



Efficient and Sustainable Home Design

Paul Westbrook

www.enerjazz.com



Outline

- ❖ Sustainability & Efficiency
- ❖ Good Home Design
- ❖ Renewable Power
- ❖ Existing Home Tips



It's the right time . . .



. . . for sustainable development.



Sustainability

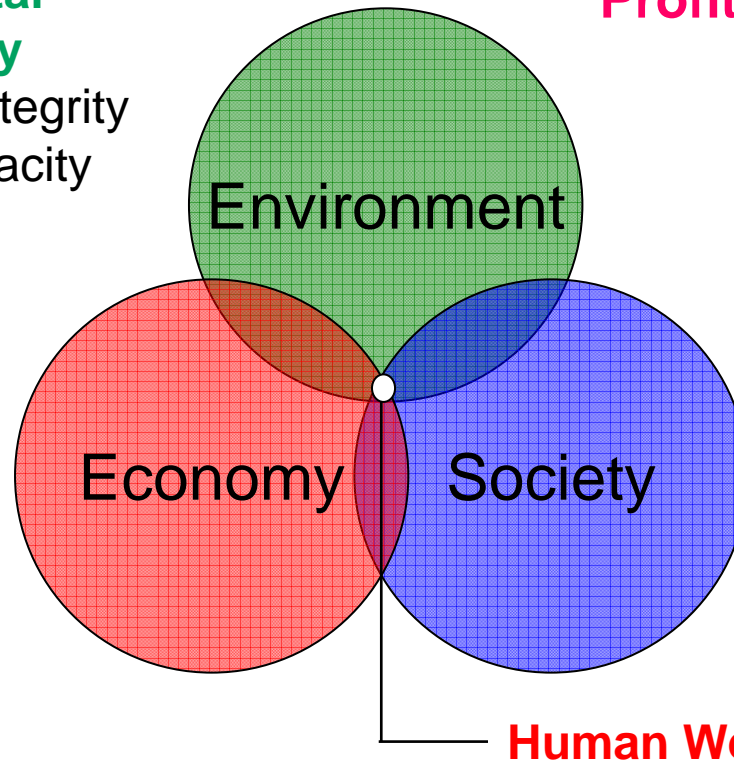
The Triple Bottom Line
The balance of **People**,
Profit, and the **Planet**

Environmental Sustainability

Ecosystem Integrity
Carrying Capacity
Biodiversity

Economic Sustainability

Growth
Development
Productivity



Social Sustainability

Cultural Identity
Empowerment
Accessibility
Stability
Equity

A sustainable system delivers services without exhausting resources. It uses all resources efficiently both in an environmental and economic sense.



Efficiency - The Negawatt

Negawatt (n) - a measure of energy efficiency; a unit in watts of energy saved

Solar and wind may be sexy . . .



. . . but **efficiency** yields the best **financial** and **environmental** benefits



The Westbrook House

- ❖ The Westbrook House, located in Fairview, Texas, was designed by Paul and Elena Westbrook. The builder was Enviro Custom Homes. The design won the 1996 NAHB Energy Value Housing Award for Innovative Design in a Warm Climate. The house uses about 1/3 the amount of electricity and 1/10 the amount of water as a conventionally built similar sized house.



Design Goals

- ❖ Energy Efficiency
- ❖ Low Maintenance
- ❖ Low Environmental Impact (Sustainable)
 - ◆ Reduce – Reduce the need for utilities and materials
 - ◆ Reuse – Make use of “waste” for other purposes
 - ◆ Recycle – Use recycled products to close the loop
- ❖ Affordable / Cost Effective



