

D. RE-DESIGNING: 'generate and test' cycles



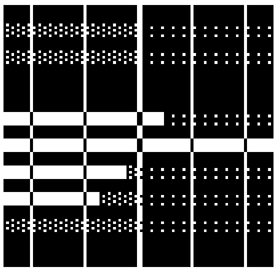
E. EVALUATING: energy codes as indicators

Download the PDF vertion of the exercise

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

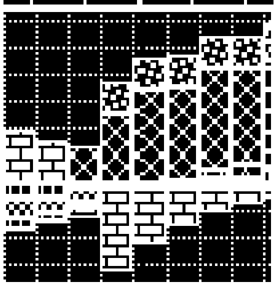
C. ANALYZING: understanding energy patterns

In Part C of this exercise, you interpret and assess the buildings performance using feedback from the Window Sizer and Graphic Reports.



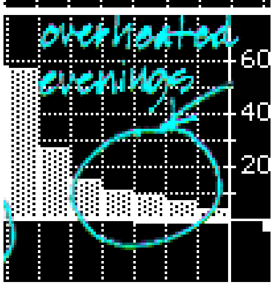
1) Use the Rule-of-Thumb Window Sizer

Now that your building specification is complete, you can look at *Energy Scheming's* graphic feedback. To understand how your design is performing at a coarse level for daylighting, solar heating, and ventilation, use the R/T window Sizer tool.



2) View the Graphic Report

- Examine the "Net Flow" graphic report showing all four climate days.
- Examine the "Total Gain and Loss" format, for the same days.
- Examine the report "By Element Group," for the same four days.



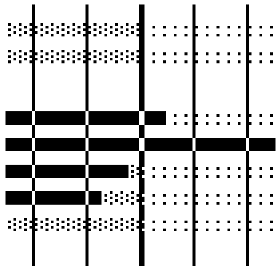
3) Interpret and assess the building's performance

Interpret the graphic reports and recommend design changes to improve performance. Annotate your reports.

Part C Grading Criteria

C. ANALYZING: understanding energy patterns

window sizer

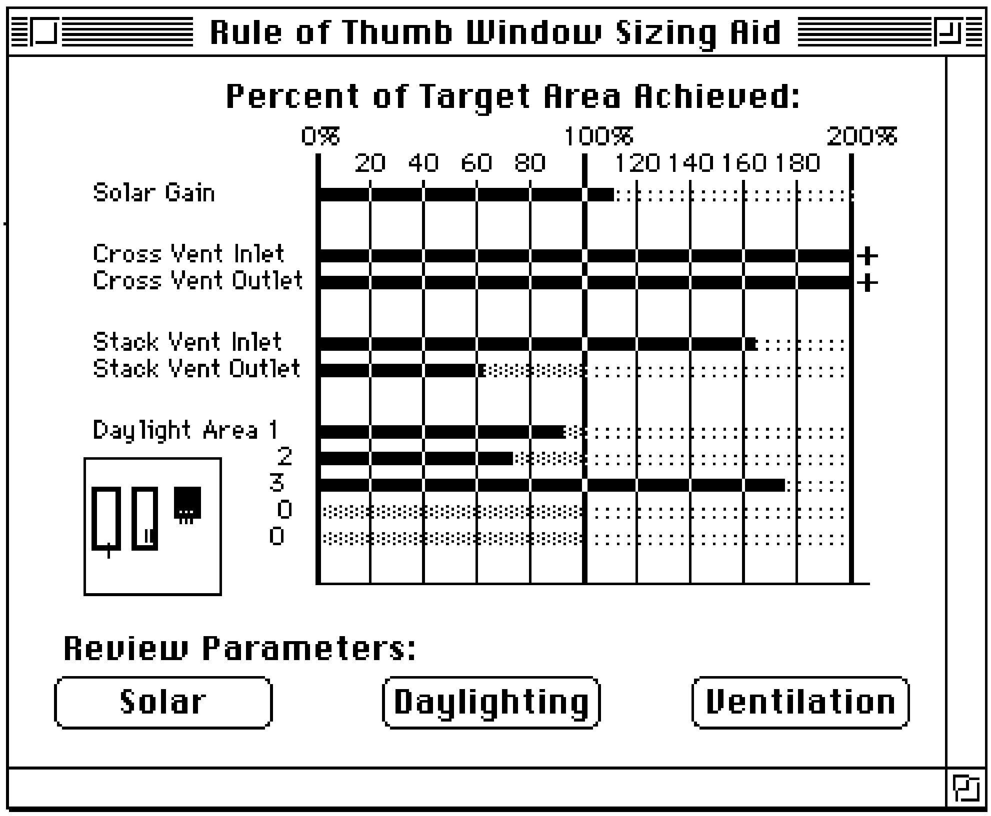


[shanley example.](#)

1. Use the Rule-of-Thumb Window Sizer

Now that your building specification is complete, you can look at *Energy Scheming's* graphic feedback. To understand how your design is performing at a coarse level for daylighting, solar heating, and ventilation, use the R/T Window Sizer tool.

The Window Sizer is accessed from the "Rule-of-Thumb / Window Sizer..." menu. From within the Window Sizer, you can also review your parameters for Solar, Daylighting and Ventilation, by clicking on the buttons.
For help, see the section "The Rule-of-Thumb for Sizing Windows," in Chapter 5 of the ES Manual.



Your design performance goal, in PART D of this exercise, will be to get as many of the factors as close to 100% of your targets as possible. For now, just make sure that you are seeing bars in all of the areas where you should.

- *If the bar for solar heating does not show up*
  Check the orientation of solar windows. For solar heating, only glass oriented within 22.5 either way from south (SSE, S, SSW) will be included in the R/T calculation.
- *If solar gain performance looks very high or very low*
  Check that the floor area you specified in the project definition matches the actual floor area of the building or portion of the building that you are studying in ES.
- *If you do not see any stack ventilation bars*
  Make sure that both inlets and outlets are specified. If only inlets or only outlets are specified, stack ventilation will not work.
- *If you do not see one of the cross ventilation bars*
  Cross ventilation requires both inlets and outlets. Make sure that you have windows facing the prevailing wind (inlets) and some windows away from the prevailing wind (outlets). ES treats as inlets windows oriented within 45 degrees of the prevailing summer wind direction.
- *If daylighting bars do not show up in each zone*
  Be sure that you have both electric lights and windows defined and associated with each zone. To associate a window or electric lighting zone

with a daylight zone, click in the appropriate part of the daylight zone icon that shows up in each window and lighting spec window.

Analyze the Window Sizer Feedback

If your bars are not all at 100% of your targets, which is probably the case, make recommendations for what you plan to change in PART D to improve performance. In the example above, the building needs the following things to improve R/T performance:

- Solar gain is 10% over target. This is probably not a problem. Pay attention to ventilation and lighting first.
- Cross ventilation outlets and inlets are both at over 200% of target. This is not necessarily a problem. Too much ventilation can be reduced by not opening the windows all the way. However, operable windows are more expensive than fixed windows, so some of the window types could be changed to fixed types. Remember that the wind speeds being used in the climate file are from the airport, so they will be higher than the wind speeds at your building, unless your site is very open, like an airport. Therefore, unless you have adjusted your climate file for a reduced wind speed that represents site conditions, you will WANT to oversize cross ventilation windows. For dense urban sites, shoot for near 200%. For suburban sites, make your target 150%.
- Stack ventilation inlets are at 165% of target, while the stack vent outlets bar shows just over 70% of target. Again some oversizing is not a problem. If the same windows are being used for cross ventilation and stack ventilation, then, because stack ventilation openings must be larger, cross venting openings may be oversized. In the example building, more stack outlets must be added, on any elevation, while inlets could be decreased by either changing window types or making smaller windows. The other design option is to increase the stack height. Higher stacks require smaller windows to remove the same amount of heat. Stack height can be increased design of the section, by making ventilation "chimneys," or by lowering inlets and raising outlets in the wall.
- Daylighting for the three zones specified shows that Zone One is close to its target, needing only a small amount of increased window area. Zone Two is substantially below target, at just over 70%. Window area in Zone Two should be increased by 30%. Zone Three is above the target by 75%. This means that the space will be much brighter than intended or needed. The windows in Zone Three probably need to be smaller. However, some of these windows may be facing south and thus used for solar gain. This can be addressed in two ways, by reducing non-south windows in Zone Three, or by changing some direct gain solar collection windows into an indirect solar gain strategy, such as a thermal storage wall or sunspace, so that the windows are collecting heat, but not necessarily admitting too much light. Excess glass above what is required for daylighting, also carries a thermal penalty because it is a poor insulator and because it may admit summer solar heat gains.

Turn in

- *A record of the "Percentages of Target Area Achieved."*
  - You will not be able to print the takeoffs unless you use a screen capture technique.
- *Recommendations to improve the Rule-of-Thumb Window Sizing Performance for*
  - Heating
  - Ventilation
  - Daylighting

For a guide, see the *shanley example.*

Jump to the next section: **View the Graphic Report**

Screen Capture Options

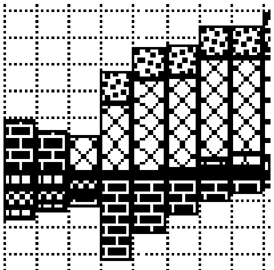
Only the graphic report, numeric reports, and the advisor report can be printed from ES. To export any screen or graphic from ES for use in another application, such as a word processor used to create your assignment report, use a screen capture technique. Options include:

- *Apple System Screen Capture.*
  The key command "COMMAND-SHIFT-3" will take a snapshot of the screen that can be opened in Photoshop or any image editor that will read PICT format. When you do this, you will hear an audible click. The image is stored on the local hard drive (MacIntosh HD) and is named, "PictureN, " where N is a sequential number. If you take several screen captures, they will be labeled, "Picture 1," "Picture 2," "Picture 3, " etc. To open them, first start Photoshop or your favorite imaging program, choose FILE /Open, and navigate to your local hard drive where you will find the images. The image will be of the entire screen, so you will want to crop it to just the part you need. The image is created by default in RGB color. If the source captured is gray scale, you can convert the image to grayscale to make a much smaller file (in Photoshop, choose IMAGE / Mode...).
- *Screen Snap Utility.*
  If you are working on your own Mac or a Mac that you can configure by adding files to the system folder, you may want to try out the screen snap utility *Snap Jot.* It is freeware. Download Snap.Jot and place it in the Extensions Folder within your System Folder. Download SnapJot DA and place it in the Apple Menu Items Folder within your System Folder. You can use *Snap Jot* to take a picture of any portion of your screen.
- *Energy Scheming Screen Snap.*
  ES version 3.0 and higher has a built-in screen capture function available for selected screens.

SAVE and BACK-UP your work.

C. ANALYZING: understanding energy patterns

reports

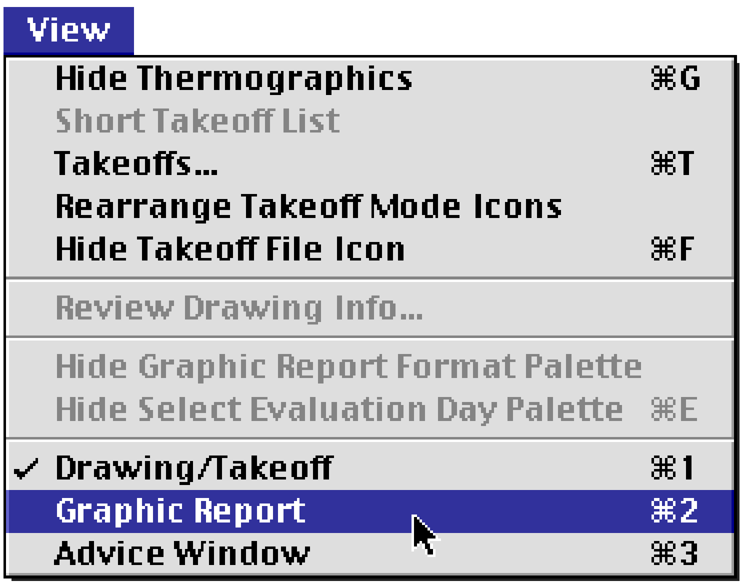


[shanley example.]

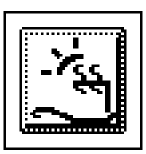
2. View the Graphic Report

- Examine the "Net Flow" graphic report showing all four climate days.
- Examine the "Total Gain and Loss" format, for the same days.
- Examine the report "By Element Group," for the same four days.

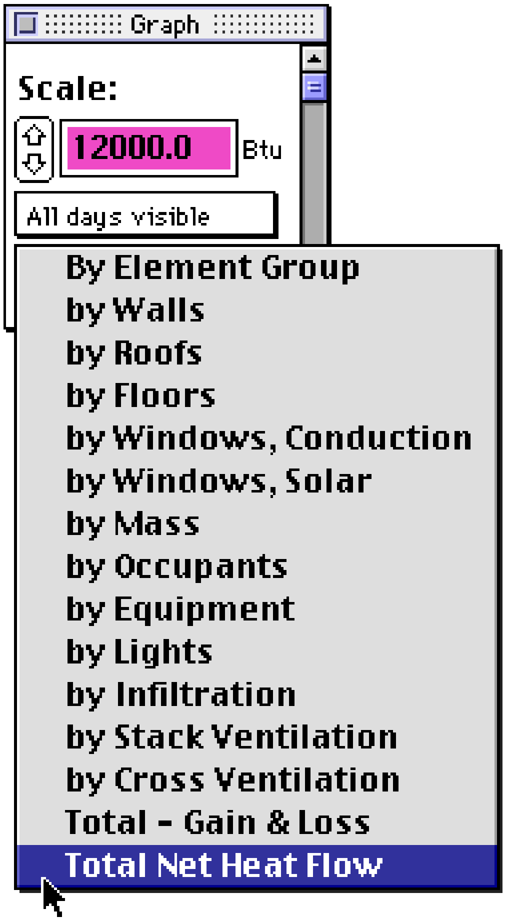
- From the "VIEW " menu, choose "Graphic Report."



- To make ES calculate and draw the graphic report, click on the "Calculate button in the lower left corner.



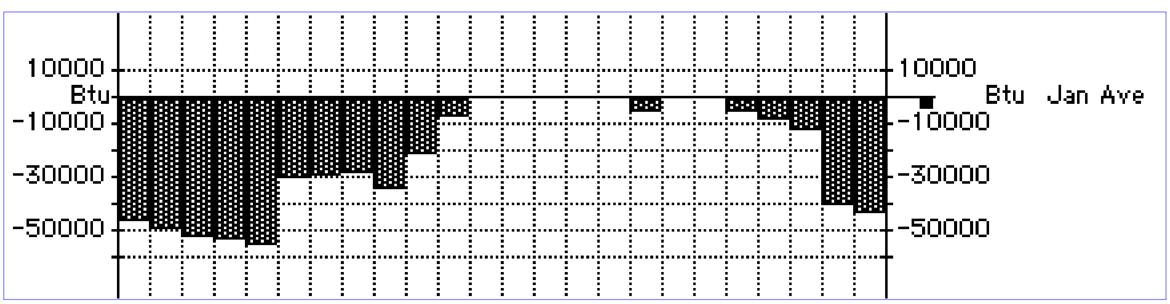
- To change the graphic report format, find the floating palette named "Graph" on the graphic report window. Hold down on the lower menu and a pop-up menu will give you a range of options for how to view the graphic report. Select the desired graph type.



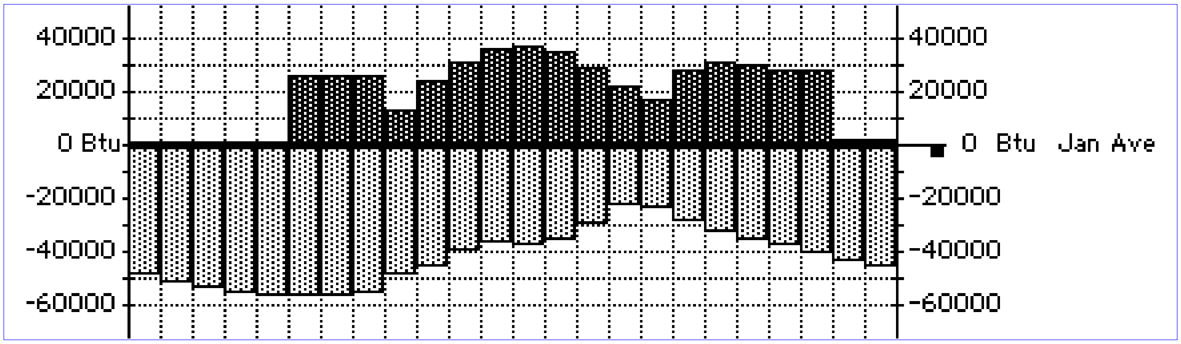
- You should generate three graphs in the types shown below. Adjust the scale as necessary, so that all four graphs fit on one page and are as large as possible on the page, yet, keep all three graph types the SAME SCALE for comparison.

  NOTE: You can also drag the graphs up or down in the report window by dragging on the black square handle at the end of each graph's zero line.

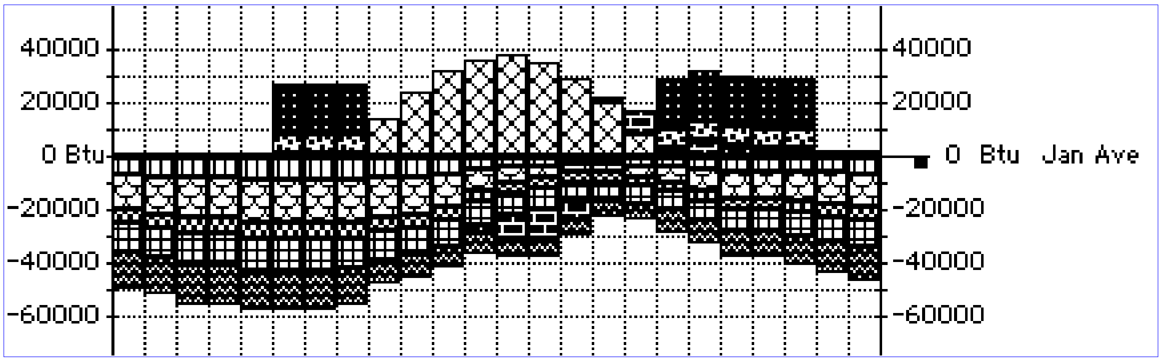
- **Examine the "Net Flow" graphic report showing all four climate days.**
  Net Flow reports are a good way to determine which season the designer should focus attention on first. Focus design attention on the season(s) with the largest net loads.



- **Examine the "Total Gain and Loss" format, for the same days.**
  Total Gain and Loss reports are useful in determining peak loads, and their causes, in summer and winter.



- **Examine the report "By Element Group," for the same four days.**
  The Element Group graph is useful for determining the relative importance of different building elements and internal gains in contributing to heat loss and gain across the day.



See Chapter 6 of the ES manual, "The Annual Energy Evaluation Report" for help in displaying and printing graphic reports.

Turn in

- *Annotated Printouts of these three reports.* They represent your beginning performance.

For a guide, see the *shanley example.*

SAVE and BACK-UP your work.

Jump to the next section: **Interpret and Assess Performance.**

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

Suggestions for how to explain your work.

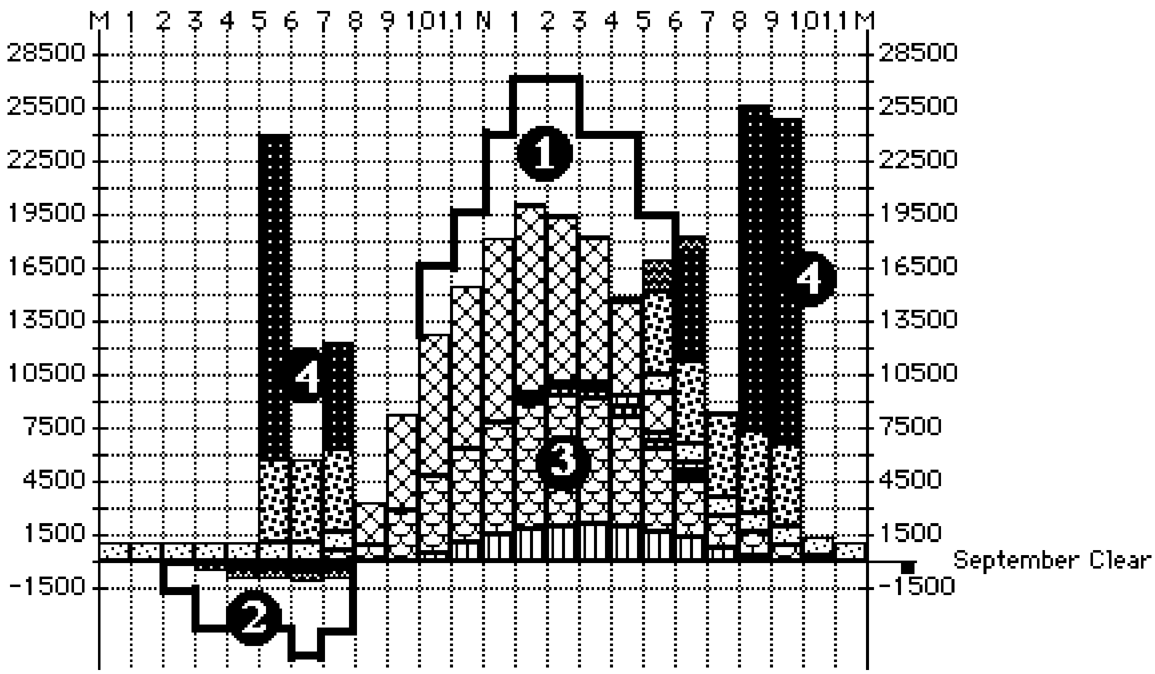
Below are some suggestions for a possible format used to annotate screen captures or prints of graphs. You may document and explain your work in any way you choose. A recommended method is to capture screens from ES, cropping and labeling in an image processor, such as Photoshop or Canvas; then import the image into a page layout program like PageMaker or a word processor like MSWord to annotate and write up your work.

1. Annotate the graphs

a. Highlight the hours on the graphs when certain phenomena are taking place and key them to your explanations.

b. Draw the outline of your "old" graph on top of your "new" graph and highlight the differences. Key the highlights to your explanations.

An example:

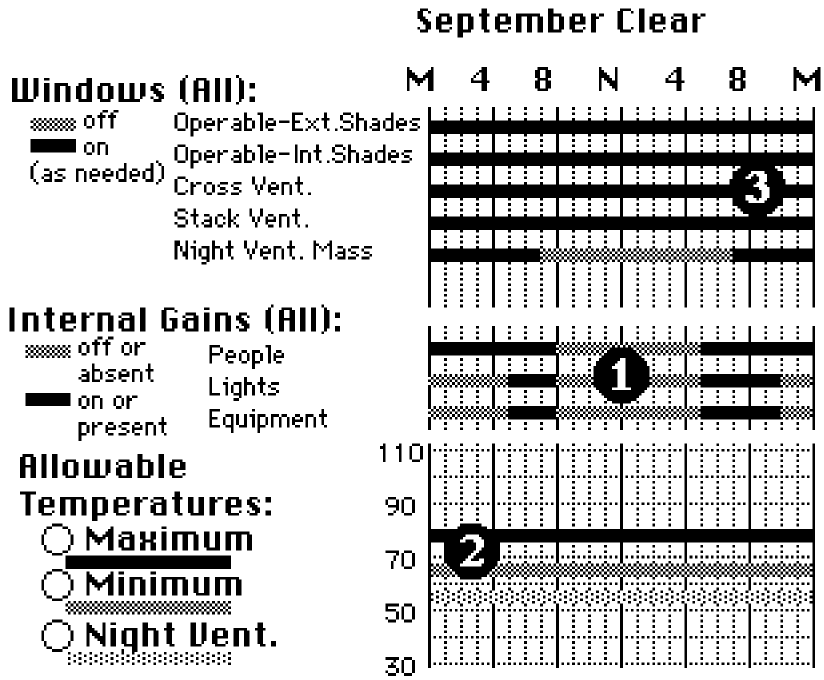


1. The dark line shows the profile of the previous graphic output. Reduction in solar gain by shading was effective in lowering the peak load.
2. Reduction in infiltration was effective in reducing loss.
3. The roof gain is still high. It may be able to be reduced by making the shingles light in color.
4. Electric lighting cannot be reduced because there is insufficient light available for daylighting.

2. Annotate the schedules

The performance of a building is often greatly influenced by when people are present, when lights and equipment are on or when shading is allowed. There are also important interactions between the climate and schedules. Annotating the schedules will sometimes help you explain why the building is performing the way it is.

For example:

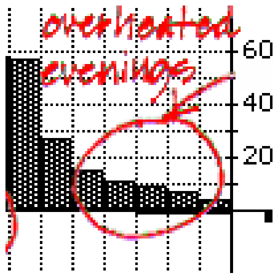


1. There is no heat gain from people in the middle of the day because the people are gone and the lights and equipment are turned off.
2. Heat gain could be reduced by having a higher thermostat set-point at mid-day when the building is unoccupied.
3. Cross ventilation is "on" all the time and there is wind , therefore there must not be any windows facing in the correct direction to ventilate because ventilation is not shown in the load graph.

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

C. ANALYZING: understanding energy patterns

assessment



shanley example.

3. Interpret and assess the building's performance.

Interpret the graphic reports and recommend design changes to improve performance. Annotate your reports.

Now your task is to figure out how your building is performing and what you should do to improve the performance.

See Chapter 6 of the ES manual, "The Annual Energy Evaluation Report" for help in interpreting graphic reports.

- *Energy Scheming* allows you to look at two basic energy design goals:
  - To reduce the daily net heat flow in the building during all 24 hours to zero or near zero, using conservation and passive strategies, thereby minimizing the energy use of the building. In practice, this "Zero Energy" goal is difficult to achieve, but ES. can help you get closer.
  - To reduce the peak loads in summer and winter, thus reducing the size and expense of mechanical equipment.
- Things to Consider:
  - To what season should you direct more of your design attention, based on performance of your first scheme?
  - What season has greatest net gain? Greatest net loss? At what time of day?
  - Are losses and gains generally high or low? What is the implication?
  - Are gains and losses likely to be in the same area of the building, so that they could be used to offset each other?
  - For the most extreme gain and loss hours, what elements are primarily responsible?
  - What design changes or strategies will you pursue?
- Recommend at least eight significant design changes, four each at each of two scales:
  - *building scale*
  - *component scale*
- If you are using ES version 3.0 or higher, first analyze your results with the advisor and thermographics functions turned off. Then, after recording your insights, run the thermographics and advisor. How good was your assessment?

Turn in:

- *A 500 word statement*
  Describe what thermal problems you have and how you will solve them. Be prepared to discuss this in class.

For a guide, see the *shanley example.*

SAVE and BACK-UP your work.

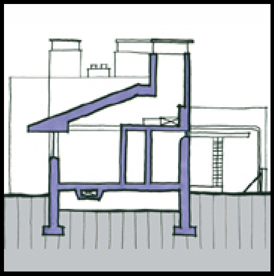
EXAMPLE PROJECT
shanley dental building, clayton, mo

harris armstrong, architect, 1936

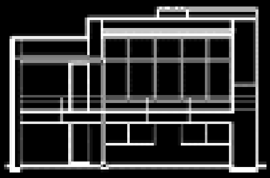
Worked Example

Re-Cycling with *Energy Scheming* exercise

Model



Final Drawings



Drawings

Site Photos

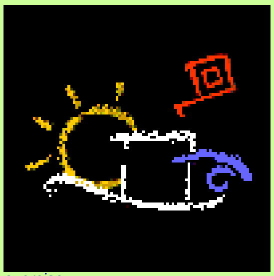
EXAMPLE PROJECT: example exercise

outline of example problem pages

exercise

A. DOCUMENTING: input your building (example)

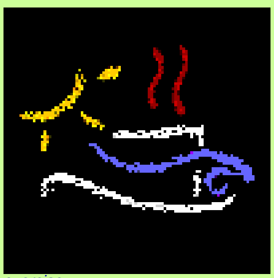
1. Assemble Schematic Plans and Elevations of Your Design
2. Identify the Building's Construction Type(s)
3. Diagram the Solar Concept
4. Determine Your Simulation Strategy
5. Diagram the Daylighting Zones
6. Get the Drawings into the Computer
7. Create a New Climate, if necessary



exercise

B. DEFINING: take-offs and specifications (example)

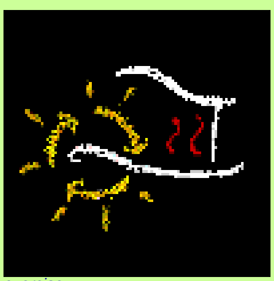
1. Tune Settings to Fit Your Building
2. Define Your Daylight Zone Icon
3. Set Performance Goals for Lighting and Heating
4. Create Plan Specifications
5. Create Elevation Specifications



exercise

C. ANALYZING: understanding energy patterns (example)

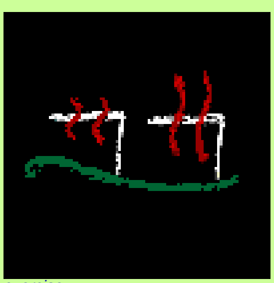
1. Use the Rule-of-Thumb Window Sizer
2. View the Graphic Report
3. Interpret and Assess the Building's Performance



exercise

D. RE-DESIGNING: generate and test cycles (example)

1. Re-Design to Meet Your Window Performance Targets
2. Re-Design to Reduce Net Flows and Peak Loads
3. Print the "Energy Performance Report"
4. Document Design Changes



exercise

E. EVALUATING: comparing with energy codes (example)

1. Set an Energy Budget
2. Choose Reference Criteria
3. Model Your Reference Case Building
4. Compare the Performance of the Two Designs

Download the PDF version of the exercise

C. ANALYZING: understanding energy patterns

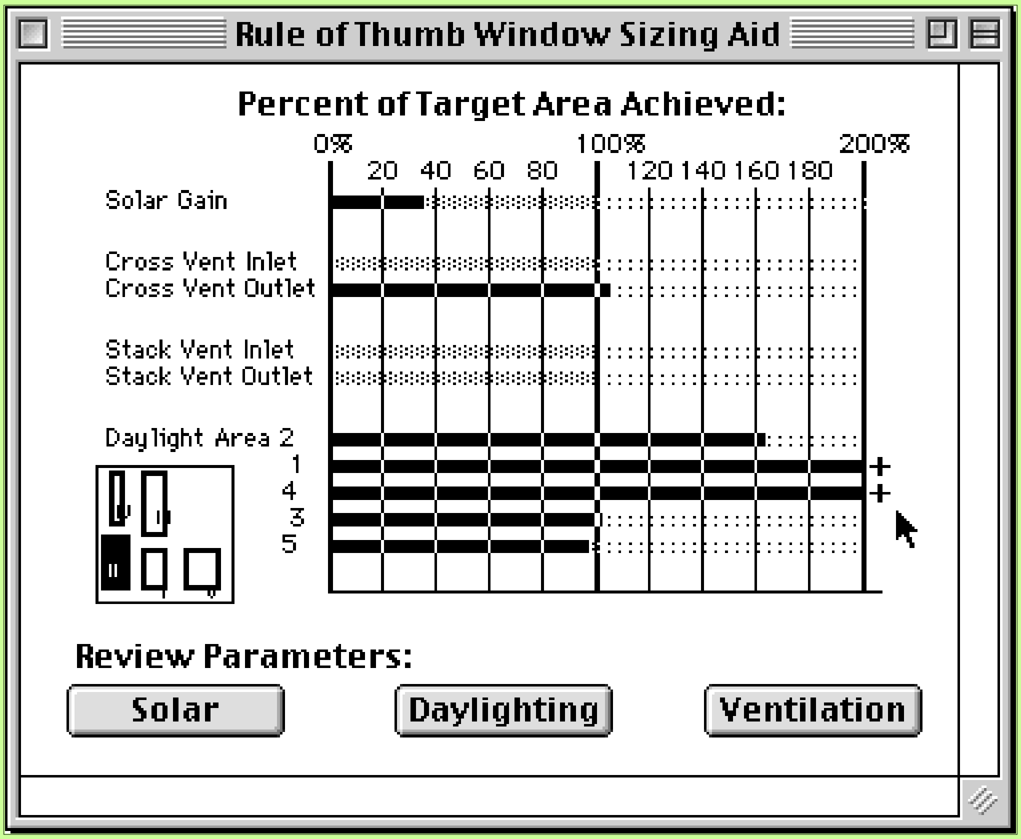
use the rule-of-thumb window sizer

exercise

1. Use the Rule-of-Thumb Window Sizer

Turn in

- A record of the "Percentages of Target Area Achieved."
- Recommendations to improve the Rule-of-Thumb Window Sizing Performance for Heating, Ventilation, and Day lighting



Click on one of the sizing bars in the graph to learn more about it. Click on any of the parameters buttons to review the design targets.

The Rule-of-Thumb Window Sizing Aid for the Shanley Building as built is shown above. Remember that the meaning of the 100% line is set for each passive strategy in the parameters section. (setting parameters)

Solar Gain

The solar gain rule-of-thumb, for which our target of 100% represents a 49% SSF, show that we are about 35% of the way toward our goal. The building could use more south facing glass. This may be a challenge in our redesign, since its narrow face is to the south, leaving the whole north wing of dental offices with no south elevation. Our redesign might look for a way to bring in south sun through the roof.

Cross Ventilation

We are currently meeting all of our needs for cross ventilation outlet, but show no inlets. The outlets are from the operable windows on the east side. There are no north, west or south operable windows on the main floor. Also, there is no path for air to move from potential south inlets at the basement level to the east side outlets. Our summer wind is form the south. Obviously, we need some south inlets! We could also get cross ventilation going in the basement recreation room if we made part of the east window on that level operable, like on the floor above. Since air flow from south to north through the building will be unlikely, given its plan, we should probably add some operable windows on the west. That way, air could move down the hall and help suck ventilation air out of the offices.

Stack Ventilation

We have no stack ventilation currently specified. Stack ventilation requires a difference in height between inlets and outlets to drive the chimney effect. In the original design, this is not possible. If there were west operable windows at the reception area, or over the stair, the open stairwell might be used as a stack to vent the basement. The waiting room has a high ceiling, so low inlets with high outlets could generate some stack cooling there. In the office, if we add south roof light, we might find a way to also get some stack outlet, preferably to the north, away from the prevailing breeze, so that any breeze could augment the stack cooling by creating a negative pressure on the outlets as it moved over the roof. Since it can sometimes be calm in St. Louis when it is hot, we will pay special attention in the redesign to improving stack ventilation, which works without the wind.

Daylighting

All daylight zones show sufficient window area to meet the daylight factor targets we set earlier for each zone. I However, zones I, II, and IV show excessively high levels, with two zones over 200%. Lets take a look in more detail to understand why. First of all, as with all rules-of-thumb, we should take a look at the assumptions used, to see how close they match the building we are analyzing or designing. The daylight sizing rule-of-thumb assumes single glass, no external obstructions, and 40% average internal reflectance. Our internal reflectances range from 45% to 55%, somewhat higher than the R/T. However, we have double glass or glass block throughout. Double glazing reduces the visible transmission of the window by about 7% from that of single glass. Glass block transmission is actually about the same as clear glass, but depends on the product used. Most of our windows are unobstructed, excepting the south facing basement windows, which have deep shading that undoubtedly reduces the amount of daylight that reaches the window. All in all, we can probably trust the R/T, as the double glazing losses are offset by the higher internal reflectances. However, we should probably oversize the zone V windows somewhat from the R/T recommendations.

Analysis and Redesign Recommendations

Zone I: Waiting Room

This zone has large windows facing south and moderate areas facing east. It registers at +200% of target. Since the south windows are providing most of our solar gain aperture so far, we probably don't want to reduce their area, unless, we can really do a good job distributing south glass to other parts of the building. We could look at reducing the area of east windows, although we should keep enough to do the cross ventilation job. We set the design target of this space at 4% DF (reading). Given its central experiential role and its role as direct gain heating, we could look at raising the target. Another option would be to redesign the south wall with more indirect solar gain, such as a south facing sun space enclosing the balcony, or a partial masonry thermal storage wall. That would allow us to keep the desirable south sun for heating, but reduce the size of the windows that are over-lighting the space, potentially causing uncomfortable glare.

Zone II: Reception Area

This zone has small glass block windows to the north and a large glass block window to the west. Since the R/T sizer shows the zone at over 160% of target, and since unshaded west windows will capture unwanted summer sun, they could be substantially reduced in size, while still meeting the daylight goal.

Zone III: Dental Offices

The offices and examination rooms in Zone III are coming in right on target. Looks like their sizing is fine.

Zone IV: Corridor

The corridor, Zone IV, shows a +200% sizing bar. Its target is set at 2% DF, plenty high for navigating a corridor. This indicates that, as in the reception area, the west facing glass block area could be reduced.

Zone V: Basement Recreation Room

This zone's bar is just under the 100% target. We should look at two things here: 1) increasing the area by say 20% to account for the reductions in lighting by the deep shading, and 2) finding a way to get more of the useful south solar heat into the south windows, perhaps by making the balcony penetrable to sun.

Jump to the next EXAMPLE section: View the Graphic Report

Jump to other EXAMPLE Sections of: C. ANALYZING: understanding energy patterns (example)

1. Use the Rule-of-Thumb Window Sizer
2. View the Graphic Report
3. Interpret and Assess the Building's Performance

RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

C. ANALYZING: understanding energy patterns

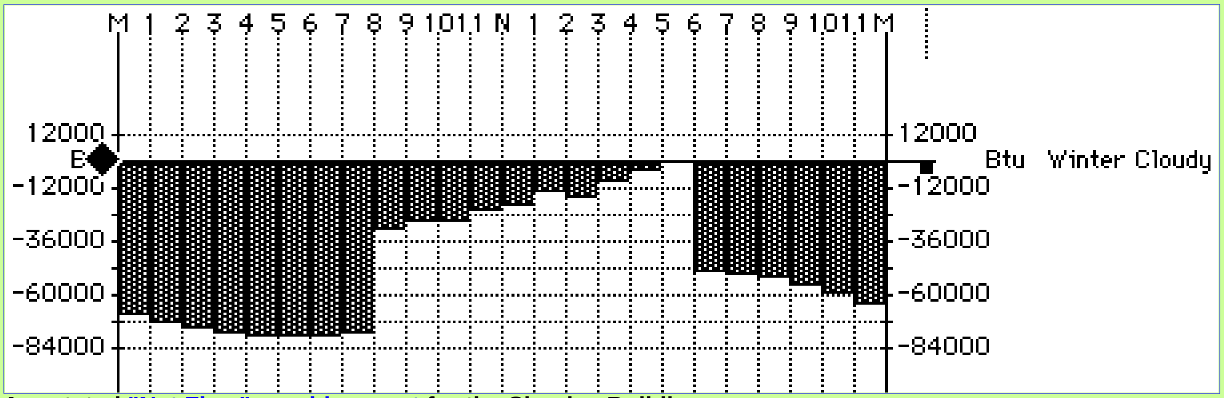
graphic report

exercise

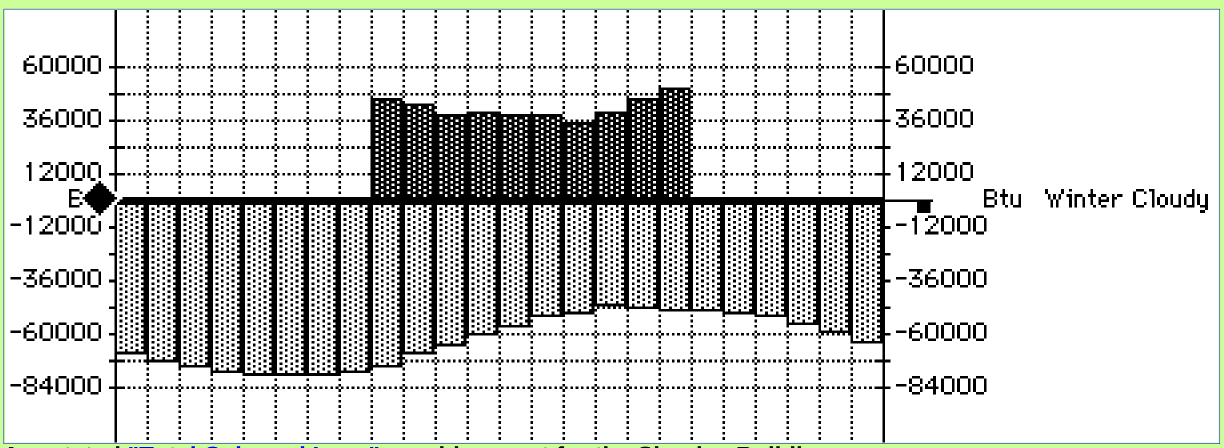
2.View the Graphic Report

Turn in

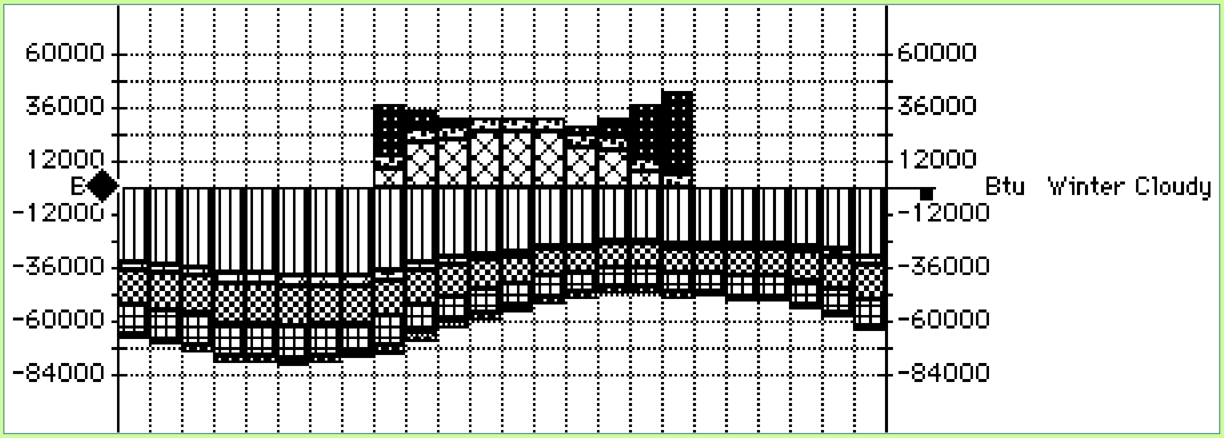
- *Annotated Printouts of these three reports.* They represent your beginning performance.



Annotated "Net Flow" graphic report for the Shanley Building.



Annotated "Total Gain and Loss" graphic report for the Shanley Building.



Annotated "By Element Group," graphic report for the Shanley Building.

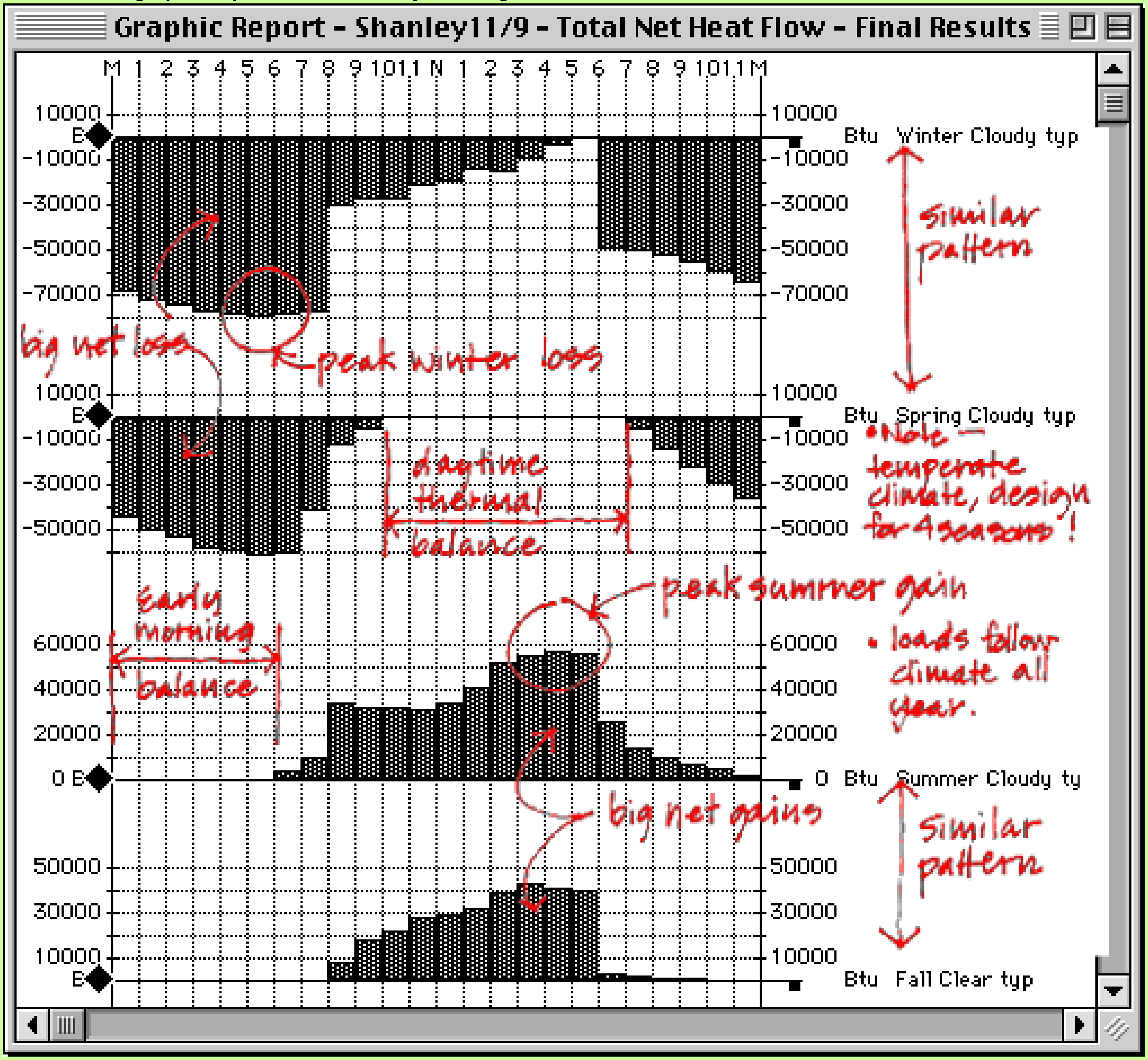
Jump to the next EXAMPLE section: Interpret and Assess the Building's Performance

worked example

graphic report: net flow report

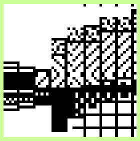
- "Net Flow" graphic report
- "Total Gain and Loss" graphic report
- "By Element Group" graphic report

"NET FLOW" graphic report for the Shanley Building.



Analysis

The "Total-Net Flow" graphic report shows that the building is thermally unbalanced in all seasons. Winter losses at night peak around 80,000 Btu/hr. Summer gains peak in the afternoon just under 60,000 Btu/h. This indicates a significant summer and winter condition, indicative of a continental temperate climate. Spring (March) and Fall (September), follow the same pattern as Winter and Summer, respectively. So even when temperatures are much less extreme, the building is not able to use gains to offset losses (or vise versa) during any time of the year. We will have to address all seasons equally in the re-design.



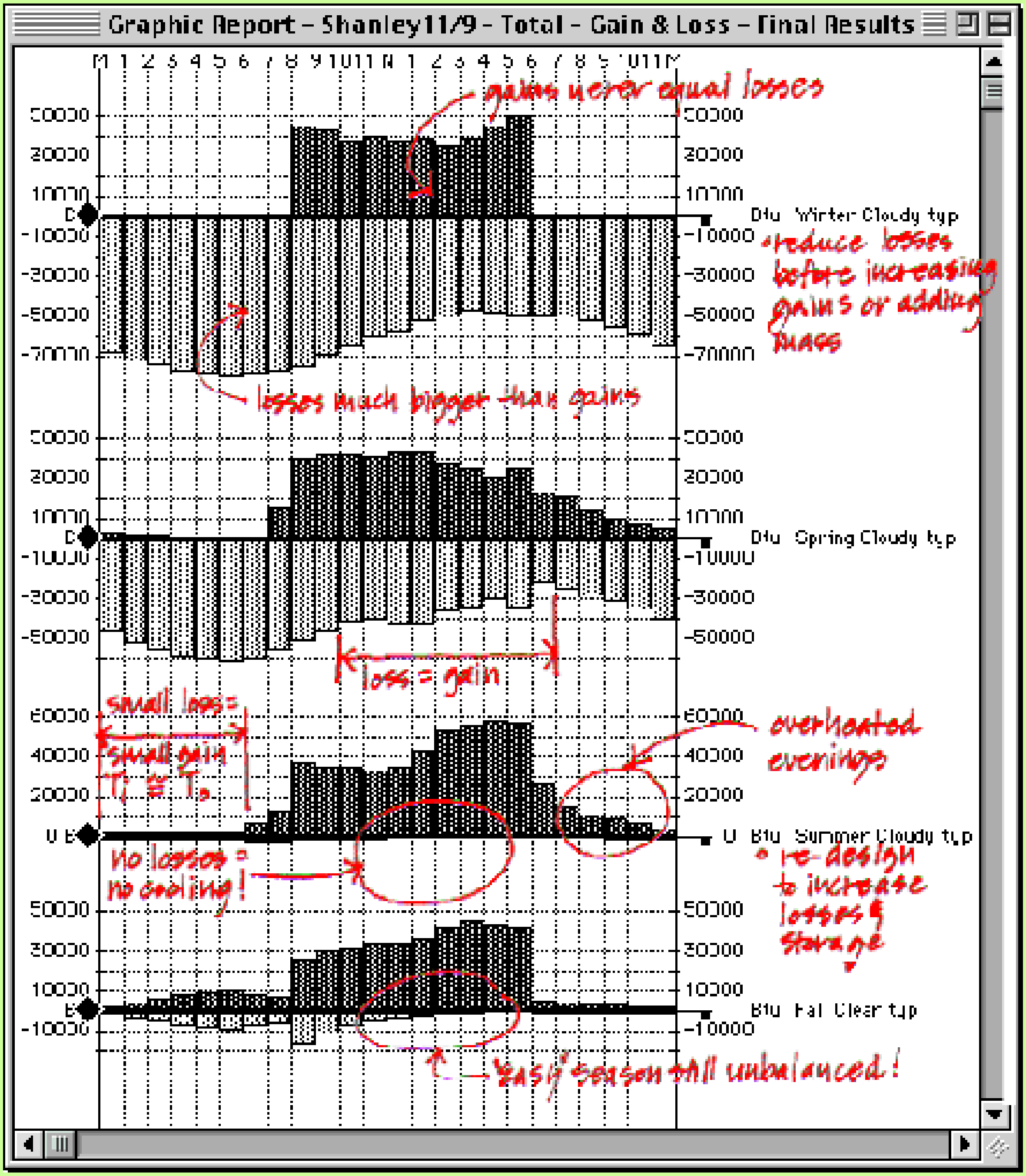
Back to **graphic report**

worked example

graphic report: total-gain & loss Report

- "[Net Flow]" graphic report
- "[Total Gain and Loss]" graphic report
- "[By Element Group]" graphic report

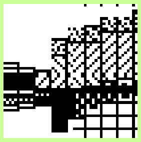
"TOTAL GAIN & LOSS," graphic report for the Shanley Building.



Analysis

The "Total-Gain & Loss" graphic report shows that in the winter, losses heavily outweigh gains. In order to get the building to balance in the heating season, we will have to drastically reduce losses. Any effort to increase gains, such as by increasing south windows to capture more sun, will be futile in the face of these large losses.

In the summer, gains occur all day long and taper off into the evening, but occur up until midnight. Almost no losses seem to be available during this season. The redesign will have to address how to increase losses, perhaps by ventilation. Until the potential for losses are increased, thermal storage will not be effective, because, even though the building may have the capacity to store heat in its mass, it seems to have no way to release it.



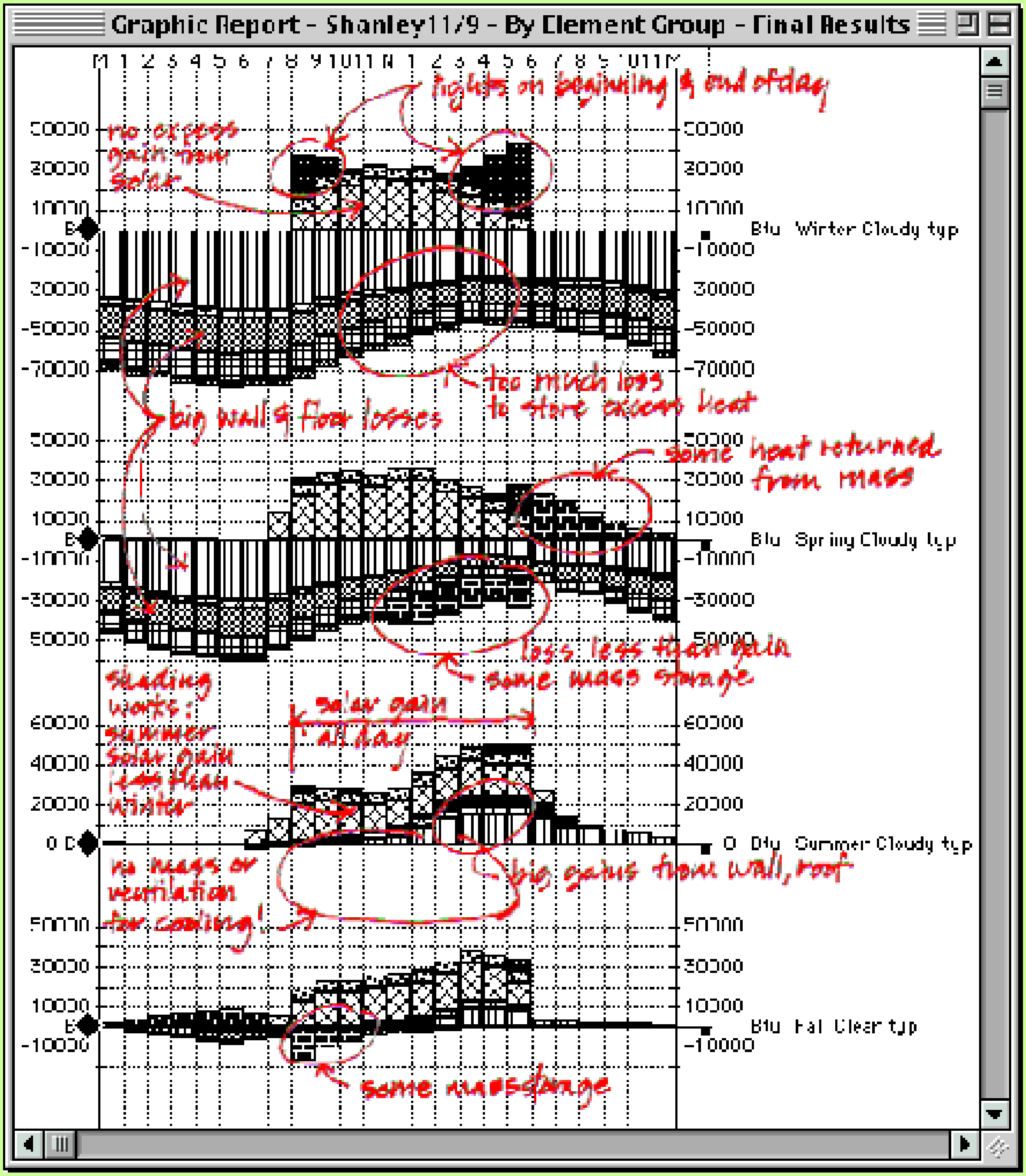
Back to **graphic report**

worked example

graphic report: "by element group" report

- "[Net Flow]" graphic report
- "[Total Gain and Loss]" graphic report
- "[By Element Group]" graphic report

"BY ELEMENT GROUP," graphic report for the Shanley Building.



Click on one of the graphs to see more detail

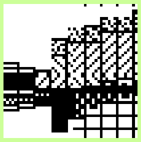
Analysis

The "by Element Group" graphic report shows which elements contribute to gains and losses in each hour. The graph legend gives the meaning of each graphic symbol. In winter, we can see that the most significant losses come from walls, followed by floors and conduction through the windows. Its a pretty good bet that the walls and floors need better insulation (since they have none!). There is some solar gain, but not enough to offset the losses. There are relatively small gains from internal loads, such as people and equipment, but the beginning and end of the day show the lights, on as there is insufficient daylight during these times to meet the lights target.

Spring shows losses reduced, relative to winter. This makes sense, since the temperatures are not as low. With losses reduced, there is some excess solar gain during the day, and we see the thermal mass coming into play to absorb those excess gains. When the sun goes down, the mass symbol switches to above the zero line, as gain from mass, and starts to release its heat to meet night time losses. Unfortunately, not enough heat is stored to meet the heating needs of the building and the same wall, floor, and windows losses as in winter start to rule.

In summer, gains through the wall increase up to a peak in late afternoon. Solar gains are actually less in summer than in spring, because of the shading on east and south windows. In the overheated periods, shading is obviously being employed. Still, unless the losses can be increased substantially, we will need to look at how to keep even more direct sun out during the hot summer days. Note that excess heat is not being stored in the mass and that no ventilation is showing up below the zero line as losses. In fact, there is no evidence of ANY ventilation in the building. That is definitely something to investigate!

Fall shows a similar pattern to the summer day, except that, because the temperature is cycling from above the interior set point during the day, through the comfort zone, and down to a temperature below the low interior set point, we can again see mass at work. Since there are some small losses at night, when outside is cooler than inside, the mass can store heat during the day and release it at night. What if we could somehow speed up or intensify that process?



Back to **graphic report**

RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

C. ANALYZING: understanding energy patterns

assessment for redesign


exercise

3. Interpret and Assess the Building's Performance

Turn in

- A 500 word statement. Describe what thermal problems you have and how you will solve them.
- **"Net Flow" graphic report**
- **"Total Gain and Loss" graphic report**
- **"By Element Group" graphic report**

Statement of the Thermal Problems in the original design for the Shanley Building
To make our descriptions easy to follow, each annotated graph (click on the links above) has a short analysis on the same page. Here we will summarize the analysis and make some plans.

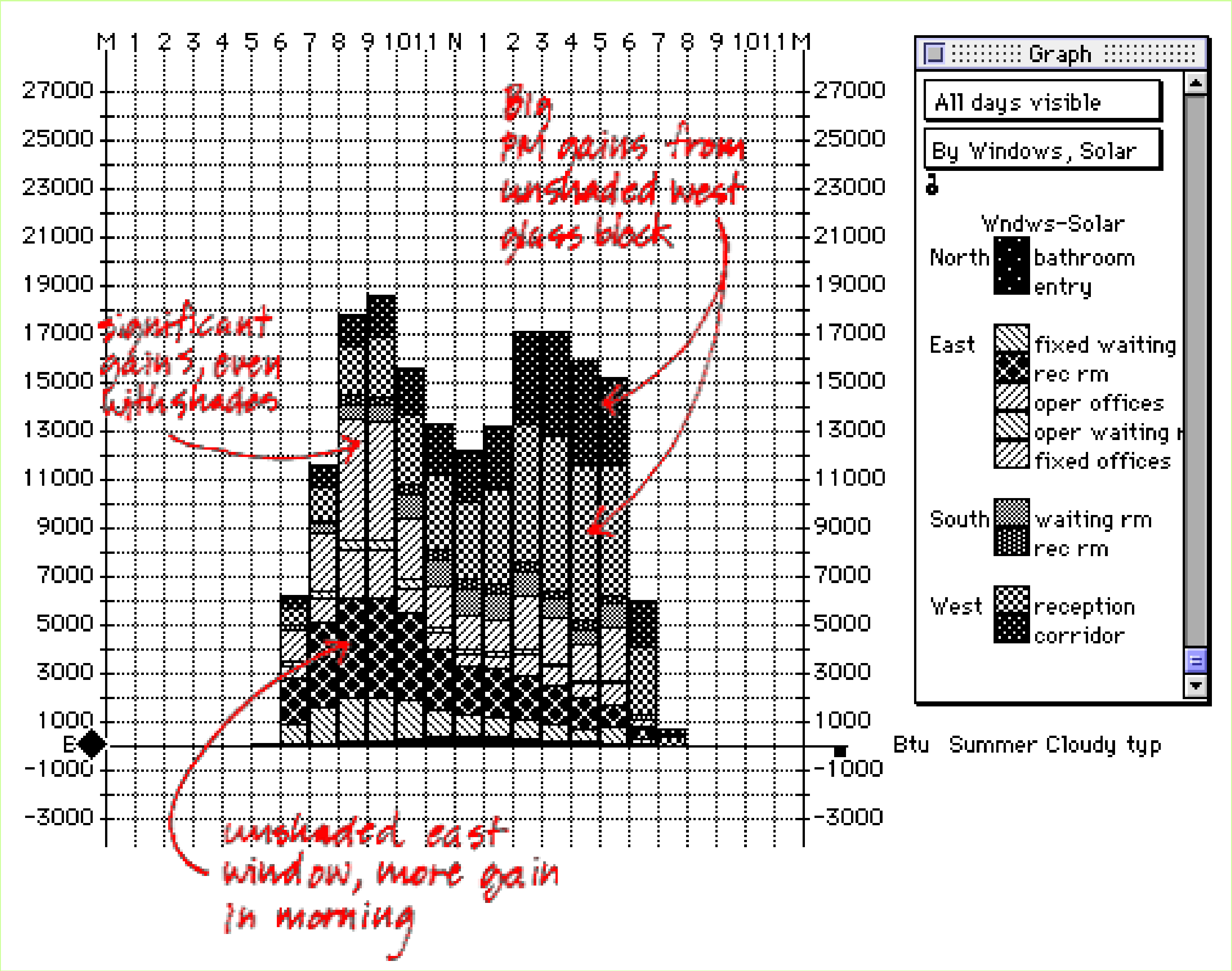
Design for All Seasons
The Shanley Building in thermal terms, follows its climate quite closely. St. Louis has a four season climate with both significant cooling and heating seasons. From the Net Flow graphs, we saw that, in the winter, our building loses heat in all but one hour. In the summer, it has net gains every hour between 6 AM and midnight. Winter peak loss is between 5 and 6 AM, near the coldest time of the night. Summer peak is between 4 and 5 PM, near the daily high temperature. The milder spring and fall season do not come near to balancing, indicating that we will need to address all seasons in the redesign.

Unequal Gains and Losses
From the Gain & Loss graphs, we found that losses are higher in winter than any other season, and are more than twice the amount of gains. In summer, gains totally dominate, with almost no losses. The building is small and tightly planned, so that, if distribution were configured properly, gains in one area might be used to offset losses in other areas. However, in the current scheme, that can probably only happen with the help of ducts and fans.

Poor Thermal Envelope + Low Winter Solar Gains
From the Element Group graphs, we found that losses from walls and floors, and to a lesser extent, windows, obviously need to be reduced. The first step in our redesign will be to tighten up the envelope by adding insulation to the walls and floors and probably increasing the roof insulation, also, to bring the building up to at least the minimum energy code standards. After reducing winter losses, we will re-run the building to see if more heat is being stored in the mass -- and to see if we need to increase the solar gain. According to the R/T Window Sizing Aid, we need to increase our south window area. We plan to look at re-scheming the roof section as a way to get more south sun deeper into the north side rooms.

Summer Gains from Walls, Windows, Roofs
The summer day element group graph shows problems with walls, this time from too much conductive gain. It also shows that roof gains, despite being moderately insulated and finished with reflective aluminum paint, are about twice the gains from the uninsulated floors, indicating the effect of direct solar radiation on the near-horizontal roofs. This suggests that some attention to both increasing thermal resistance of the walls and finding a way to reduce the loads on the roofs would help. When we redesign the roof, we will try to reduce the horizontal component: more south or north facing roof will reduce its summer solar load.

No Inlets! Poor Ventilation Pathways
The summer day element group graph shows no mass or ventilation. Since we see some mass working in the spring and fall, we will assume for now that our first task is to get mass working in the summer and winter, before considering adding more. The R/T Window Sizing Aid, shows no inlets and about the right amount of outlets. Since the summer wind is from the south, we need to make some of the south windows operable, and plan a way for the air to move through the building, as we outlined in the Window Sizer analysis. Since the summer wind in St. Louis can sometimes be slow, especially at night, we think that we should give a shot to redesigning the building section to promote stack ventilation. Inlets can happen through the existing windows, but we will need lots of outlet!



"by Windows, Solar" element graph.

Unshaded Gains from East and West Windows
The [Element Group graph for summer]showed solar gain through windows as as the largest contributor to gains. To see more detail, we looked at the graphic report for summer only, and set the graphic report format to "by Windows, Solar." The graph is shown above. The east windows are showing big gains in the morning, even with shading on the office windows, which are reduced as the sun moves to the south a near noon, leaving only diffuse solar gains from sky and ground reflection. Morning gains could be reduced by externally shading the glass block window in the waiting room and the basement recreation room. South windows, despite their large size, show low gains and appear to be well shaded. Afternoon gains are overwhelmingly from the unshaded west glass block windows. This could be addressed by reducing window area on the west, shading the windows, or both.

Check With the Advisor
To see how our interpretive skills are progressing, we checked in with the Energy Scheming Advisor. Read about how our analysis compares with that of the ES Adviser:

==========================
Advice for Shanley11/9
==========================
Most Important
Very Important
Important
Somewhat Important
Least Important

Summary

While it is tempting to suggest a dramatic (and simple) improvement, such as changing the orientation of the building from north-south elongated to east-west elongated, to get full sun exposure and full cross ventilation, we don't think that Harris Armstrong's client, Dr. Shanley, would have liked the idea of having to buy another lot to accomplish this. So, instead, we plan to stick with the site and basic footprint as given.

Here is a summary of our planned next design revisions:

Building Scale Strategies

- Redesign the roof section to get more south sun to north rooms.
- Redesign the roof section to reduce summer solar gain by having less horizontal slopes.
- Redesign the building section to increase the potential for stack ventilation.
- Redesign the south wall to retain or increase solar collection aperture, while reducing daylight, perhaps using a thermal storage wall or sunspace.

Component Scale Strategies

- Increase Insulation in walls, floors, basement walls, and roof to decrease winter conduction losses.
- Make south windows operable to promote cross ventilation. Track the path of airflow through the building and make sure each inlet has a way for the air to get out, such as in the basement.
- Improve shading on west facing windows to reduce solar gains.
- Reduce west facing window in the reception area (Zone II) to reduce solar gain and conduction loss/gain, while still meeting day lighting target.
- Redesign the south balcony to get more south sun to the basement.

Return to the EXAMPLE OUTLINE

Teaching Architecture + Energy

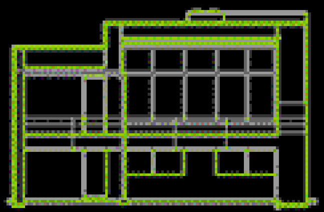
Hosted by Washington University in St. Louis

- Contacts
- Contents
- Climate
- ES Tour
- Exercises
- Example
- Help
- Home
- Instructors
- Manual
- Students

Welcome to the Teaching Architecture + Energy project at Washington University. This site is part of a collaborative network of energy technology teachers in architecture schools, sponsored in part by the U.S. Dept. of Education . Our goal is to make it easier for architecture students to understand energy concepts and to design energy efficient buildings. The curricula developed here and at other universities is centered around Energy Scheming, a energy simulation tool that helps the student think about energy as an integral part of building design.

Climate:
context for design

Exercises:
"recycling with energy scheming"

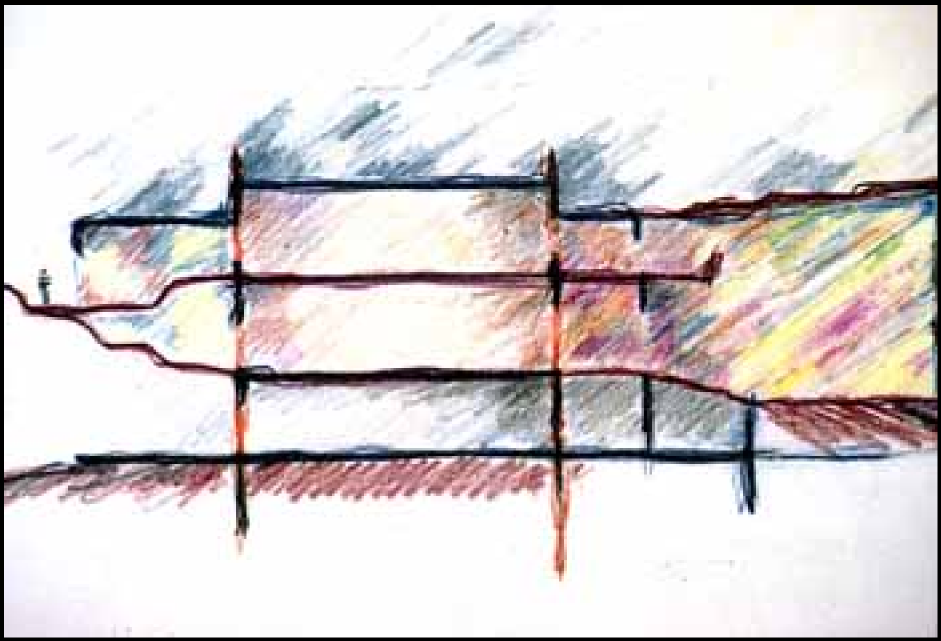


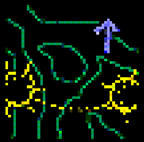
Example:
shanley building

Student Work

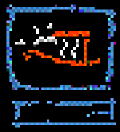
Legal Disclaimer

RECYCLING WITH *ENERGY SCHEMING*:
Schematic Design & Performance

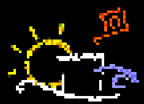




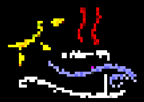
TERRAIN MAP: outline of exercise



A. DOCUMENTING: input your building



B. DEFINING: take-offs and specifications



C. ANALYZING: understanding energy patterns

D. RE-DESIGNING: 'generate and test' cycles

E. EVALUATING: energy codes as indicators

Download the PDF vertion of the exercise

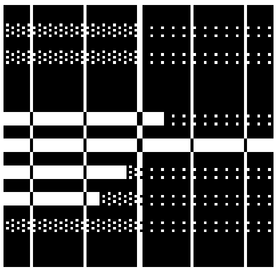
RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

D. RE-DESIGNING: 'generate and test' cycles

In Part D of this exercise, you creatively re-design your schematic design and evaluate it using Energy Scheming until it meets your performance goals.

Before You Start Part D

Make a copy of your Part C file as an archive. Rename the file you will be using for Part D. You may want to use the "before" (part C) file later to compare your performance with your new design. It is also good insurance to have the back up.



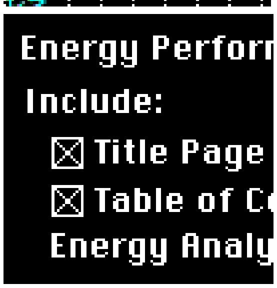
1) Re-Design to Meet Your Window Performance Targets

Work back and forth between the design of your elevations and the bars shown in the Rule-of-Thumb Window Sizing Aid until you have as many performance factors near 100% of your target as possible.

2) Re-Design to Reduce Net Flows and Peak Loads

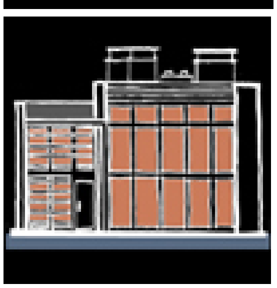
Use graphic reports to help you re-design to:

- Reduce the building's net daily heat flow.
- Reduce the magnitude of gains and losses.
- Minimize the peak loads.



3) Print the "Energy Performance Report"

The Energy Performance report allows you to examine energy flows in tabular format, review the energy strategies and schedules used, and check the definition of all of your elements (building data).



4) Document Design Changes

Make a NEW set of Schematic Design Drawings that show changes made to improve energy and lighting design.

Part D Grading Criteria

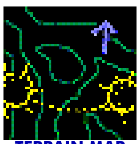
Discussion

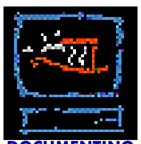
Energy Scheming helps you to understand the relationship between architectural design decisions and the energy use of the building being designed. You can propose a design and then see how it performs. After you have used it for a while, you will also develop an intuition for the complex relationships between energy use and form, such that you can also use energy ideas to help generate form.

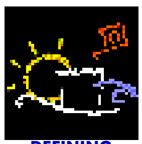
You can make design changes to affect energy use by both *"Strategic"* and *"Tactical"* means. Energy loads are most affected by larger form decisions that set the context for smaller decisions. In general, the designer needs to get the strategic moves right BEFORE fine tuning with tactical moves. This avoids the problem of an elegant part in a dysfunctional whole. For instance, a building with a very long west facing facade is a missed strategic level opportunity and will set up a difficult problem for the designer to solve with the tactical strategy of shading elements at the envelope. In the end, it is the interaction of all the elements and decisions in the design, taken together, that determine the building's energy use patterns. However, keep in mind that problems can be solved at more than one scale and that there are often several ways to solve the same issue. Consider for any particular issue, whether one of the following approaches makes the most sense.

- **Strategic Choices**
  - *Making major form decisions*
    (such as design of the section, roof shape, organization of rooms, orientation, massing, floor area, size, etc.),
  - *Compositional changes that keep the major forms the same*
    (such as shading devices, mass placement, and window size and location),
- **Tactical Choices**
  - *Component choices*
    (such as insulation thickness, electric lighting selection, and color).
  - *Working with schedules*
    (occupancy, internal temperature, etc.)

RECYCLING WITH *ENERGY SCHEMING*

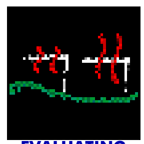

TERRAIN MAP


DOCUMENTING


DEFINING

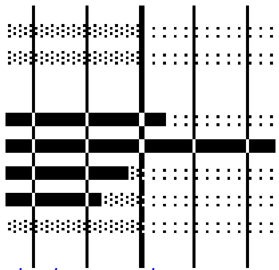

ANALYZING


RE-DESIGNING


EVALUATING

D. RE-DESIGNING: 'generate and test' cycles

re-designing for performance targets



shanley example.

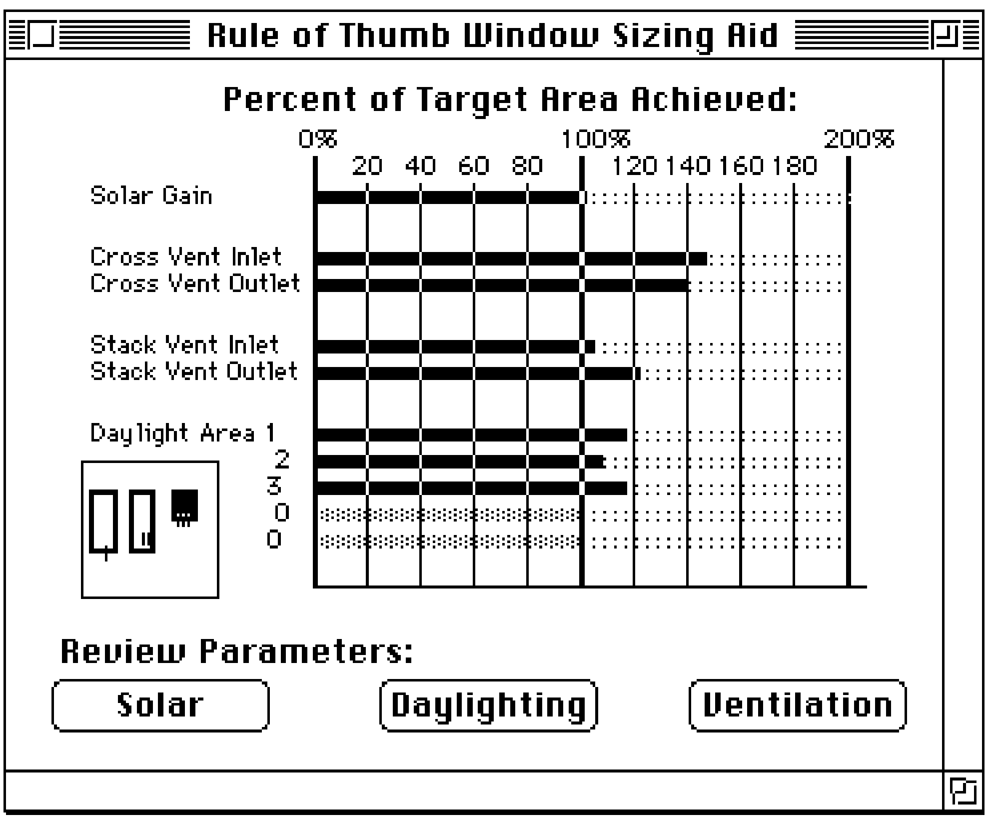
1) Re-Design to Meet Your Window Performance Targets.
Work back and forth between the design of your elevations and the bars shown in the Rule-of-Thumb Window Sizing Aid until you have as many performance factors near 100% of your target as possible.

As you probably know, windows have a larger influence over energy use, both gains and losses, than any other building element. Getting the window size and placement in the right ballpark early in the design is important.

Work back and forth between the design of your elevations and the bars shown in the Rule-of-Thumb Window Sizing Aid until you have as many performance factors near 100% of your target as possible. Depending on your climate, site context, and building type, one of the variables (heating, cooling, or lighting) may govern window sizing.

- Solar heating performance is increased by more south facing glazing.
- Cross ventilation performance is increased by larger windows facing the breeze and by outlets at least as large as inlets. Remember, since ES is using airport wind data, it is fine to oversize cross ventilation by as much as 90% if your building is in a dense urban area, or 40% in a suburban area.
- Stack ventilation performance is increased by larger inlets and outlets or by increasing the height between them.
- Daylighting is increased by larger windows in the appropriate zone.

Lowering your performance targets (parameters) is NOT the best solution.



Turn in

- A record of the "Percentages of Target Area Achieved" AFTER your re-designs. Bring BOTH the initial performance AND the revised performance figures or graphs.

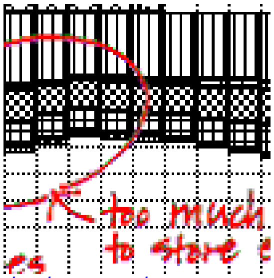
For a guide, see the *shanley example.*

Jump to the next section: **Net Flows and Peak Loads**

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

D. RE-DESIGNING: 'generate and test' cycles

net flows and peak loads



shanley example.

2) Re-Design to Reduce Net Flows and Peak Loads.
Use graphic reports to help you re-design to:

- Reduce the building's net daily heat flow.
- Reduce the magnitude of gains and losses
- Minimize the peak loads

Energy Scheming gives you several types of graphic feedback that help you to reduce the building's energy use through good design. *See the ES Manual, Chapter 6, for more information.*

There are three basic energy goals that *Energy Scheming* can help you to move towards:

- ***Reducing the building's net daily heat flow***
  Net heat flow is the difference between heat loss and heat gain for a given hour. The net heat flow during each hour determines whether a building will need to be heated, cooled, or is in thermal balance. The sum of all net heat gain hours during a particular day represents the additional energy that will have to be met by a mechanical cooling system. The sum of all net heat loss hours during a particular day represents the additional energy that will have to be met by a mechanical heating system. The sum of all heat net gains over the course of the cooling season determines the annual cooling energy use, and thus the operating cost for cooling. The same holds for the sum of all heating season net losses. Therefore, reducing the building's net heat flows will reduce energy use, environmental impact, and operating costs.

  Your goal should be to reduce the building's net heat flow to zero during all months. By examining the graphic report, you can determine which months have the greatest net loads and focus your attention there first. Try to get the building to flat line in the "Total Net Flow" graphic report.

- ***Reducing the magnitude of gains and losses***
  Heat gains and heat losses can be used to offset each other. Ideally, heat loss and heat gain equal each other and the building is in thermal balance each hour of the day. Because internal gains vary with the occupancy schedule, because solar gains vary with the sun's seasonal and daily path, and because the outside temperature fluctuates daily and seasonally, gains and losses do not often balance unless heat storage or passive cooling is employed. When a building has low net loads, this may be the result of either a combination of low losses offsetting low gains, or high losses offsetting high gains.

  Your goal should be to reduce the magnitude of gains and losses, even if large gains are balanced by large losses. Try to reduce the height to the hourly bars in the "Total-Gain and Loss" graph.

  For instance, a building may be designed for passive heating using large heat gains from large amounts of south facing glass to offset large heat losses from poorly insulated walls and roof. The building could be in balance, but improving the insulation levels would allow less expensive windows and thermal mass, while improving acoustics and dampening internal temperature swings. Alternatively, a commercial building may appear to be thermally balanced in winter, using large heat gains from low efficiency lights to offset envelope losses. More efficient lights would lower the internal heat gains and might shift the building to a need for more heating, thus the solar collection area could be increased. This would have the double advantage of reducing summer cooling loads and reducing overall energy costs, since auxiliary cooling Btu's from electricity often cost five times as much as auxiliary heating Btu's from gas.

- ***Minimize the peak loads***
  Peak loads are the largest hourly heat gain and the largest hourly loss during any hour of the year. These hourly peaks determine the size of heating and cooling equipment. The peak energy demand for commercial buildings also often sets the building's electric rate or demand charges. Higher peak demands equal higher cost per kWh (for electricity).

  To determine the peak heating load and the peak cooling load, look at the "Total Net Flow" graphic report. If you hold down the curser on the largest hour, you can see the loads contributed by each element.

  You goal should be to minimize the peak loads by flattening the curves in the graph.

Redesign your building for the above goals.
Keep working between the graphic report (several formats) and the building design and specifications. In this process, explore the impact of at least one from each of the following categories:

- Strategic Choices
  - *Making major form decisions*

- *Compositional changes that keep the major forms the same*
- Tactical Choices
    - *Component choices*
    - *Working with schedules* , settings, and parameters.

Turn in

- *Annotated graphic reports*
  Show "Before" AND "After" performance. These will indicate how your understanding of energy design allowed you to improve the building's performance.
- *A minimum 500 word explanation of your process.*
  List changes you have made in response to your initial run and intermediate cycles of design and evaluation. Document the success or failure of your changes using *Energy Scheming* runs. Comment on any remaining thermal issues and suggest how they might be resolved.

Be prepared to discuss these in class.

For a guide, see the *Shanley Example*.

Jump to the next section: **Energy Performance Report**

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

Suggestions for how to explain your work.

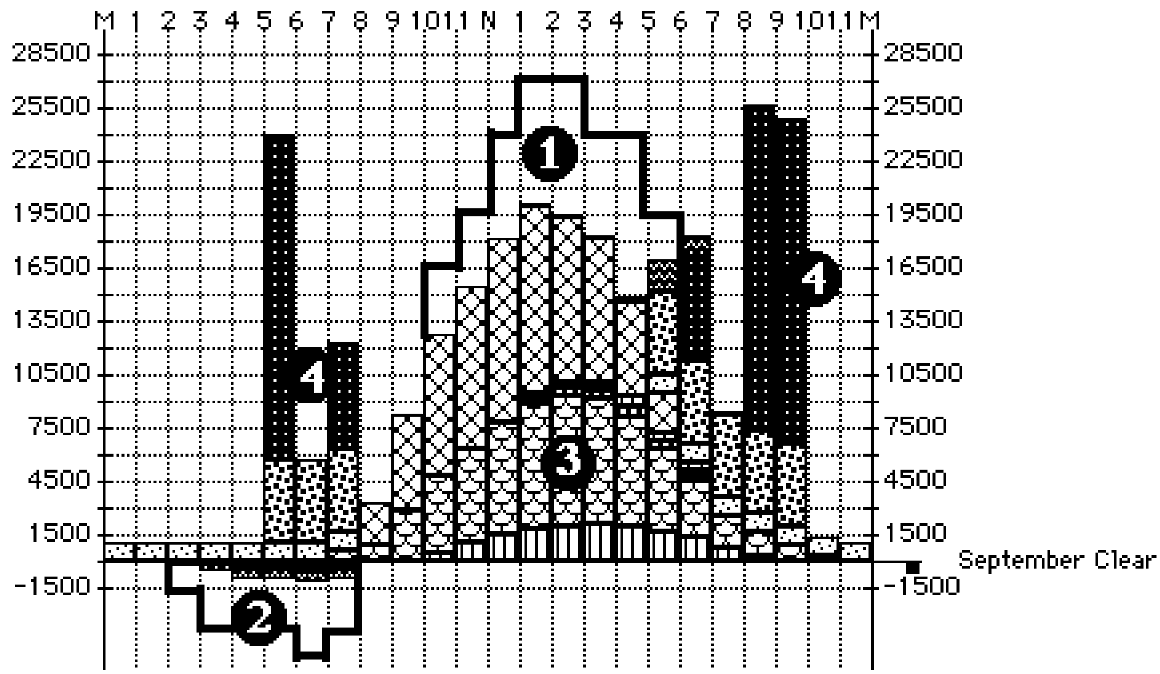
Below are some suggestions for a possible format used to annotate screen captures or prints of graphs. You may document and explain your work in any way you choose. A recommended method is to capture screens from ES, cropping and labeling in an image processor, such as Photoshop or Canvas; then import the image into a page layout program like PageMaker or a word processor like MSWord to annotate and write up your work.

1. Annotate the graphs

a. Highlight the hours on the graphs when certain phenomena are taking place and key them to your explanations.

b. Draw the outline of your "old" graph on top of your "new" graph and highlight the differences. Key the highlights to your explanations.

An example:

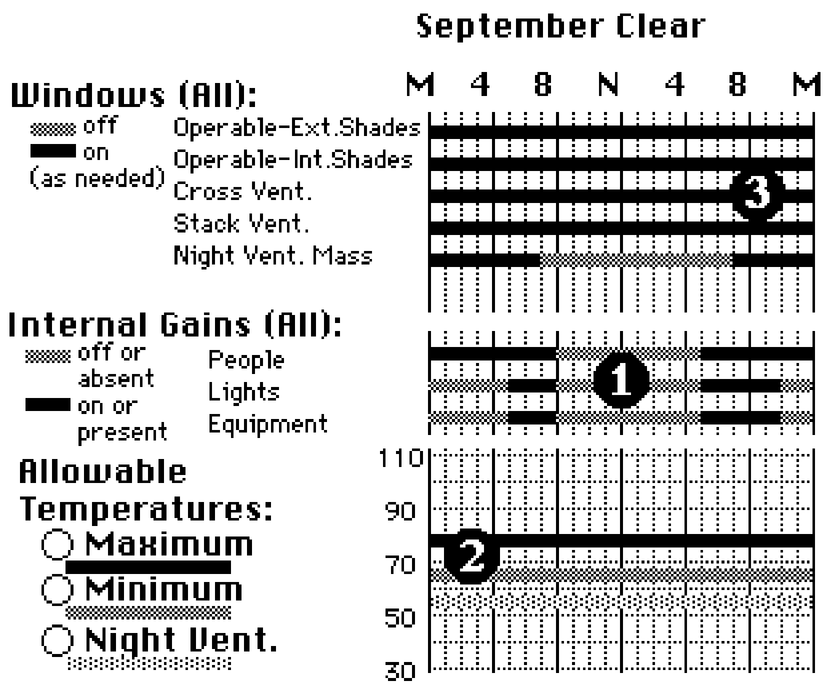


1. The dark line shows the profile of the previous graphic output. Reduction in solar gain by shading was effective in lowering the peak load.
2. Reduction in infiltration was effective in reducing loss.
3. The roof gain is still high. It may be able to be reduced by making the shingles light in color.
4. Electric lighting cannot be reduced because there is insufficient light available for daylighting.

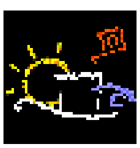
2. Annotate the schedules

The performance of a building is often greatly influenced by when people are present, when lights and equipment are on or when shading is allowed. There are also important interactions between the climate and schedules. Annotating the schedules will sometimes help you explain why the building is performing the way it is.

For example:

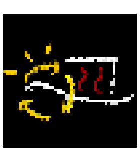


1. There is no heat gain from people in the middle of the day because the people are gone and the lights and equipment are turned off.
2. Heat gain could be reduced by having a higher thermostat set-point at mid-day when the building is unoccupied.
3. Cross ventilation is "on" all the time and there is wind , therefore there must not be any windows facing in the correct direction to ventilate because ventilation is not shown in the load graph.

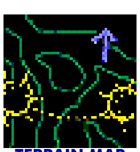
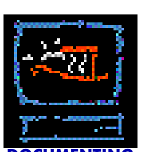
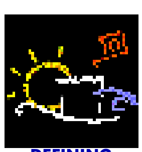
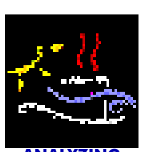
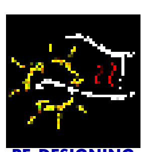
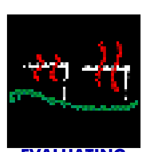


Jump to other Sections of: B. DEFINING: take-offs and specifications

- 1) Tuning Settings to Fit Your Building.
- 2) Define Your Daylight Zone Icon
- 3) Set Performance Goals
- 4) Create Plan Specifications.
- 5) Create Elevation Specifications.
- 6) Use the Rule-of-Thumb Window Sizer
- 7) View the Graphic Report
- 8) Interpret and Assess Performance.



RECYCLING WITH *ENERGY SCHEMING*

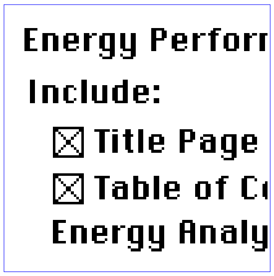







TERRAIN MAP | DOCUMENTING | DEFINING | ANALYZING | RE-DESIGNING | EVALUATING

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

D. RE-DESIGNING: 'generate and test' cycles

energy performance report



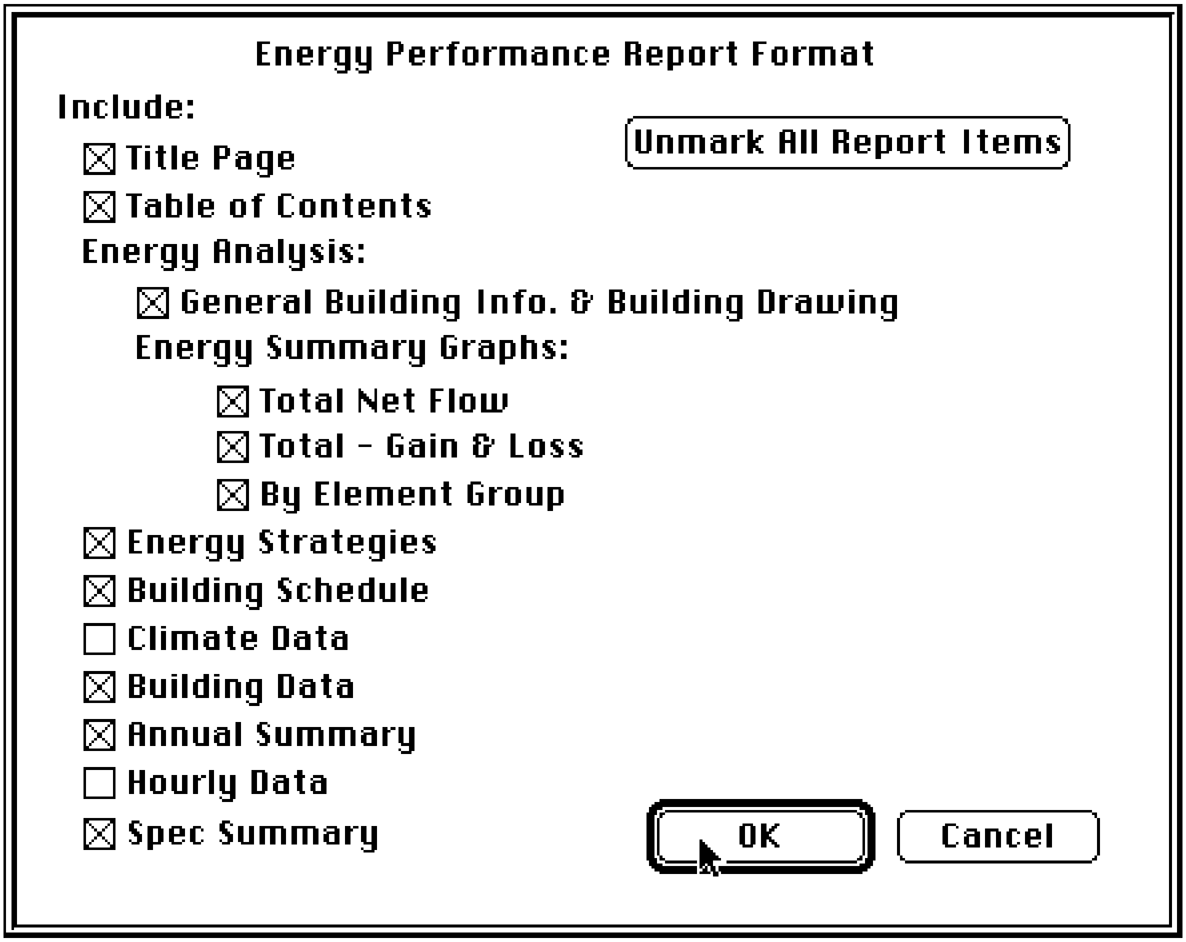
shanley example.

3) Print the "Energy Performance Report"

The Energy Performance report allows you to examine energy flows in tabular format, review the energy strategies and schedules used, and check the definition of all of your elements (building data). The report will also provide information that your instructor will use to track down the causes of any remaining problems with your building's performance as shown on the graphic reports

---

- From the FILE menu, select "Print Energy Performance Report"
- Check the boxes for:
  - Title Page
  - Table of Contents
  - General Building Information and Building Drawing
    - Total Net Flow
    - Total; Gain and Loss
    - By Element Group
  - Energy Strategies
  - Building Schedules
  - Building Data
  - Annual Summary
  - Sec Summary



Turn in

- *A copy of the Energy Performance Report.*
  The report should represent your final scheme.

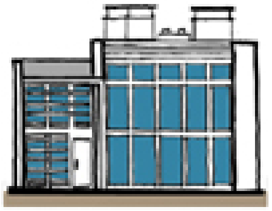
For a guide, see the *Shanley Example.*

Jump to the next section: **Document Design Changes**

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

D. RE-DESIGNING: 'generate and test' cycles

documenting changes



shanley example.

4) Document Design Changes

Make a NEW set of Schematic Design Drawings that show changes made to improve energy and lighting design that you made as a result of using *Energy Scheming.*

Turn in

- *Annotated Drawings*
  Make drawings at 11 x 17, showing your final design. **Indicate on the drawings** the most important design changes you made from your initial schematic design. Bring the following drawings to lab. They will be used as the basis for your final design + energy review.

	HEATING	**COOLING**	**LIGHTING**
SITE SCALE	1) only required if changes were made	2) only required if changes were made	3) only required if changes were made
BUILDING SCALE	4) floor plan & section	5) floor plan & section	6) floor plan & section
COMPONENT SCALE	7) typical sections for wall, roof, floor	8) shading elements	9) lighting distribution

For a guide, see the *Shanley Example.*

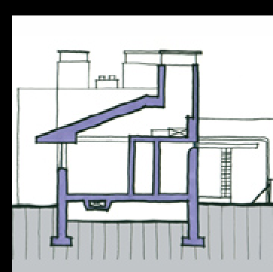
EXAMPLE PROJECT
shanley dental building, clayton, mo

harris armstrong, architect, 1936

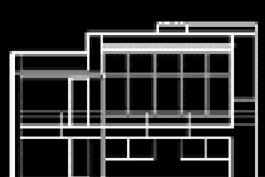
Worked Example

Re-Cycling with *Energy Scheming* exercise

Model



Final Drawings



Drawings

Site Photos

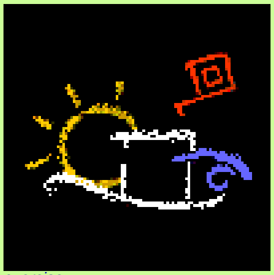
EXAMPLE PROJECT: example exercise

outline of example problem pages


exercise

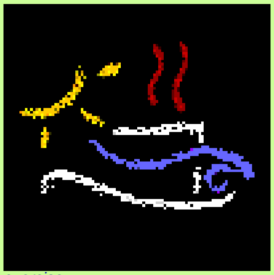
A. DOCUMENTING: input your building (example)

1. Assemble Schematic Plans and Elevations of Your Design
2. Identify the Building's Construction Type(s)
3. Diagram the Solar Concept
4. Determine Your Simulation Strategy
5. Diagram the Daylighting Zones
6. Get the Drawings into the Computer
7. Create a New Climate, if necessary


exercise

B. DEFINING: take-offs and specifications (example)

1. Tune Settings to Fit Your Building
2. Define Your Daylight Zone Icon
3. Set Performance Goals for Lighting and Heating
4. Create Plan Specifications
5. Create Elevation Specifications


exercise

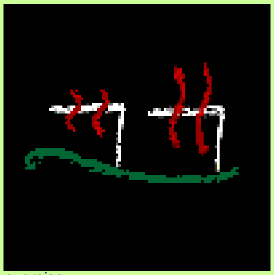
C. ANALYZING: understanding energy patterns (example)

1. Use the Rule-of-Thumb Window Sizer
2. View the Graphic Report
3. Interpret and Assess the Building's Performance


exercise

D. RE-DESIGNING: generate and test cycles (example)

1. Re-Design to Meet Your Window Performance Targets
2. Re-Design to Reduce Net Flows and Peak Loads
3. Print the "Energy Performance Report"
4. Document Design Changes


exercise

E. EVALUATING: comparing with energy codes (example)

1. Set an Energy Budget
2. Choose Reference Criteria
3. Model Your Reference Case Building
4. Compare the Performance of the Two Designs

PDF

Download the PDF version of the exercise

RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

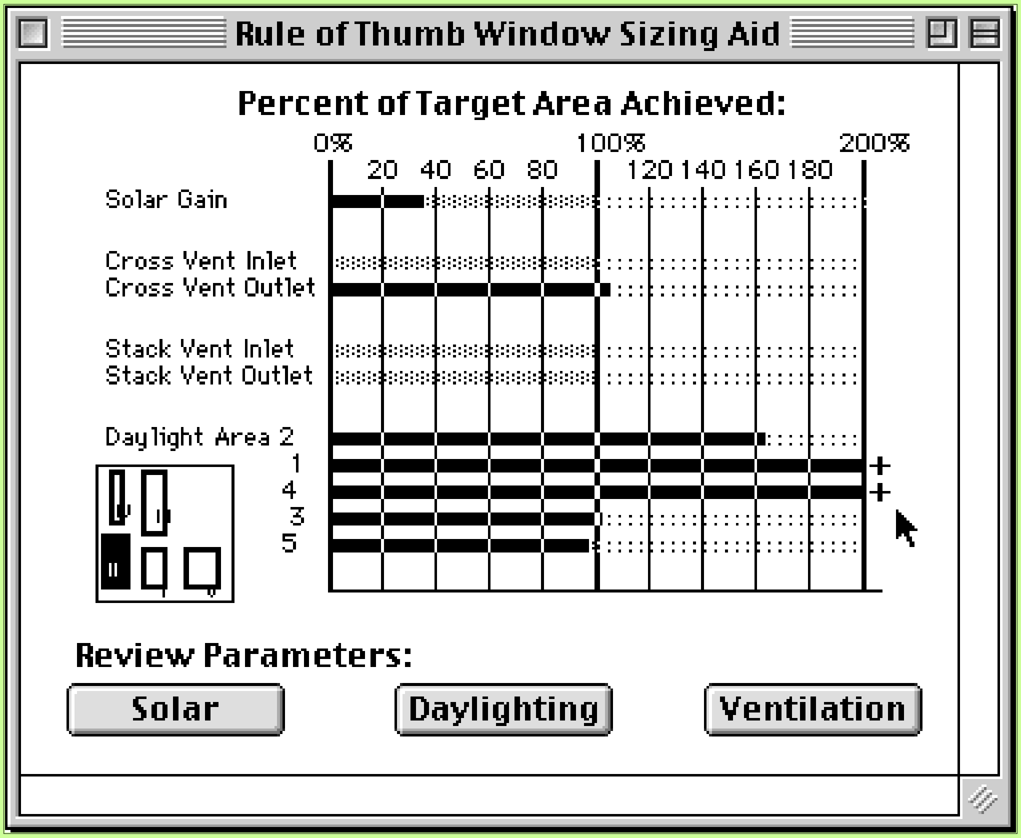
D. RE-DESIGNING : generate and test cycles.

window preformance targets

1. Re-design to Meet Your Window Performance Targets

exercise

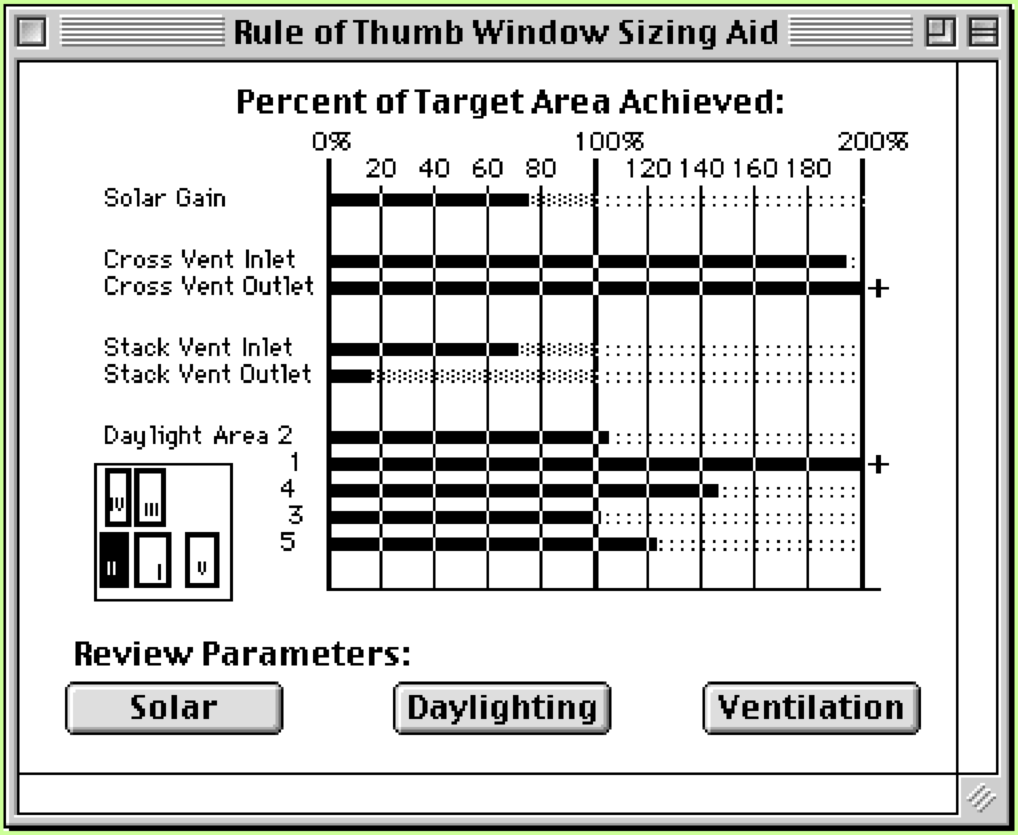
Performance Targets "BEFORE"



Click on one of the sizing bars in the graph to learn more about it. Click on any of the parameters buttons to review the design targets.

Performance Targets "INTERMEDIATE" first re-design

Performance Targets "INTERMEDIATE" first re-design



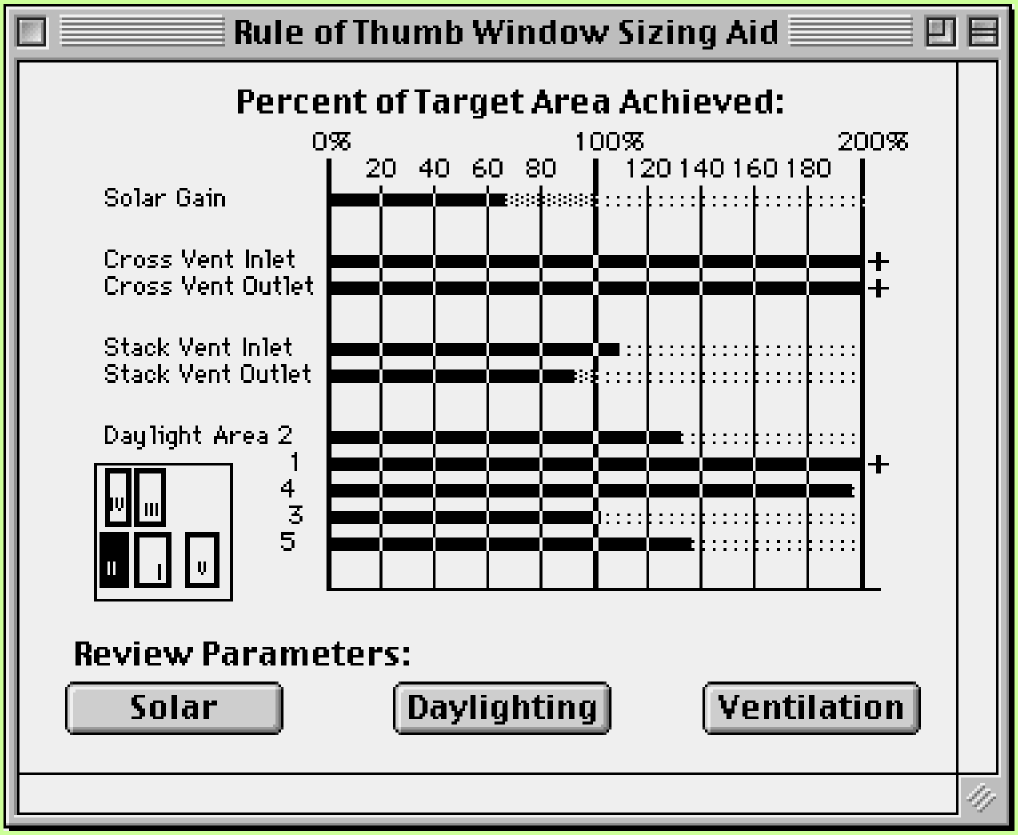
Solar Gain
Our re-design added a sunspace in two sections across the narrow south facade, linked by a fan-driven loop to the north side rooms. Our performance after this initial re-design increased from about 35% to about 75% of our target. Any additional south glass would have to be added to the roof of the north wing.

Cross Ventilation
Previously, we had lots of cross ventilation outlet, but no inlets. We made operable some of the windows on the south, north and west sides of the building. South windows are the only inlets possible, since the wind comes from that direction in summer. Even though the overall performance for cross ventilation now exceeds what is necessary, according to the rule-of-thumb, we know that the north side offices can not be effectively cooled with cross ventilation.

Stack Ventilation
In the re-design, there is now stack outlet at the back of the waiting room and over the corridor to serve the offices. Inlets are provided via the south sunspace, which open up completely in summer, and through the operable portion of the east office windows. As one can see, the stack inlets are only about 70% of what is required, and the outlets are a miserable 18%. To solve this, we will change the double-hung east and windows to casements (inlets) and make the stack towers much larger by increasing them in the E/W dimension.

Daylighting
In the initial design, zones I, II, and IV showed excessively high levels, with two zones over 200%. In our redesign, we added a sunspace. It will obviously have very high levels of daylight. We re-ordered the daylight zones, assigning zone 1 to the sun space and combining the previous zones I (waiting) and II (reception) into a single new zone II. Windows in the back wall of the sunspace are now a part of zone II, reducing the light in the waiting area to a more reasonable level. All sunspace windows now go with zone I, so we don't care if it overshoots the daylighting target. Zones II and II are now right at 100%. Given the shading and double glazing, we might consider adding more window area later. Otherwise, we are doing good.

Performance Targets "AFTER" first re-design



Stack Ventilation

In the final design, we have substantially increased the size of the stack ventilation towers; we also made the windows at the top of the sunspace operable. The stack outlet is now up to 92% of the target. Since our graphic reports show that we have no net cooling loads on the typical summer day, we believe that our target is achieved. Although, more ventilation will likely help on the extreme days.

Jump to the next EXAMPLE section: Re-design to Reduce Net Flows and Peak Loads

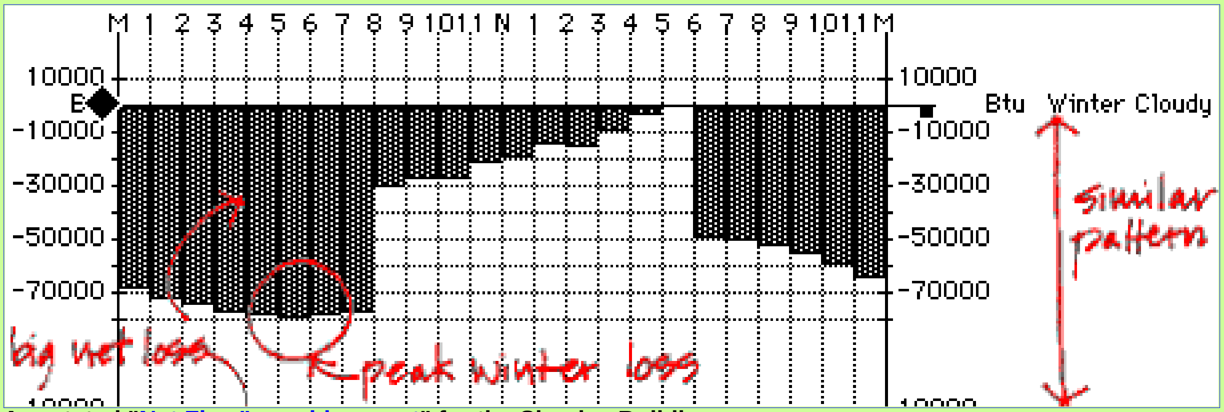
RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

D. RE-DESIGNING : generate and test cycles.

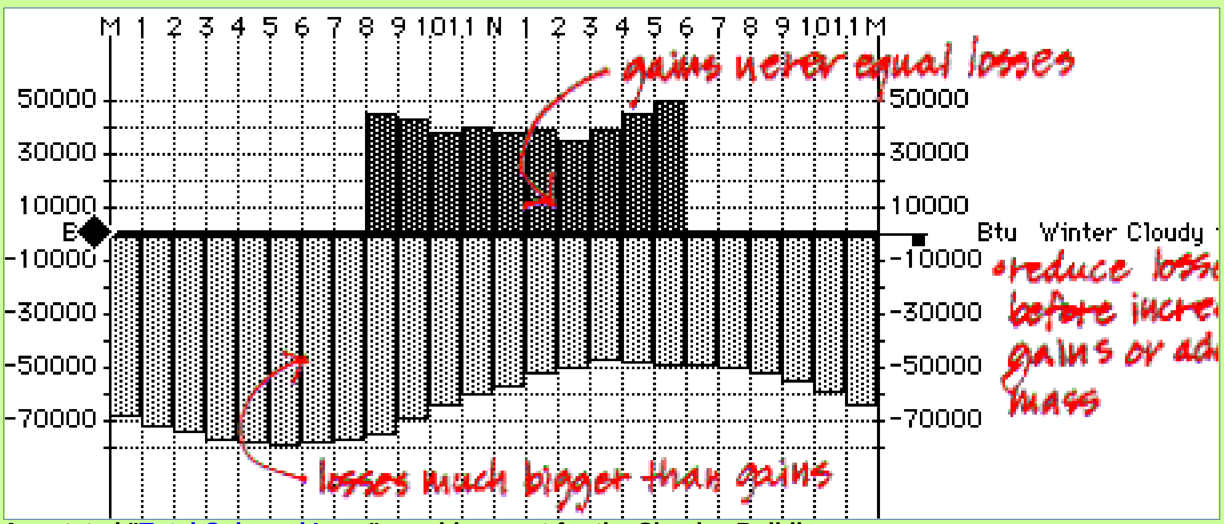
net flows and peak loads

2.Re-Design to Reduce Net Flows and Peak Loads

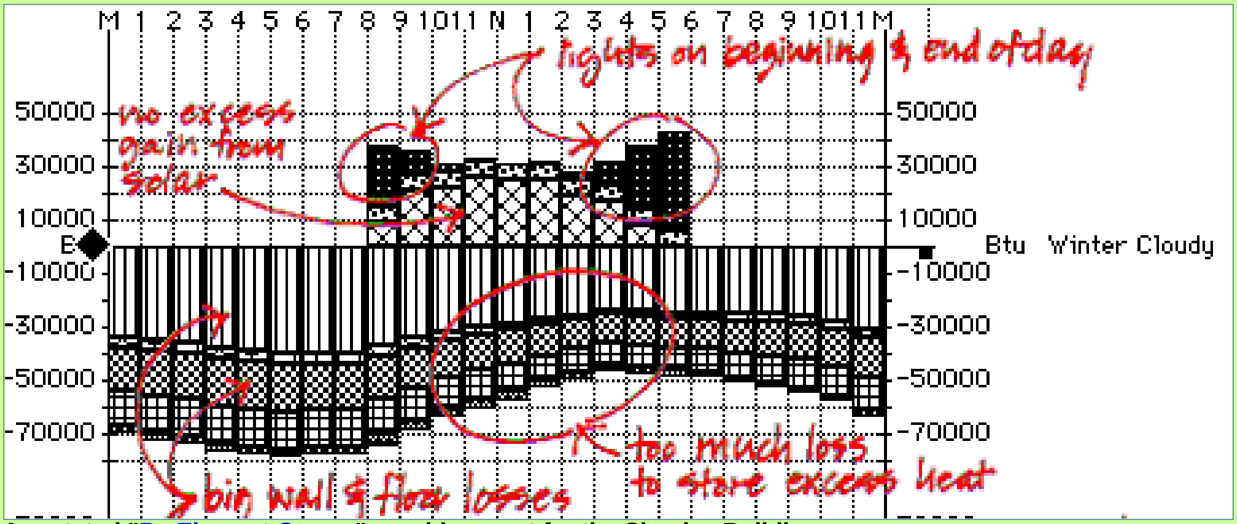
exercise



Annotated "Net Flow" graphic report" for the Shanley Building.



Annotated "Total Gain and Loss" graphic report for the Shanley Building.



Annotated "By Element Group," graphic report for the Shanley Building.

ANALYSIS

- **Reducing the building's net daily heat flow.**
- **Reducing the magnitude of gains and losses**
- **Minimize the peak loads**

Jump to the next EXAMPLE section: Print the "Energy Performance Report"

D. RE-DESIGNING : generate and test cycles.

energy perforance report

 **3.Print the "Energy Performance Report"**

exercise

We printed as instructed.

Jump to the next EXAMPLE section: Document Design Changes

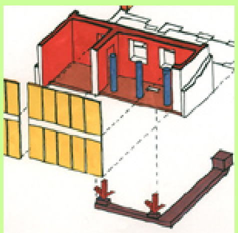
RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

D. RE-DESIGNING : generate and test cycles.

design changes

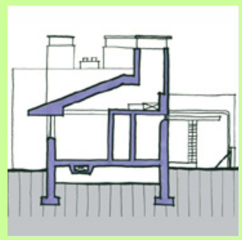
4. Document Design Changes

exercise

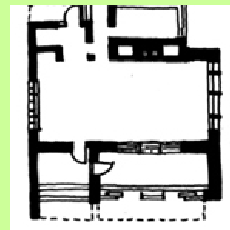


Solar Concept

New Elevations



New Sections



New Plans

INTERMEDIATE SCHEME

The following design changes were made in the initial re-design cycle (the Intermediate Scheme):

Strategic Changes

- Changed roof form over offices to promote flow to stack outlets, increasing its slope.
- Created a series of new ventilation stacks on west side of offices and on north side of waiting room.
- Added a Sun Space on south elevation for solar heating, allowing a large increase in collection area.

Tactical Changes

- Added wall insulation to uninsulated walls.
- Added floor insulation to uninsulated floor over crawl space.
- Increased ceiling insulation.
- Made windows operable on south side for inlets.
- Changed some windows to operable types, creating a ventilation path from inlets to outlets for each space.
- Changed windows to double glazed, low-e type to improve their R-value.
- Added shading on all sides, except north

FINAL SCHEME

The following design changes were made in the final re-design cycle (the Final Scheme):

Strategic Changes

- Made stacks much bigger, expanding them to the width of the corridor.

Tactical Changes

- Added additional thermal storage in the Sun Space, in the form of water.
- Changed block mass in exterior walls from "Hollow" to "Solid" mass, by filling with high sand content grout.
- Changed South windows in Sun Space to clear glazed to increase solar transmission.
- Added Night Insulation to all windows: R-5 for most windows, R-9 for Sun Space.
- Added rigid insulation to walls below grade.
- Added insulation to floor of Sun Space and to Sun Space slab edge.
- Changed electric lights from incandescent general diffuse type to the more efficient fluorescent indirect type.

Return to the EXAMPLE OUTLINE

Teaching Architecture + Energy

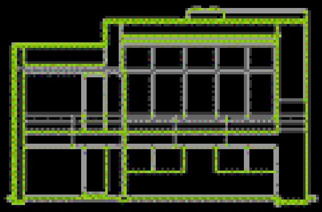
Hosted by Washington University in St. Louis

- Contacts
- Contents
- Climate
- ES Tour
- Exercises
- Example
- Help
- Home
- Instructors
- Manual
- Students

Welcome to the Teaching Architecture + Energy project at Washington University. This site is part of a collaborative network of energy technology teachers in architecture schools, sponsored in part by the U.S. Dept. of Education . Our goal is to make it easier for architecture students to understand energy concepts and to design energy efficient buildings. The curricula developed here and at other universities is centered around Energy Scheming, a energy simulation tool that helps the student think about energy as an integral part of building design.

Climate:
context for design

Exercises:
"recycling with energy scheming"

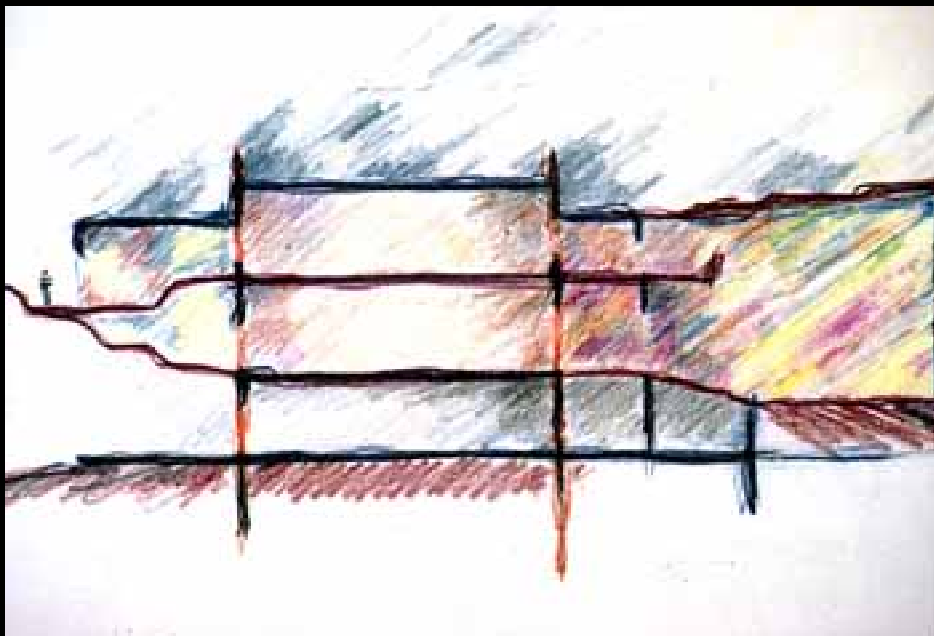


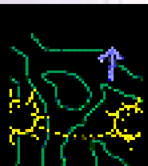
Example:
shanley building

Student Work

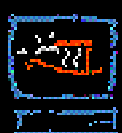
Legal Disclaimer

RECYCLING WITH *ENERGY SCHEMING*:
Schematic Design & Performance





TERRAIN MAP: outline of exercise



A. DOCUMENTING: input your building

B. DEFINING: take-offs and specifications

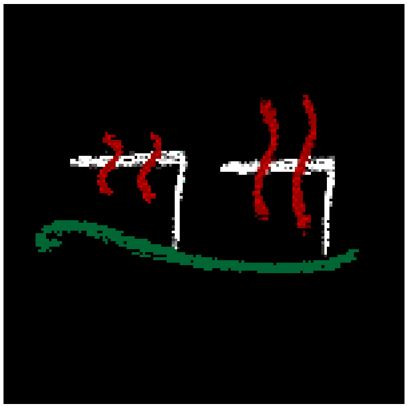
C. ANALYZING: understanding energy patterns

D. RE-DESIGNING: 'generate and test' cycles

E. EVALUATING: energy codes as indicators

Download the PDF vertion of the exercise

E. EVALUATING: energy codes as indicators



How Low is Low Energy Use?

When working with *Energy Scheming,* the question often arises, "How do I know when I have reduced my energy use enough?" The problem is not unlike the difficulty designers often have in determining when to "stop designing." The short answer to the question is that the goal is to achieve "Zero Net Energy Use," to flat line the building's net flow graphs for al seasons. In practice, determining how much to focus on reducing energy use depends on many factors, such as the project's life cycle energy costs, the use of the building, and the values of the designer and clients. While reducing the net flows on typical days for each season to zero may be achievable and even economically beneficial, using passive means to achieve zero net energy on extreme design days is rarely feasible.

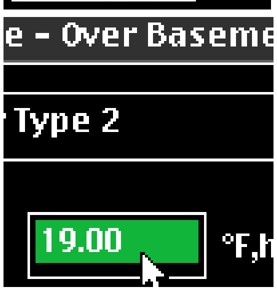
One way to get a sense of how your building is performing is to compare it to a similarly designed building that uses standards found in energy codes. Energy codes vary widely from state to state. Some states have no energy code other than the requirements found in "basic" building codes, the same codes that cover issues such as life safety. Other states have adopted energy codes based on the Model Energy Code or on the standard developed by the American Society of Heating, Refrigeration, and Air Conditioning Engineers, the ASHRAE / IES Standard 90.1-1989 requirements. Still other states, such as California, and some municipalities, go beyond these model codes to develop their own more stringent requirements.

1. Setting an Energy Budget: a range of values

One of the designer's first decisions is to set an energy use goal for the building. This is a programming level design choice that will effect both the process of how the building is designed and the final design product.

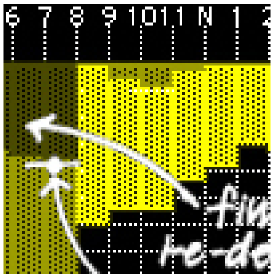
2. Choosing Reference Criteria

After setting your energy use goal, you must find the prescriptive standards for your building type and climate.



3. Model Your Reference Case Building

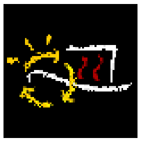
Using the prescriptive values for your building type and climate, model you building in Energy Scheming.



4. Compare the Performance of the Two Designs

After changing settings and takeoffs for the reference building, calculate the energy performance. Compare the following graphs:

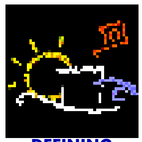
- net flow graphs for the Code Reference
- net flow graphs for your Initial Run Building (as is with no design changes)
- net flow graphs for your Final Run Building (after all design changes to improve performance)

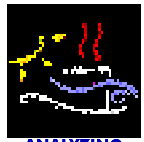


RECYCLING WITH *ENERGY SCHEMING*

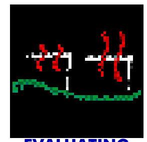

TERRAIN MAP


DOCUMENTING


DEFINING


ANALYZING


RE-DESIGNING


EVALUATING

E. EVALUATING: energy codes as indicators

setting an energy budget

1. Setting an Energy Budget: a range of values

One of the designer's first decisions is to set an energy use goal for the building. This is a programming level design choice that will effect both the process of how the building is designed and the final design product.

shanley example.

Setting an Energy Budget: a range of values

Although it requires lots of "embodied intelligence," it is possible to design buildings that use little or no net energy. The following examples show a range of different goals for saving energy in buildings. Some, like the *Model Energy Code*, are targeted at governments; others, like the *Energy Star* and *Canadian 2000* programs, are designed to use market-based approaches that go beyond the codes. Comprehensive environmental standards like BEPAC support drastically reduced energy use within a credit system that integrates many criteria, for voluntary use by designers and owners. These BEPAC scores are then used to market the building to highly educated workers and to corporations seeking a green image. Zero net energy buildings that produce at least as much energy as they consume are technically feasible and at present aremostly represented by educational facilities and research or demonstration projects.

Choose an Energy Use Goal

Use the examples on the *Energy Budgets* page to choose an energy use goal in relation to Model Energy Code standards. A modest goal would be 20% less than code (the *Energy Smart* standard). A challenging goal would be 70% less than code (the BEPAC maximum credit standard).

- ***Barely Legal***
  The AIA membership, back in 1995, passed a resolution that all buildings should meet the ASHRAE 90.1 standard. This standard, along with the MEC standards for residential buildings, should be taken as the MINIMUM standards for energy conserving buildings. Indeed, in many places, the represent the worst energy use allowed by law.

Multiple Pathways

Requirement of energy codes can usually be met by at least two paths, a *Prescriptive* approach and a *Performance* Approach. Under the Prescriptive Approach, the designer has only to verify that a standard set of requirements, such as minimum envelope R-values and maximum window U-values are met. Under the performance method, the building's energy use is calculated using computer software. Two runs are usually required, one using the prescriptive values for the building's design and construction, and one for the building as designed. The performance approach allows the design to break some rules as long as the overall energy use is lower than that of the prescriptive path reference building.

Energy Star Buildings: 30% less

The U.S. Environmental Protection Agency and the U.S. Department of Energy are sponsoring a joint program called ENERGY STAR Homes and ENERGY STAR Buildings. These buildings are designed to use a minimum of 30% less energy than code designed buildings, while reducing an equivalent amount of associated pollution. SO, this would be a modest, conservative, achievable, and economically feasible goal.

- "ENERGY STAR Homes use at least 30% less energy than required by the national Model Energy Code while maintaining or improving indoor air quality. A more efficient ENERGY STAR Home simply COSTS LESS to own and operate! "

- "EPA's ENERGY STAR Buildings program is a voluntary energy-efficiency program for U.S. commercial buildings. The ENERGY STAR Buildings program focuses on profitable investment opportunities available in most buildings using proven technologies. A central component of the program is the five stage implementation strategy that takes advantage of building system interactions, enabling building owners to achieve additional energy savings while lowering capital expenditures. Through these actions, Partners can expect to reduce total building energy consumption by 30% on average."

Canadian Standards: even less

Wouldn't you know it, the Canadians at the Canadian Centre for Mineral and Energy Technology have a more ambitious program than EPA.

- C-2000 Buildings: 50% less
  The requirements cover a broad range of performance criteria, including the need to demonstrate annual energy consumption of less than 50% of that required by ASHRAE 90.1 Other performance requirements have been established to assure minimal environmental impact, a high quality indoor environment, as well as adaptable and long-lived building components.

- R-2000 Homes: 40% less
  R-2000 Homes are some of the most energy efficient and comfortable homes being built commercially today and, following the introduction of new technical requirements in 1994, are the most environmentally friendly and provide a healthier indoor environment.
  http://www.ualberta.ca/~amulder/house/R2000/Overview.html

- Advanced Houses Program: 80% less
  This is a program/project sponsored by Natural Resources Canada (NRCan, formerly Energy Mines and Resources -- EMR). It's goal is to push the R2000 standard even further. These houses would at minimum be twice as energy-efficient as current R-2000 homes

Environmental Performance Criteria: 70% less

The Building Environmental Performance Assessment Criteria (BEPAC) is the first comprehensive method for evaluating the environmental performance of both new and existing office buildings in Canada. BEPAC evaluates the environmental merits of office buildings and is incentive oriented to guide and encourage the market to value more environmentally responsible practices and higher performance standards. It is voluntary in its application and offers a certificate of design and management performance for office buildings and their tenancies. BEPAC has several standards related to energy use; maximum credit awards are give to buildings reducing energy use by at least 70% in comparison to a datum building.

Zero Emissions Buildings: achieving the sustainable ideal

Several houses have been built that use renewable technologies such as active solar systems and photovoltaics to supplement what passive design and the building fabric alone can not achieve. They all depend on very low net loads from heating, cooling and lighting. Here are two examples you can see on the web:

- Oberlin's Environmental Studies Center

  "Booming student interest prompted David Orr, professor of environmental studies, to propose that the college build "a highly visible model of ecological design in a zero-emissions building." Press release. The project is being designed by William McDonough + Partners.

- Zero Energy House in Woubrugge.

  A Dutch energy consultant has developed and demonstrated a house designed to produce as much energy as it consumes.

Jump to the next section: Choosing Reference Criteria

E. EVALUATING: energy codes as indicators

reference criteria

2. Choosing Reference Criteria

After setting your energy use goal, you must find the prescriptive standards for your building type and climate.

shanley example.

For purposes of this exercise, we will use the model energy code (residential) and the Commercial Energy Code (based on ASHRAE 90.1). The designer can then use *Energy Scheming* to model the building with these prescriptive values in one run and compare the graphs generated to those of the building as designed.

Model energy codes (MEC) in the USA are divided into residential and commercial codes. The Residential MEC is further divided into Single Family and Multi Family standards. For more information on model energy codes, see the United States Department of Energy Building Standards & Guidelines Program (BSGP) a program run by Pacific Northwest National Labs.

Find Your Prescriptive Standards

Use the following help pages to find heat transfer values for your building's envelope.

- Prescriptive Standards for Residential Buildings
- Prescriptive Standards for Commercial Buildings

- California's Title XXIV
  Tips on how to compare your building to a code building in California.

Jump to the next section: Model Your Reference Case Building

E. EVALUATING: energy codes as indicators

MEC prescriptive standards: residential

RESIDENTIAL BUILDINGS

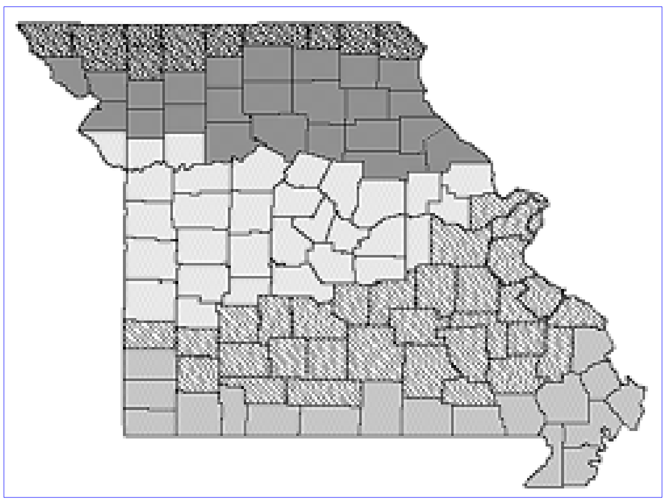
Model Energy Code for Residential Buildings
The *Model Energy Code* (MEC) is published by the Council of American Building Officials (CABO) and is updated annually by the CABO Code Changes Committee.

The prescriptive approach, the simplest of the three approaches, allows builders or designers to select from various combinations of energy conservation measures based on "climate zone" location. Each combination or "package" specifies insulation levels, glazing areas, glazing U-values (thermal performance), and sometimes heating and cooling equipment efficiency. By locating the correct climate zone and looking up the appropriate table of packages, one can ensure the project meets one of the packages listed for that zone.

To determine if your proposed design complies with the climate-specific requirements:

1. Determine the climate zone for your proposed building's location from the appropriate state map.

The state maps are divided into climate zones that fall along county boundaries. Based on the county in which your building is located, find your zone from the appropriate state map. The zones are shown graphically on each map along with their corresponding zone numbers.



Map of Missouri Climate Zones.
Click to enlarge and see climate legend.

To find climate zones by county from a map for any US state, you can download the following file:
Maps of All States *(1.5 MB Adobe Acrobat file)*

2. Find the prescriptive package table for your building's climate zone.
Once you know the number of your climate zone, you can go to the prescriptive package table for that zone. The tables of prescriptive packages correspond to the climate zones depicted on the state maps. Each climate zone has a one-page table of prescriptive packages from which you can select one package. If your building meets the insulation R-value, glazing, and (sometimes) heating and/or cooling equipment efficiency requirements specified for the package you select, then the building complies with the MEC.

Your table will look something like the excerpt from climate Zone 10 (St. Louis, MO city and county) below:

Prescriptive Packages - Zone 10

1995 Model Energy Code for Single-Family Buildings

Package	MAXIMUM		MINIMUM				
	Glazing Area Percent[1]	Glazing U-Value[2]	Ceiling R-Value[3]	Wall R-Value[4]	Floor R-Value[5]	Basement Wall R-Value[6]	Slab Perimeter R-Value[7]
1	12%	0.65	R-38	R-19	R-19	R-9	R-7
2	12%	0.45	R-30	R-13	R-19	R-9	R-6
3	15%	0.55	R-38	R-19	R-21	R-10	--
4	15%	0.40	R-38	R-13	R-19	R-9	R-5
5	18%	0.45	R-38	R-19	R-19	R-9	R-7
6	18%	0.35	R-38	R-13	R-19	R-9	R-6
7	22%	0.40	R-49	R-21	R-19	R-9	R-6

Table for Single-Family Residences (Zone 10) (St. Louis, MO)

Table for Multi-Family Residences (Zone 10) (St. Louis, MO)

Prescriptive Compliance Packages for All States *(765 K Adobe Acrobat file)*
The MEC check Prescriptive Packages were developed to demonstrate compliance with the insulation and window requirements of the Council of American Building Officials (CABO) Model Energy Code (MEC). This version of the prescriptive packages demonstrates compliance with the 1995 edition of the MEC.

Map of Missouri with Prescriptive Packages *(153 K Adobe Acrobat file)*

Status of Energy Codes

- **Status of Energy Codes in Missouri**
- **Status of Energy Codes in Illinois**

3. Select a Prescriptive Package from Those Possible in Your Climate Zone

To select the correct package from the table for your building:

- ***Make an Assumption about HVAC Equipment***
  Decide whether the building will have either 1) "Normal" efficiency systems; 2) "High Heating" efficiency systems; or 3) "High Heating AND High Cooling" efficiency systems. This determines what block of packages are available to you. Note that the envelope requirements are more stringent for less efficient HVAC systems. *Energy Scheming* calculates loads only, and does not address HVAC systems.

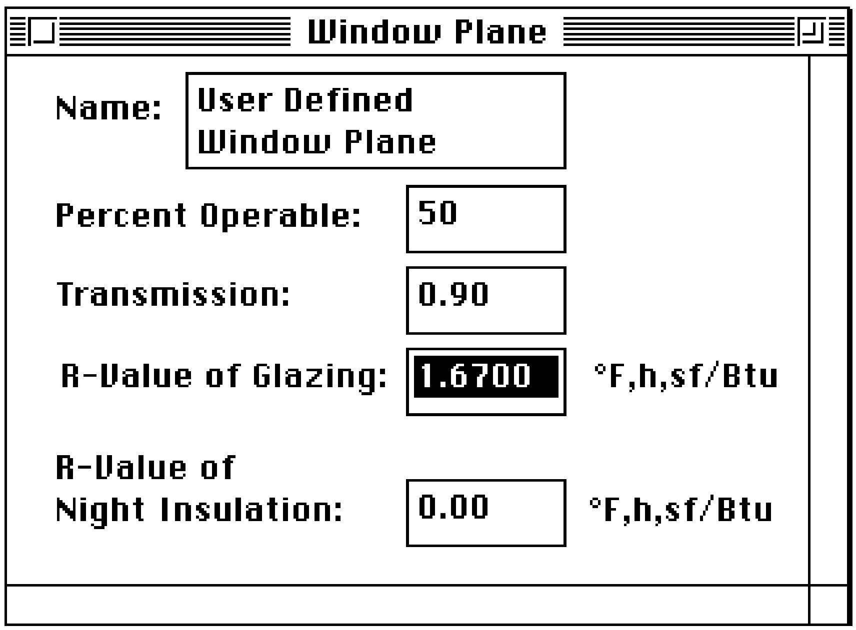
- ***Calculate the Proposed Glazing Area Percentage***
  Check the "Building Data" and "Spec Summary" sections of your ES Energy Performance Report to find the total takeoff areas of windows and walls. You can print just these sections of the report by checking their boxes in the "Print Energy Performance Report" dialog box.
  - *Calculate the Glazing Area*
    Calculate the total area (ft) of all glazing assemblies (windows, sliding glass doors, skylights, etc.) located in the building envelope. The nominal area or rough opening is acceptable for windows. The area of windows in the exterior walls of conditioned basements should be included. Windows in unconditioned basements are NOT included.
  - *Calculate the Gross Wall Area.*
    The gross wall area includes the following:
    - all above-grade walls enclosing conditioned spaces (including attic knee walls and skylight shafts)
    - the peripheral edges of floors (the area of the band joist and subfloor between floors)
    - walls of conditioned basements with an average depth less than 50% below grade (include the entire wall area even the below-grade portions).
    - all windows and doors (including windows and doors in conditioned basements).
  - Divide the glazing area by the gross wall area and multiply by 100 to determine the *Proposed Glazing Area Percentage.*

- ***Select the package that fits best with your combination of assumed HVAC efficiency and calculated Glazing Area Percentage.***

- ***Find the corresponding requirements for glazing, ceiling, wall, roof, floors, slabs, and below-grade walls. Input them Into Energy Scheming***
  Here are a few notes from the prescriptive guide to remember:

  - **General Notes**
    - The insulation R-values listed for each package are the minimum allowed for that package. R-value requirements refer to the R-value of the insulation only.
    - Wall and ceiling insulation R-values refer to the sum of the stud cavity insulation plus insulating sheathing (if used). For example, an R-16 wall requirement can be met with R-13 cavity insulation and R-3 sheathing.
    - It is important to select a package consistent with the proposed framing used in the building. For example, it would be impossible to comply with a package specifying R-38 ceiling insulation (approximately 12 in. thick) if the building plans include a cathedral ceiling with 2x8 framing (approximately 7.5 in. thick).

  - **Glazing**
    The glazing U-value and the glazing area percentage listed for each package are the maximum allowed for that package. To input the window U-value into ES, first convert the U-values to R-values. Then input the window R-values in the detailed window spec layer for "Window Plane."

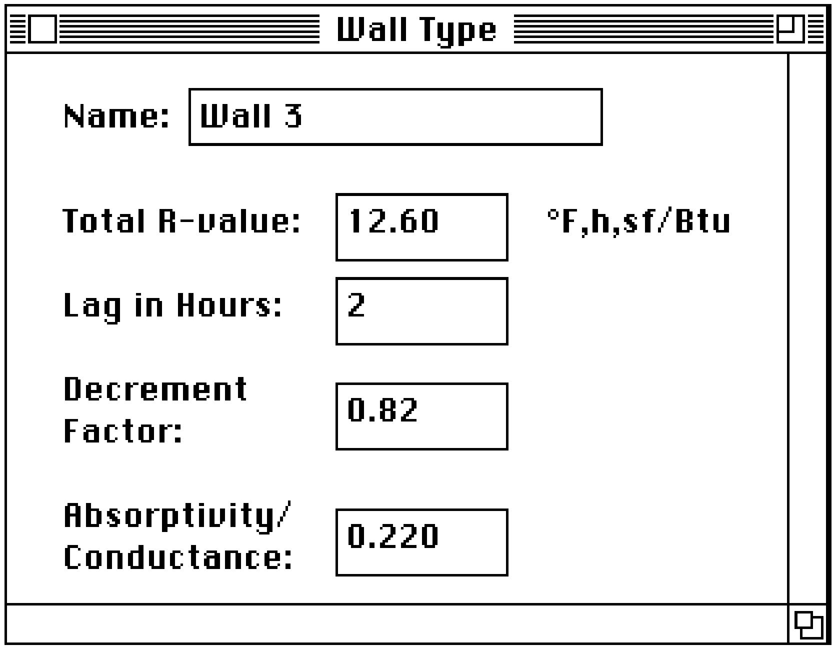


  - **Ceiling**
    Proposed R-values for ceilings represent the sum of the cavity insulation plus insulating sheathing (if used). For ventilated ceilings, insulating sheathing must be placed between the conditioned space and the ventilated portion of the roof (typically applied to the trusses or rafters immediately behind the drywall or other ceiling finish material).

    The ceiling R-value requirements do not assume a raised or oversized truss construction. If the insulation achieves the full insulation thickness over the exterior walls, R-30 insulation may be used to meet an R-38 insulation requirement and R-38 insulation may be used to meet an R-49 insulation requirement.

    Input the R-value for ceilings into the detailed section of the roof spec, similar to the wall spec illustrated below.

  - **Walls**
    Since you will probably have already defined the wall materials of you base building, ES selects and calculates a variety of factors about the wall section for you. Input R-values from the prescriptive standards into the detailed wall spec. Leave all other values the same as those chosen by ES.



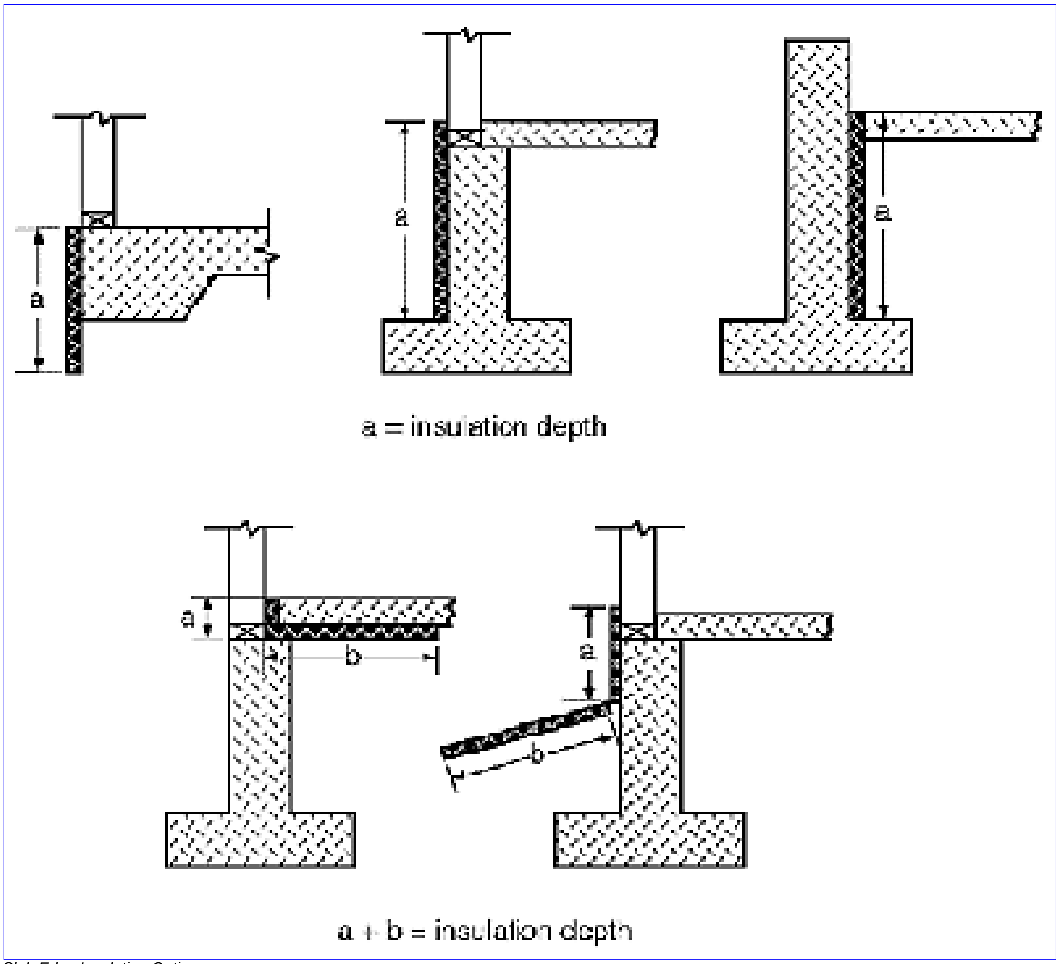
- **Roofs**
  Input the R-value into the detailed section of the roof spec, similar to the wall spec illustrated above.

- **Floor**
  Floors over unconditioned space include floors over unconditioned crawl spaces, basements, and garages. Floors over outside air include floor cantilevers, the floor of an elevated building, and floors of overhangs (such as the floor above a recessed entryway or open carport). Floors over outside air must meet the ceiling R-value requirement. Input the R-value into the detailed section of the floor spec.

- **Basement**
  Basement walls that enclose conditioned spaces must be insulated from the top of the basement wall to 10 ft below ground level or to the basement floor, whichever is less. Any individual wall of a conditioned basement with an average depth 50% or more below grade is considered a basement wall; a wall over 50% above grade is considered an above-grade wall and must meet the wall R-value requirement for the package.

  Take off basement walls like regular walls. Include the area below grade. Begin with R-values given in the code and add to that value, the R-value of the earth. To estimate the R-value of the earth surrounding a below grade wall, use *Sun, Wind, and Light,* strategy 30, pp. 86-7.

- **Slab R-Value**
  The prescriptive package slab R-value requirements are for unheated slabs. Add an additional R-2 for heated slabs, except in Zone 1 which does not require slab insulation. For packages with a slab insulation requirement, the insulation must extend a total linear distance of at least 24 inches in Zones 2-12 and 48 inches in Zones 13-19. A heated slab is a slab with ducts or hydronic heating elements in or under the slab.



- *Slab Edge Insulation Options*

- **Crawl Space**
  Crawl space wall R-value requirements are for walls of unventilated crawl spaces (i.e., not directly vented to the outside). Ignore crawl space insulation requirements, because this uncommon construction type can not be evaluated effectively in Energy Scheming.

RECYCLING WITH "*ENERGY SCHEMING*": Schematic Design Performance

E. EVALUATING: energy codes as indicators

MEC prescriptive standards: commercial

COMMERCIAL BUILDINGS

Requirements for All Buildings

To meet the MEC, all buildings must comply with requirements for limiting air leakage through the building envelope and installing vapor retarders. For commercial buildings modeled in ES, these requirements do not have a significant effect. For non-residential buildings, ES models ventilation according to ASHRAE requirements for ventilation, based on occupancy type.

Climate-Specific Requirements

The COMcheck-EZ prescriptive package tables contain climate-specific envelope requirements for walls, windows, skylights, roofs, floors, and below-grade walls. Included are required insulation levels, glazing areas, and glazing U-factors.

There are several packages for each climate zone, based on the window-wall ratio (WWR), which is the gross window area divided by the gross wall area. The gross wall area includes:

- the opaque area of all above-grade walls enclosing conditioned spaces (excluding doors and windows)
- the area of the band joist and subfloor between floors
- the area of all doors and windows.

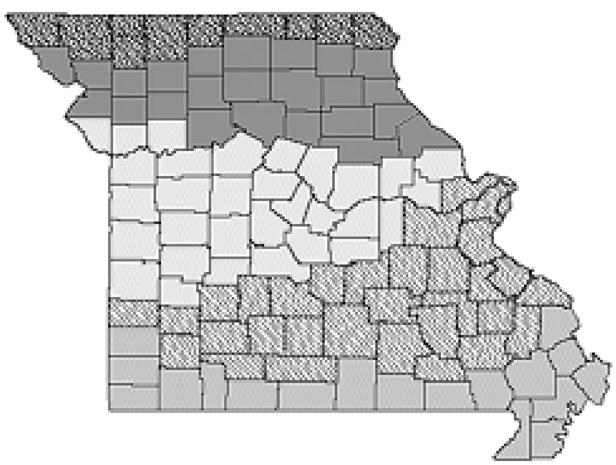
The gross window area includes the rough-opening area of the window, not just the transparent-glass area.

To determine if your proposed design complies with the climate-specific requirements

Calculate the WWR for your design.

As described above. Check the "Building Data" and "Spec Summary" sections of your ES Energy Performance Report to find the total takeoff areas of windows and walls. You can print just these sections of the report by checking their boxes in the "Print Energy Performance Report" dialog box.

Determine the climate zone for your proposed building's location from the appropriate state map.



Map of Missouri Climate Zones.
Click to enlarge and see climate legend.

To find climate zones by county from a map for any US state, you can download the following file:
Maps of All States *(1.5 MB Adobe Acrobat file)*

Find the prescriptive package table for your building's climate zone.

Once you know the number of your climate zone, you can go to the prescriptive package table for that zone. These standards apply to most commercial and high-rise residential buildings three stories or more above grade. A building designed and constructed to meet the COMcheck-EZ requirements generally meets or exceeds the energy efficiency of a similar building constructed to meet ASHRAE/IES Standard 90.1-1989 requirements.

Your table will look something like the excerpt from climate Zone 10b (St. Louis, MO city and county) below:

COMcheck-EZ™ Prescriptive Packages — Climate Zone 10b

Envelope Component		Low Fenestration Area (0-10% Window-Wall Ratio)		
Walls [a]		No Framing or	Metal Framing or	Wood Framing
Framed Any Spacing	Minimum R-value	NA	11	11
CMU, 8" or greater with Integral Insulation(b)	Minimum R-value	5	11	11
All Other Masonry Walls	Minimum R-value	5	11	11
Windows		No Projection	≥.25 Projection	≥.5 Projection
	Maximum Solar Heat Gain Coefficient	Any	Any	Any
	Maximum U-Factor	Any	Any	Any
Skylight (Limit 3% of Roof Area)				
	Maximum U-Factor	0.8		

Table of St. Louis City and County Commercial Prescriptive Standards (Zone 10b) Click on the chart or text above to view the whole chart.

Click here to download specific State Maps and Prescriptive Packages in Adobe Acrobat format from DOE's web server

Map of Missouri with Prescriptive Packages *(85 K Adobe Acrobat file)*

Prescriptive Packages for All States *(119 K Adobe Acrobat file)*

MEC Envelope Compliance Guide
This guide offers more details about code compliance related to the envelope. It is not necessary that you refer to it for schematic design with ES, but you might find it interesting.

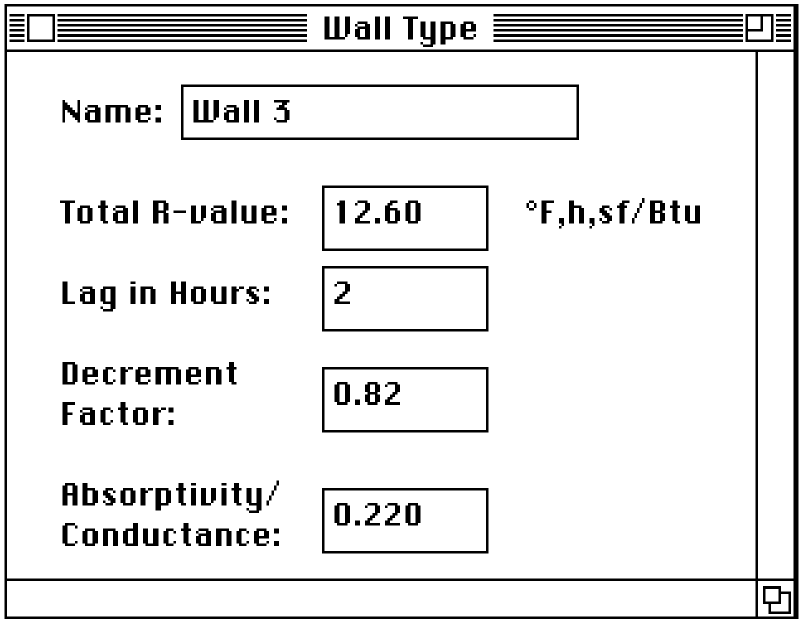
Select the package from the table that best fits your design's construction characteristics based on WWR.
There are three categories (columns) of WWR:

- 0 to10 % Window - Wall Ratio
- 10 to 25 % Window - Wall Ratio
- 25 to 40 % Window - Wall Ratio

Within each WWF category, select values based on your construction characteristics.

Find the corresponding requirements for walls, windows, skylights, roof, floor, and below-grade walls. Input them Into Energy Scheming.

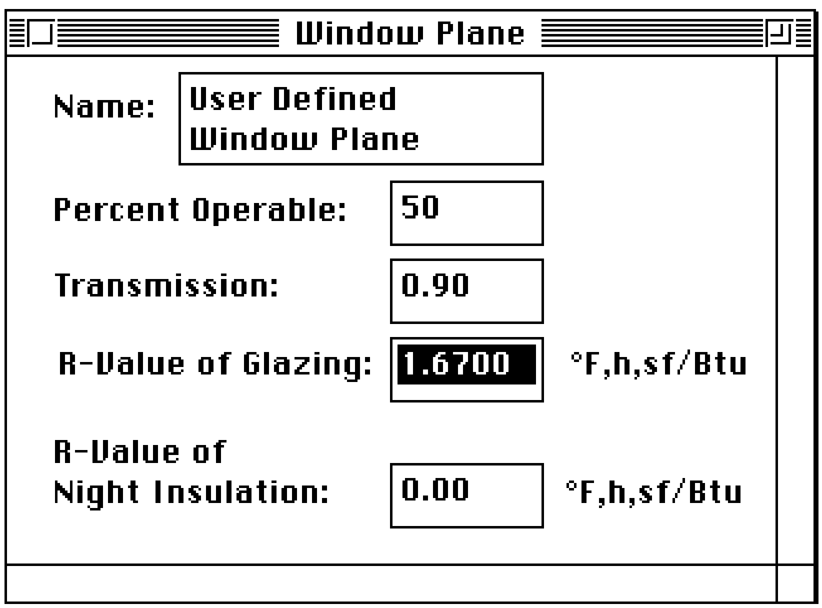
- **Walls**
  Since you will probably have already defined the wall materials of you base building, ES selects and calculates a variety of factors about the wall section for you. Input R-values from the prescriptive standards into the detailed wall spec. Leave all other values the same as those chosen by ES.

❍ 

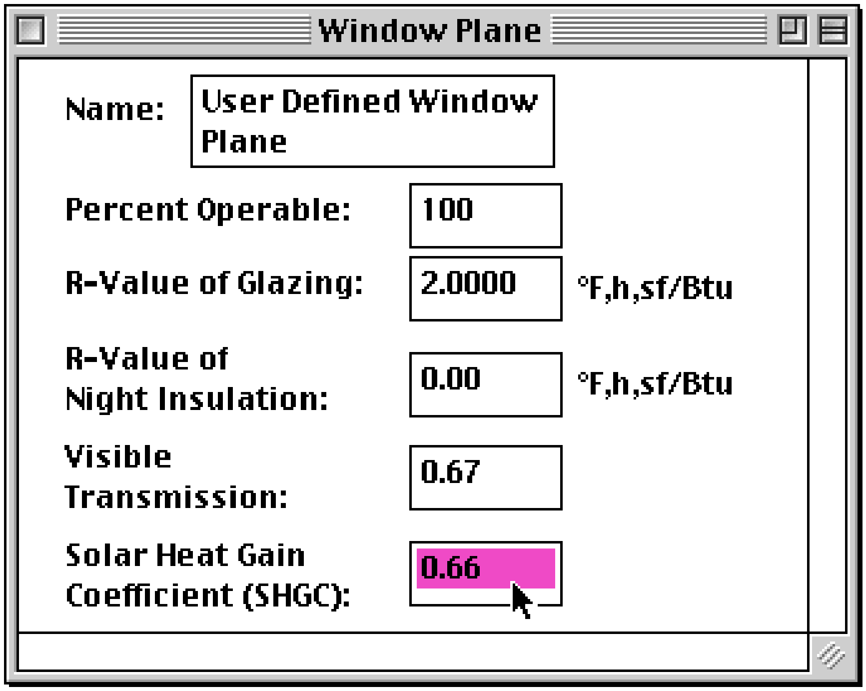
- **Windows**

  Natural Ventilation
  The codes typically require that a free opening of at least 4% of the floor area be available for natural ventilation. Make sure that you <u>define 4% of your windows as operable</u> cross ventilation openings. This will allow you to compare the code minimum against your actual design, which in some cases may have more than 4%

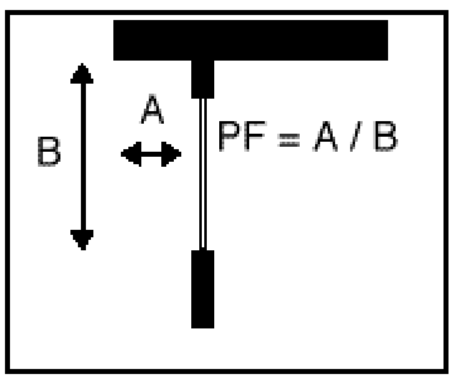
  In most cases, the WWR will affect the window requirement.
  To input the window U-value into ES, first convert the U-values to R-values. Then input the window R-values in the detailed window spec layer for "Window Plane."

❍ 

  Solar Heat Gain Coefficient
  Your (base case) design must also have a Solar Heat Gain Coefficient (SHGC) less than or equal to that in the prescriptive package. In ES, input values of SHGC in the "Window Plane" spec layer of the Detailed Window Spec.



Projection Factor
The SHGC required by the prescriptive standards is affected by the projection factor (PF) of qualifying overhangs. The projection factor is based on the ratio of the overhang depth to the overhang height above the window sill. Based on the characteristics of your building's overhangs (if any), choose the correct SHGC and window U-factor.



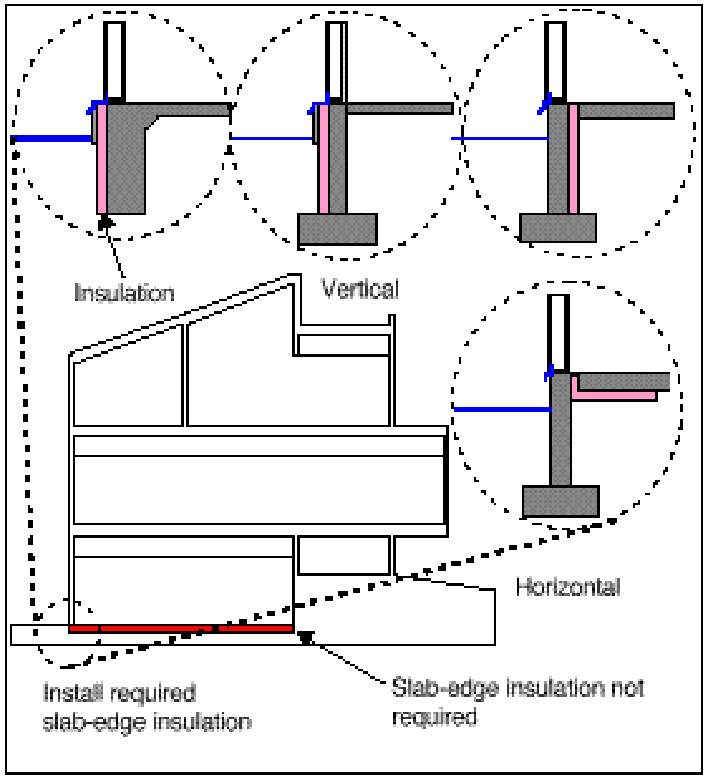
Projection Factor

- **Skylights**
  Skylights are limited in area by code, usually to 3% of floor area. Check the limits for your climate zone. If your building has more skylights than allowed by code, reduce your skylight area for the code building ES run to the maximum allowed.

  To input the prescriptive skylight U-value into ES, first convert the U-values to R-values. Then input the window R-values in the detailed window spec layer for "Window Plane." Horizontal skylights are taken off in plan. Sloped skylights are taken off in the elevation drawings.
- **Roofs**
  First find the roof construction that most closely matches your building. Then, for each construction type, the prescriptive standards give two options for roofs, one for continuous insulation, such as rigid insulation over a concrete deck, and one for cavity insulation such as between rafters. Input the R-value into the detailed section of the roof spec.
- **Floors**
  First find the floor construction that most closely matches your building. Then, for each construction type, the prescriptive standards give two options for floors, one for continuous insulation, such as rigid insulation under joists, and one for cavity insulation such as batt insulation between joists. Input the R-value into the detailed section of the floor spec. These conditions apply only for floors over unheated basements, crawl spaces, and exposed outdoor conditions. They do not apply to slabs on grade.

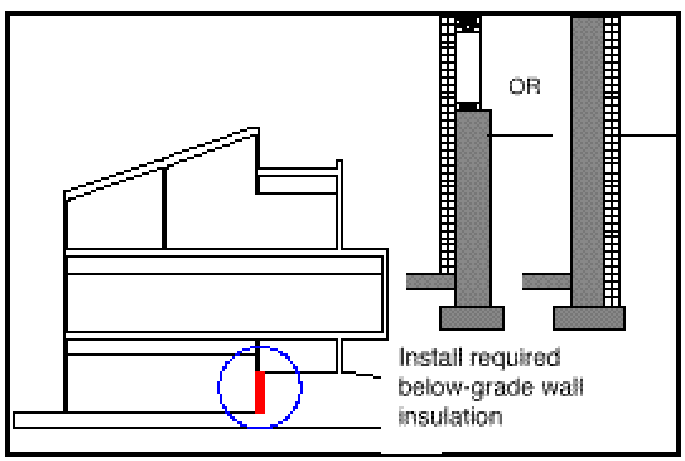
- **Slab Edge and Below-grade walls**
  The required minimum slab edge and basement insulation is given as R-values.
  - *For slabs on grade*
    ES uses an arcane F_2 value, which has to be calculated by an ASHRAE method. To simplify, assume that slab insulation

is rigid insulation with an R-value of 4 per inch. Determine how many inches of rigid insulation would be required to meet the code. Then select the closest insulation thickness in inches from the table view (by clicking on "Select Floor Components") in the floor spec.



Location of Slab-Edge Insulation

- *For Basement Walls*
  Take off basement walls like regular walls. Include the area below grade. Begin with R-values given in the code and add to that value, the R-value of the earth. To estimate the R-value of the earth surrounding a below grade wall, use *Sun, Wind, and Light,* strategy 30, pp. 86-7.



Location of Below-Grade Wall Insulation

* All images not taken from *Energy Scheming* are from the *ComCheck EZ Envelope Guide*

E. EVALUATING: energy codes as indicators

California Title XXIV prescriptive standards

WHAT CAN BE COMPARED

The California code covers envelope loads, lighting, HVAC, and water heating. Since *Energy Scheming* only calculates heating and cooling loads, we can compare the heating and cooling loads of your design against those of the minimum (worst) building allowed by code. This analysis will include the envelope loads and internal loads, including the heat gain effects of lighting, We can not, using this tool, compare HVAC performance, total lighting system energy use, or hot water energy. **General Overview of CA Title XXIV code**

HOW TO FIND TITLE XXIV PRESCRIPTIVE STANDARDS

Title 24 on-line

- **Administrative Regulations**-- California Code of Regulations
- **SubChapter 1**-- All Occupancies -- General Provisions
- **SubChapter 2**-- All Occupancies -- Mandatory Requirements for the Manufacture, Construction, and Installation of Systems, Equipment, and Building Components
- **SubChapter 3**-- Nonresidential High-Rise Residential, and Hotel/Motel Occupancies -- Mandatory Requirements for Space Conditioning and Service Water Heating Systems and Equipment
- **SubChapter 4**-- Nonresidential High-Rise Residential, and Hotel/Motel Occupancies -- Mandatory Requirements for Lighting Systems and Equipment
- **SubChapter 5**-- Nonresidential , High-Rise Residential, and Hotel/Motel Occupancies -- Performance and Prescriptive Compliance Approaches for Achieving Energy Efficiency
- **SubChapter 6**-- Nonresidential High-Rise, and Hotel/Motel Occupancies -- Additions, Alterations, and Repairs
- **SubChapter 7**-- Low-Rise Residential Buildings -- Mandatory Features and Devices
- **SubChapter 8**-- Low-Rise Residential Buildings -- Performance and Prescriptive Compliance Approaches
- **SubChapter 9**-- Low-Rise Residential Buildings -- Additions and Alternations in Existing Low-Rise Residential Buildings
- **APPENDIX 1-A** -- Standards Referenced In Energy Efficiency Regulations

Tips on modeling a TITLE XXIV CODE BUILDING in *Energy Scheming*

NATURAL VENTILATION

- Use 5% of floor area for the total of inlets and outlets. Make sure that all your windows are fixed, except for the 5% of floor area required.
- Turn off all stack ventilation, since the configuration of ventilation is not specified by code.

WINDOWS

Total area of windows:

- Use the lesser of
  - a) the proposed building design, OR
  - b) 40% of the wall area
- For U-values and Shading Coefficients, see: TABLE NO. 1-I.

  For the shading coefficient of the reference building, use the values listed in the table for "Relative Solar Heat Gain." The RSHG is equal to the shading coefficient (SC) of the window multiplied by the shading coefficient of the exterior shading. For the reference building, interior shades are ignored. Since the glazing itself will likely have some shading effect (relative to single clear glass, for which SC = 1.0), find the required maximum SC for the exterior shading by:
  - $SC_{exterior} = RSHG \div SC_{glass}$
  - SC_{glass} can be found by selecting the glass type in the ES window spec and then clicking on the button for "detailed window specs." Assume that "Transmission" is equal to SC plus 0.10, for the window. So: $SC_{wind} = T_{wind} + 0.1$. Default values for T can also be found in the ES Manual Appendix.

SKYLIGHTS

- Use the lesser of
  - a) the proposed building design, OR
  - b) 5% of the wall area
- For U-values and Shading Coefficients, see: TABLE NO. 1-I.

WALLS AND ROOFS

- Configuration, orientation, and areas are the same as the proposed building design.
- For R-values, see: TABLE NO. 1-I.
- Change your wall and roof construction to a metal framed wall with no mass. Use the detailed spec to set R-value to tabled value for metal framing.
- Set exterior color to "medium" and turn mass off by setting to "none."

FLOORS

- Configuration, orientation, and areas are the same as the proposed building design.
- For R-values, see: TABLE NO. 1-I. These value apply to exposed floor areas only, NOT to slabs on grade.
- For slabs, set insulation to "none." Turn mass off in floor.

Set exterior color to "medium" and turn mass off by setting to "none"

DOORS
There are no R-value or area requirements for doors. Treat them the same in the reference building as in your design.

MASS
The code does not account for mass in the prescriptive requirements. Eliminate all mass takeoffs from the code reference building, that is, anything taken off in the mass icon, either in plan or in elevation.

PEOPLE and EQUIPMENT
Since these are not architectural design variables, use the same takeoffs and specs as you did for your design.

VENTILATION and INFILTRATION
Mechanical ventilation is not required for spaces with natural ventilation. The code allows for "demand controlled" ventilation during occupied hours. This fits well with the ES method of calculating energy from ventilation. Model the code reference building in the same way as your design.

LIGHTING
Title XXIV sets maximum Lighting Power Densities (LPD) by building or space occupancy type:

Occupancy Type	Lighting Power Density (Watts / ft^2).
Schools, average of all spaces	1.8
Classrooms	2.0
Corridors, restrooms, support spaces	0.8
Offices	1.6

To spec lights in ES using these rates, you must use the "Detailed Lighting Design" method from the window spec. Energy Scheming requires two inputs for each lighting type:

- The Efficiency (E) of the lighting system in Btu per hour per square foot per footcandle (Btuh/h, ft^2, fc)
- The Illumination level (I) required in the space, in footcandles (fc)

To spec lighting in ES that meets these LPD requirements ES, do the following:

1. Convert the units: LPD (W/ft^2) ÷ 0.2928 (Btuh/W) = E (I)
2. Divide EI by the required Illumination in fc to get the maximum E allowed.
3. Input the value for E in the Detailed Lighting Design Spec.

The Lighting Types table from ES 3.0 is included here for reference.

Select Visual Tasks and Lighting Type

Visual Task (fc)	Lighting Type (Btu/h,sf,fc)
Corridor (5)	Surface-High Pressure Sodium (0.082)
Warehouse (10)	Surface-Metal Halide (0.096)
Residential (20)	Troffer (0.122)
Classroom (30)	Open Direct Fluorescent (0.124)
Factory (35)	Batwing Lourvered (0.136)
Office (40)	Direct Open Reflector-Compact Fluor (0.163)
Library (50)	Indirect Luminous Bottom (0.164)
Assembly Line (75)	Luminous Ceiling (0.164)
	Direct Down-Compact Fluorescent (0.211)
	General Diffuse-Compact Fluorescent (0.234)
	Direct Open Reflector-Halogen (0.332)
	Direct Down-Halogen (0.430)
	General Diffuse-Halogen (0.476)
	Direct Down-Incandescent (0.860)

OK

Example:

- Classroom LPD , from the above table is 2.0 W/sf maximum
- Since LPD (W/ft^2) ÷ 0.2928 (Btuh/W) = E (I) ,
  2.0 ÷ 0.2928 = EI = 6.83
- 6.83 ÷ 30 fc = 0.228 Btuh/h, ft^2, fc
- From the above schedule of lighting types, it is clear that incandescent, halogen and general diffuse fluorescent lighting will not meet the code. For the code reference building, input a value of 0.228 as the least efficient system allowed.

Accounting for Daylight Controls

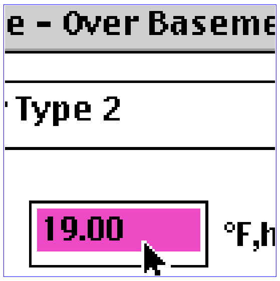
Energy Scheming assumes continuous dimming using daylight sensors and variable lighting controls. When there is enough daylight to meet the required illumination level (fc), no lights are used. When daylight is insufficient (or when it is blocked by opaque shades), electric light is used during occupied hours to make up the difference. Since Title XXIV does dot require automatic daylight sensitive controls, you can add the full value of the electric lighting load back to the graphic reports of your code reference building, thus making your design look outstanding! To do this:

- Set your occupancy schedule for the code building to include some night time hours. Run the ES calculation.
- Copy the graphic report to Photoshop.
- Cut out an hourly bar for electric lights during a night hour (all lights on).
- Reset your occupancy schedule to the correct times. Recalculate your graph.
- Copy the graphic report to a new Photoshop file. Cut and paste the electric lighting bar into the new graph for each hour of occupancy.
- You can do the same for the net flow with a little creative Photoshop work.

Obviously, this should be the LAST thing that you do.

E. EVALUATING: energy codes as indicators

model case building



3. Model Your Reference Case Building
Using the prescriptive values for your building type and climate, model you building in *Energy Scheming*.

shanley example.

Use the same geometry and takeoffs as you do for the actual building design. You may begin with either case first. After finishing you first case, make a copy of the file to use as the beginning point for your comparative case.

When modeling your reference case building:

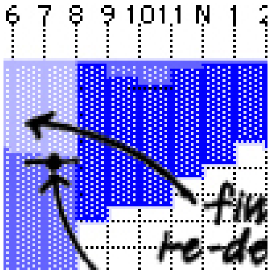
- Keep the floor, wall, and roof area takeoffs the same as in your design.
- Change R-values in the floor, wall, and roof specifications to match the prescriptive standards. Use the detailed specs to input exact R-values from the prescriptive standards.
- Do not specify stack ventilation.
- Do not specify any shading other than that specifically allowed in the prescriptive standards.
- For Residential Buildings, do not specify cross ventilation.
- For Commercial Buildings, limit opersable cross ventilation openings (inlets plus outlets) to 4% of floor area.
- Do not add additional thermal mass or south facing glass.

Keep internal temperature settings the same.

Jump to the next section: Compare the Performance of the Two Designs

E. EVALUATING: energy codes as indicators

compare two designs



shanley example.

4. Compare the Performance of the Two Designs

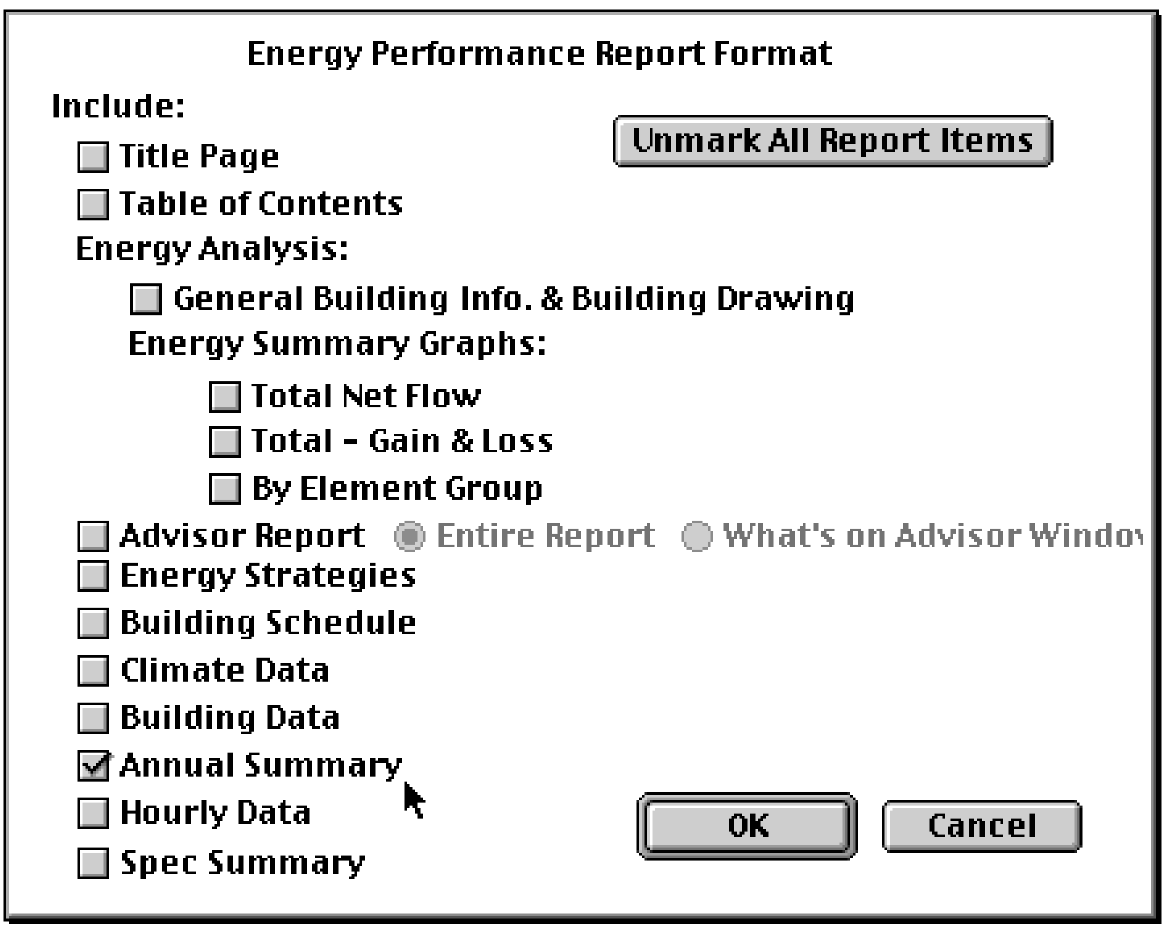
After changing settings and takeoffs for the reference building, calculate the energy performance. Compare the following graphs:

- net flow graphs for the Code Reference
- net flow graphs for your Initial Run Building (as is with no design changes)
- net flow graphs for your Final Run Building (after all design changes to improve performance)

For each set of graphs, estimate the following factors and compare for the three runs.

Month	Peak Load	Total Net Load
Winter	the lowest hourly loss in winter	sum of all hourly net losses for winter day
Summer	the highest hourly gain in summer	sum of all hourly net gains for summer day

To find the sum of hourly loads for a daily graph, printout the "Annual Summary" part of the "Energy Report". Choose **ONLY** the "Annual Summary". If you don't then you will get more information than you want, about 75 pages.



Compare the peak loads for your initial and final runs to the Code Reference Building.

- ***Compare the Peak Loads for each season***
  What percentage improvement (% load reduction) do your Initial and Final Run show, relative to the Code Reference Building?
  To find out:
  - 100 - (Run Z Peak ÷ Reference Bldg. Peak x 100%)
- ***Compare the Total Net Loads for each season***
  What percentage improvement (% load reduction) do your Initial and Final Run show, relative to the Code Reference Building?
  To find out:
  - 100 - (Run Z Total Daily Net ÷ Reference Bldg. Total Daily Net x 100%)

Evaluate how your final design performed relative to your Energy Use Goal
Did your initial run pass code? Did you meet your target of reducing code minimum performance by the percentage of your goal? If not, what changes could you make to improve performance further?

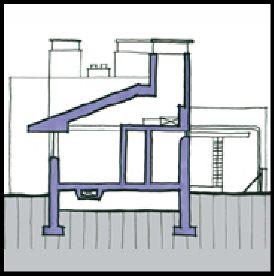
EXAMPLE PROJECT
shanley dental building, clayton, mo

harris armstrong, architect, 1936

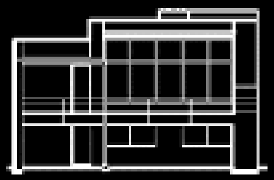
Worked Example

Re-Cycling with *Energy Scheming* exercise

Model



Final Drawings



Drawings

Site Photos

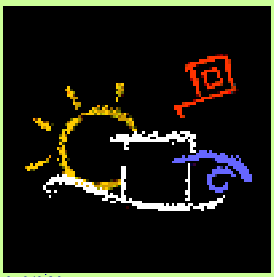
EXAMPLE PROJECT: example exercise

outline of example problem pages


exercise

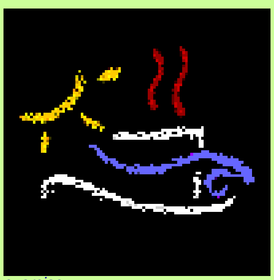
A. DOCUMENTING: input your building (example)

1. Assemble Schematic Plans and Elevations of Your Design
2. Identify the Building's Construction Type(s)
3. Diagram the Solar Concept
4. Determine Your Simulation Strategy
5. Diagram the Daylighting Zones
6. Get the Drawings into the Computer
7. Create a New Climate, if necessary


exercise

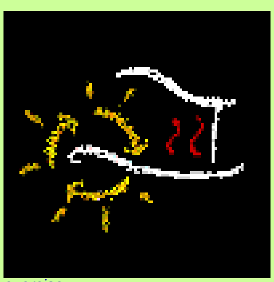
B. DEFINING: take-offs and specifications (example)

1. Tune Settings to Fit Your Building
2. Define Your Daylight Zone Icon
3. Set Performance Goals for Lighting and Heating
4. Create Plan Specifications
5. Create Elevation Specifications


exercise

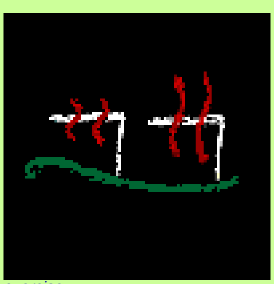
C. ANALYZING: understanding energy patterns (example)

1. Use the Rule-of-Thumb Window Sizer
2. View the Graphic Report
3. Interpret and Assess the Building's Performance


exercise

D. RE-DESIGNING: generate and test cycles (example)

1. Re-Design to Meet Your Window Performance Targets
2. Re-Design to Reduce Net Flows and Peak Loads
3. Print the "Energy Performance Report"
4. Document Design Changes


exercise

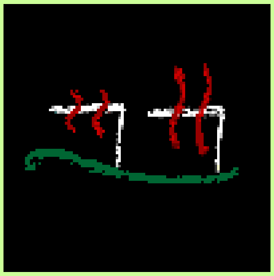
E. EVALUATING: comparing with energy codes (example)

1. Set an Energy Budget
2. Choose Reference Criteria
3. Model Your Reference Case Building
4. Compare the Performance of the Two Designs

Download the PDF version of the exercise

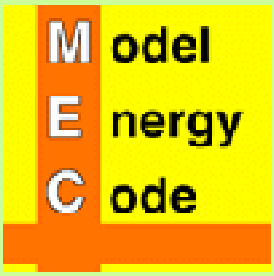
E. EVALUATING: comparing with energy codes

energy budget



1. Set an Energy Budget

exercise



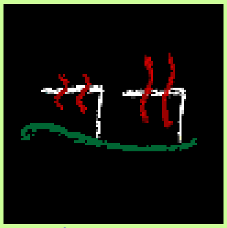
When upgrading an older existing building with poor insulation, such as the Shanley Building, bringing the building up to the standard of the Model Energy Code can be a challenge in itself. However, the MEC sets a standard that can basically be met by addressing conservation to reduce loads.

It does not require passive approaches to reducing the remaining loads. But since using *Energy Scheming* helps us to make buildings that "sail" on available site-based energy forces, we will go beyond the MEC. Ideally, we would like to make a building with zero heating and cooling loads, but being constrained by our existing site, with less than optimum orientation and building massing (the short south side), our goal for the Shanley Building re-design will be to improve the the building as much as possible while keeping the original design intentions of the architect. We choose a modest goal of 50% less than MEC.

Jump to the next EXAMPLE section: 2. Choose Reference Criteria

E. EVALUATING: comparing with energy codes

reference criteria



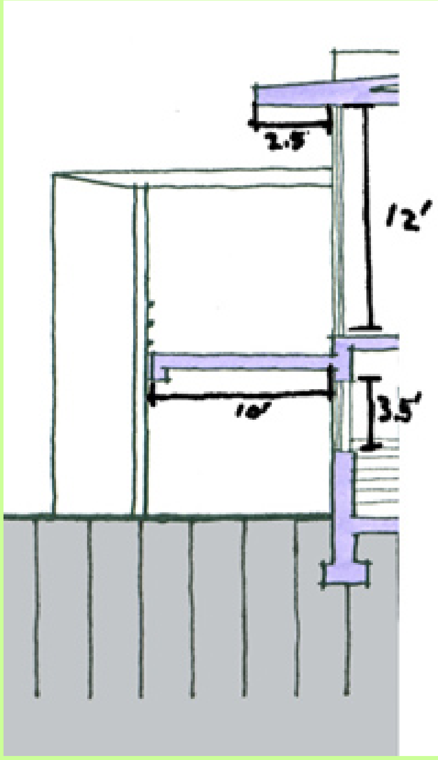
2. Choose Reference Criteria

exercise

To compare our redesign to the building required by code, we established the MEC criteria by beginning with the original building as designed, and then upgrading its elements, while holding fixed such existing conditions as the shading design and building form. Our climate zone for St. Louis City and County is Zone 10b for commercial buildings. The following criteria are base don the prescriptions for zone 10b (see table below).

1. The Shanley building has 761 sq. ft. of windows and 2732 sq. ft of wall area. So, that puts the building in the "High Fenestration Area " (25-40% of wall area) . Our total "window wall- ratio" for the entire building is 27% (716 / 2732 = 0.27).

2. The walls are masonry with no framing. From the table for the combination of masonry walls and high fenestration with no framing, we select the Minimum R value = 5.

3. 

Window U-value requirement is based on the WWR, while the Solar Heat Gain Coefficients (SHGC) requirements are based on the shading of the window as measured by a simple projection ratio, with lower SHGC required for poorer shading. There are several conditions for shading of windows in the original Shanley building. We selected U-values and SHGC's for each window, depending on its conditions.

The section illustrates the calculation of two projection ratios for the south facade.

- The main floor is shaded by a large overhang with proportions: 2.5 / 12 = 0.20. Therefore, from table below,
  - Max SHGC = 0.4
  - Max U-value = 0.5. Taking the reciprocal, the minimum R-value = 2. Use the R-value to input to ES.
- The lower windows are shaded by a balcony with proportions: 10 / 3.5 = 2.8. Therefore, from table below,
  - Max SHGC = 0.6
  - Max U-value = 0.5. Taking the reciprocal, the minimum R-value = 2. Use the R-value to input to ES.

This is a office window on the east side

- The office windows have projection = 2.5 / 4.
  Max SHGC = 0.6
  Max U-value = 0.5, so min. R-value = 2

This is the bathroom window on the north side

- Windows that are glass block have no projection
  Max SHGC = 0.4
  Max U-value = 0.5, so min. R-value = 2

4. There are no sky lights.

5. The roof system is all-wood joists with insulation in the roof cavity, so use R- 25 min.

6. The floor system is all-wood joists with insulation in the floor cavity, so use R- 19 min.

7. No insulation is required for the slab.

COMcheck-EZ™ Prescriptive Packages — Climate Zone 10b

Envelope Component		High Fenestration Area (25%-40% Window-Wall Ratio)		
Walls [a]		No Framing or	Metal Framing or	Wood Framing
Framed Any Spacing	Minimum *R*-value	NA	11	11
CMU, 8" or greater with Integral Insulation(b)	Minimum *R*-value	5	11	11
All Other Masonry Walls	Minimum *R*-value	5	11	11
Windows		No Projection	≥.25 Projection	≥.5 Projection
	Maximum Solar Heat Gain Coefficient	0.4	0.5	0.6
	Maximum U-Factor	0.5	0.5	0.5
Skylight (Limit 3% of Roof Area)				
	Maximum U-Factor		0.8	
Roof		Continuous Insulation	or	Roof Cavity Insulation
All-Wood Joist/Truss	*Minimum R-Value*	19		25
Nonwood Joist/Truss	*Minimum R-Value*	20		25
Concrete Slab or Deck	*Minimum R-Value*	19		NA
Metal Purlin with Thermal Break	*Minimum R-Value*	20		30
Metal Purlin without Thermal Break	*Minimum R-Value*	20		X
Floor		Continuous Insulation	or	Floor Cavity Insulation
All-Wood Joist/Truss	*Minimum R-Value*	12		19
Nonwood Joist/Truss	*Minimum R-Value*	13		19
Concrete Slab or Deck	*Minimum R-Value*	13		NA
Slab Edge or Basement Walls			Insulation	
	Minimum R-Value		0	

Notes:
(a) For walls next to unconditioned spaces, use the Low Fenestration Area wall requirements.
(b) Integral insulation in concrete masonry units may be perlite, vermiculite, or other insulating material.

- "NA" indicates the category is not applicable.
- A minimum R-value of zero indicates no insulation is required.
- "Any" indicates any available product will comply.
- "X" indicates no complying option exists in the prescriptive packages.

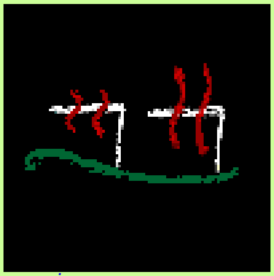
Note: this is an excerpt from the full table for Zone 10b, showing only the values for high WWR.

Jump to the next EXAMPLE section: 3. Model Your Reference Case Building

RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

E. EVALUATING: comparing with energy codes

reference case building



exercise

3. Model Your Reference Case Building

Methods

To set your buildings specifications for the MEC, you should work from an ES file that has the elements already defined. Then, go into the detailed specification windows and change the settings to match the MEC requirements.

Mass

Since MEC has no requirements for mass, you have a choice:

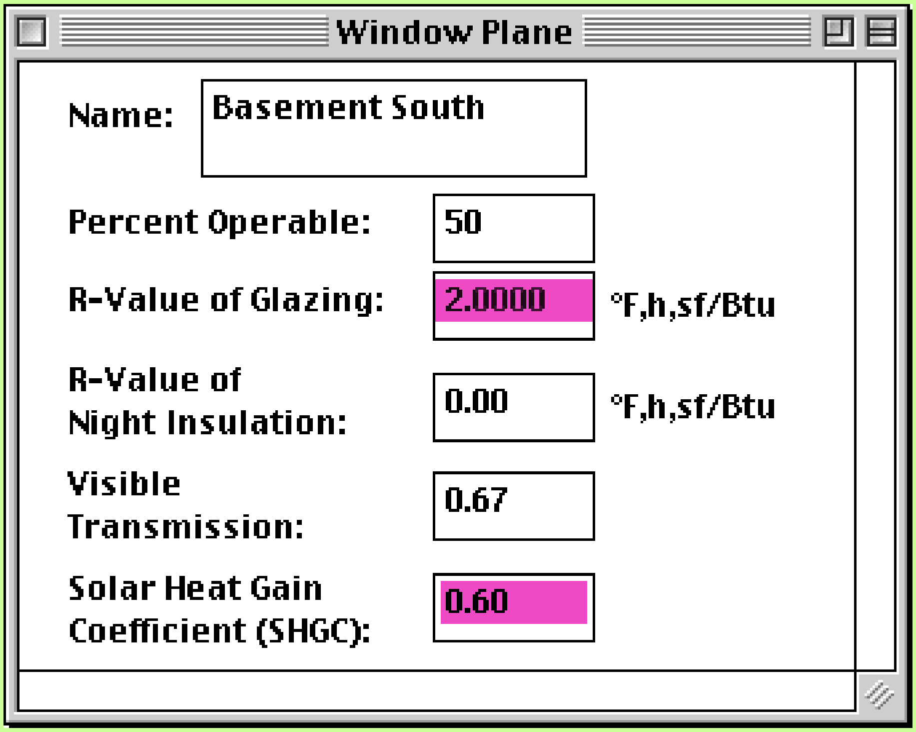
- Model your building with mass characteristics as originally designed, in which case ES will use mass for heat storage.
- Mode the "worst building allowed by code" by turning OFF all the mass in the specs. This will generally decrease your overall performance and show a bigger difference between the code building and your design, if you have used mass in your design.

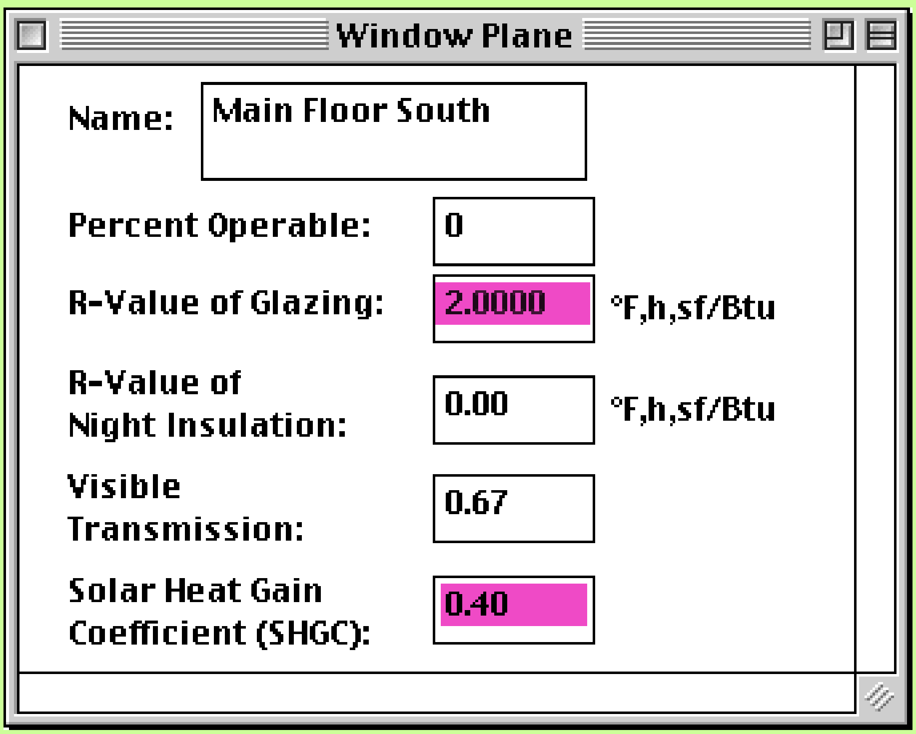
We used the first option, assuming that the basic characteristics of the original design, with its exposed mass surfaces, would be preserved while the insulation upgrades and window retrofits were carried out. So, the MEC building for our study INCLUDES the effect of all of the original mass. This means that we are assuming that wall insulation is added to the outside of the masonry and the building is re-stuccoed. If insulation were added to the inside, we would turn the mass off, since it would no longer be thermally coupled to the interior air.

Natural Ventilation.

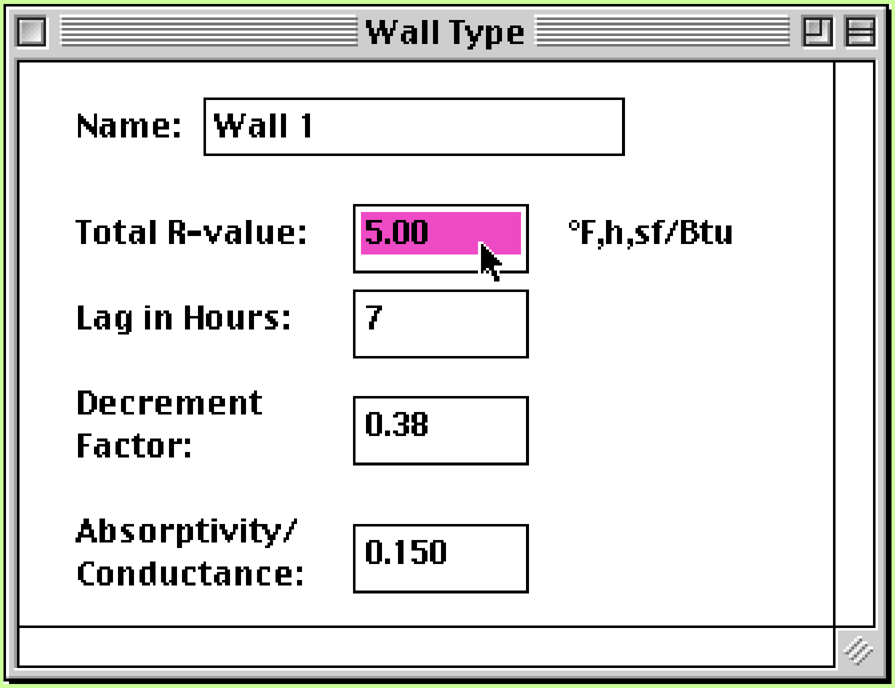
Remember to reduce the operable window areas to the minimum. The codes typically require that a free opening of at least 4% of the floor area be available for natural ventilation. Make sure that you define 4% of your windows as operable cross ventilation openings. This will allow you to compare the code minimum against your actual design, which in some cases may have more than 4% .

1. **Windows.**
   In the Detail Window Specs, we changed all the windows to an R-value of 2 and a SHGC of ether 0.6 or 0.4, depending on their shading projection.

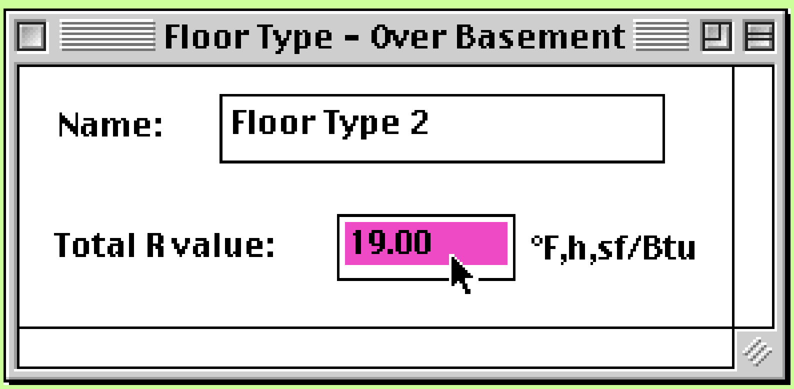




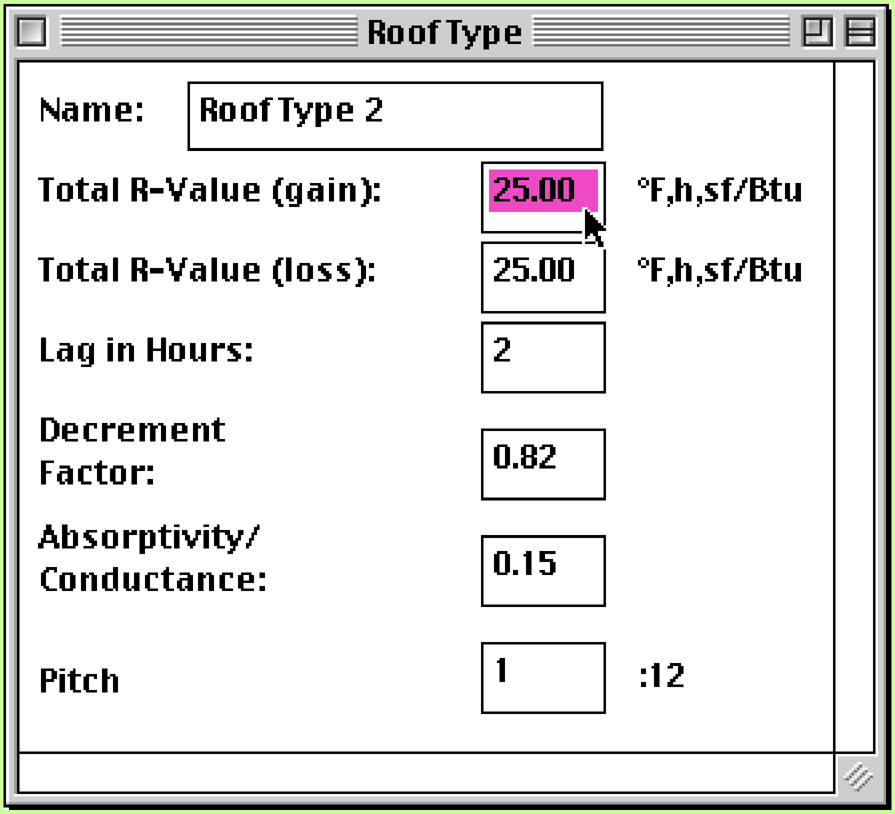
2. **Walls.**
In the Detail Wall Specs, we changed all the walls to have an R-value of 5, keeping their previously defined masonry characteristics.



3. In the Detail Floor Specs, we changed all the floors to have an R-value of 19.



4. **Floors**
   In the Detail Roof Specs, we change all the Roofs to have an R-value of 25 (note: change the loss and gain R-values to the same R- value)

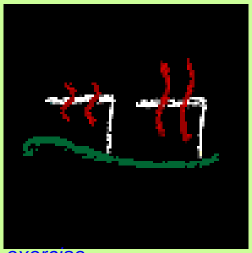


Jump to the next EXAMPLE section: 4. Compare the Performance of the Two Designs

RECYCLING WITH "*ENERGY SCHEMING*": Worked Example

E. EVALUATING: comparing with energy codes

compare



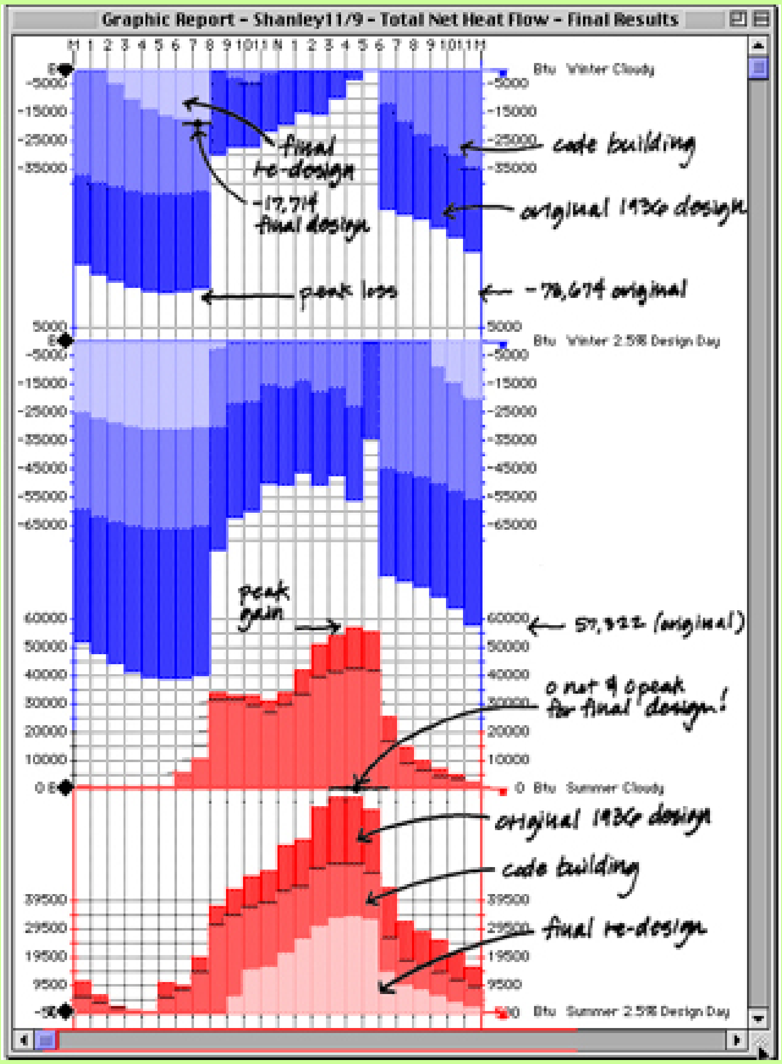
4. Compare the Performance of the Two Designs

[exercise](#)

NET FLOW PERFORMANCE REPORT

The following graphs show overlaid net flow graphs for three designs for two days, an average seasonal day and an extreme design day, in each of two seasons. The three designs shown are:

- The **Original Building** from 1936, as designed by Harris Armstrong
- The MEC **Code Building**, with minimum envelope requirements as specified by code.
- Our **Final Re-Design**



Overlaid Net Flow Graphs for Three Versions of the Shanley Building

Note: To see the annual Summary report that we used for the code building see ["Annual Summary"](#)

ORIGINAL BUILDING				
Season	**Peak Load**	**Total Net Load**		
Winter Cloudy	-78674	-1105971		
Winter Design Day	-119456	-1993788		
Summer Cloudy	57322	508228		
Summer Design Day	76360	826720		
CODE BUILDING			**Percent better then original**	
Season	**Peak Load**	**Total Net Load**	**Peak Load**	**Total Net Load**
Winter Cloudy	-43816	-487148	44 %	56 %
Winter Design Day	-66959	-998450	44 %	50 %
Summer Cloudy	41736	394125	27 %	22 %
Summer Design Day	52295	562120	32 %	32 %
INTERMEDIATE			**Percent better then Code**	
Season	**Peak Load**	**Total Net Load**	**Peak Load**	**Total Net Load**
Winter Cloudy	-32328	-117637	26 %	76 %
Winter Design Day	-59052	-634678	12 %	36 %
Summer Cloudy	39799	84779	5 %	78 %
Summer Design Day	50837	442657	3 %	21 %
FINAL BUILDING			**Percent better then Code**	
Season	**Peak Load**	**Total Net Load**	**Peak Load**	**Total Net Load**
Winter Cloudy	-17714	-80012	60 %	84 %
Winter Design Day	-30754	-279917	54 %	72 %
Summer Cloudy	0	0	100 %	100 %
Summer Design Day	34792	272033	33 %	52 %

Numeric Comparisons for Three Versions of the Shanley Building

EVALUATION:

Peak Loads for each season

The initial run showed large decreases in peak loads in both summer and winter, relative to the mostly uninsulated original design. Our Intermediate Re-Design was 26% better than the Code Building on a typical winter day, but only 5% better in summer. Since the building had reasonably good shading to begin with, we can assume that on hot days, when the building must remain closed, the difference between our envelope loads and those of the code building is not much. On average days, the better performance of the Intermediate building came from better ventilation.

In the Final design, a few more detail changes allowed improved ventilation and more mass storage, thus cutting the peak loads further: 60% better than code in winter and, because there is zero load all day in summer, there is no average day peak load! However, our extreme day peak loads show 52% and 33% improvements for winter and summer, respectively. This indicates that our re-design may have cut the mechanical equipment and duct sizing by about 1/2 for winter and by 1/3 for summer. The improvement is primarily due to the effects of mass in delaying and spreading peak load.

While these values are an indicator of peak load, they should not be used to size equipment, because the site forces of sun and wind may combine to create more extreme conditions. Equipment sizing is conventionally based on the maximum heat loss or gain under the design day conditions, ignoring the effects of passive strategies such as mass, ventilation, and solar heating. When taking account of these effects in sizing equipment, a more detailed assessment should be made in the design development stage, using conservative assumptions about site resources.

Compare the Total Net Loads for each season

The total net load is the sum of hourly loads for each of the 24 hours on the day modeled. The is can be determined easily from the Annual Summary portion of the Energy Performance Report in ES.

Upgrading to the MEC standards cut energy use on typical days by 56% in winter and 22% in summer. Our Intermediate design improved on this by 76% in winter and 78% in summer! Not bad. The final improvements cut the summer day to flat line balance and reduced winter days to 84% of the MEC building.

Evaluate how your final design performed relative to your Energy Use Goal

We substantially surpassed our design goal of reducing energy use to 50 below MEC requirements. Think of what one could do with a newly constructed building!

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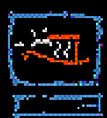	**A. DOCUMENTING: input your building**	**.5MB zipped**
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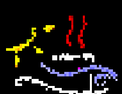	**C. ANALYZING: understanding energy patterns**	**.5MB zipped**
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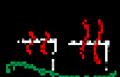	**E. EVALUATING: energy codes as indicators**	**.8MB zipped**