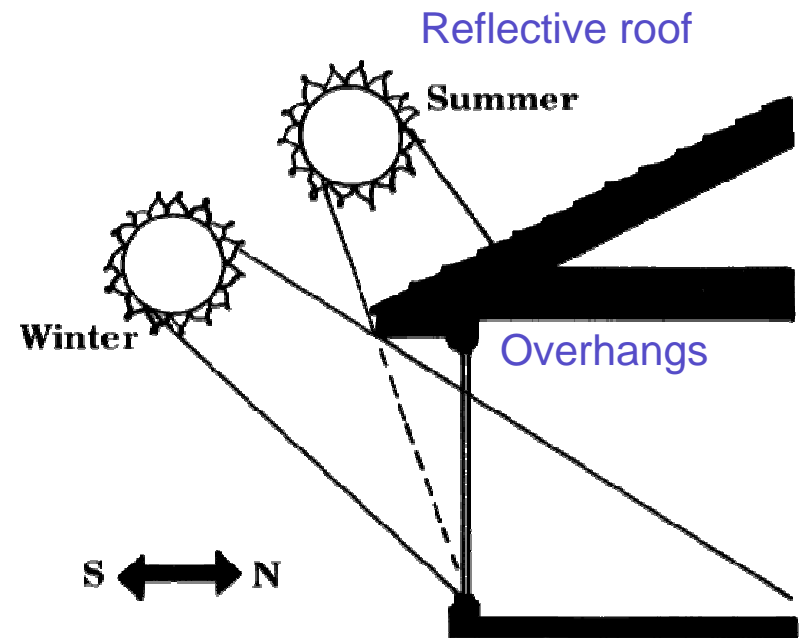
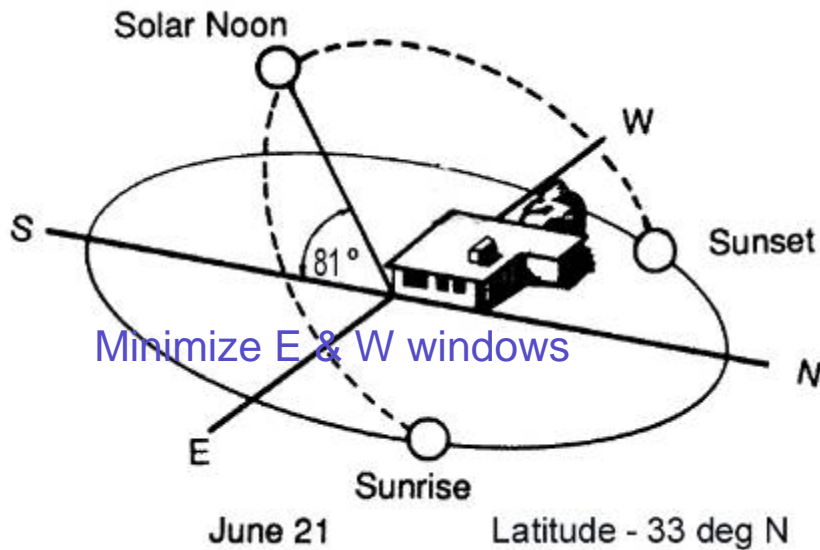
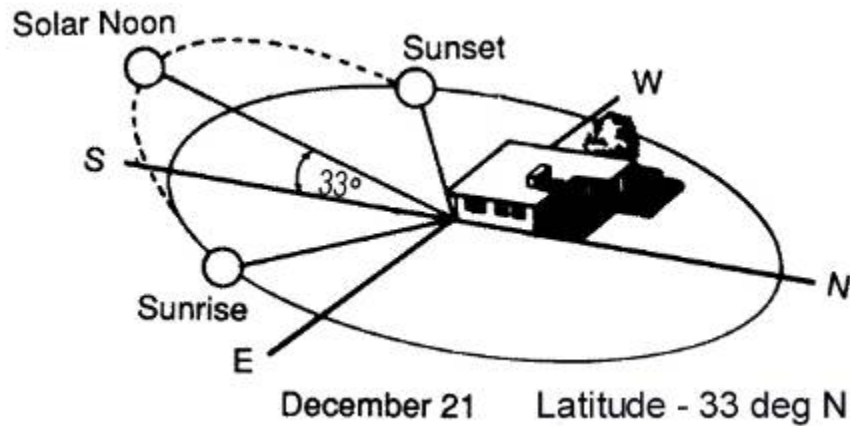
Design Methodology

- ❖ Site Selection/House Placement & Orientation
- ❖ Structure Size/Shape/Materials
- ❖ Window & Door Selection/Location/Placement
- ❖ Heating, Ventilation, and Air-Conditioning (HVAC)
- ❖ Water Heating / Water Efficiency
- ❖ All the Little Things



Passive Solar

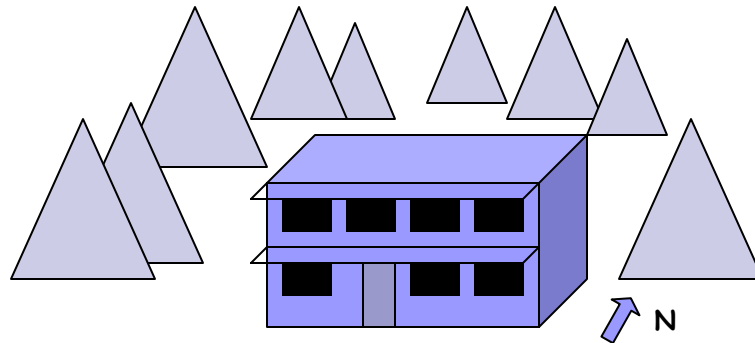
- ❖ Orientation
- ❖ Solar Control
- ❖ Mass and Insulation





Site / Placement / Orientation

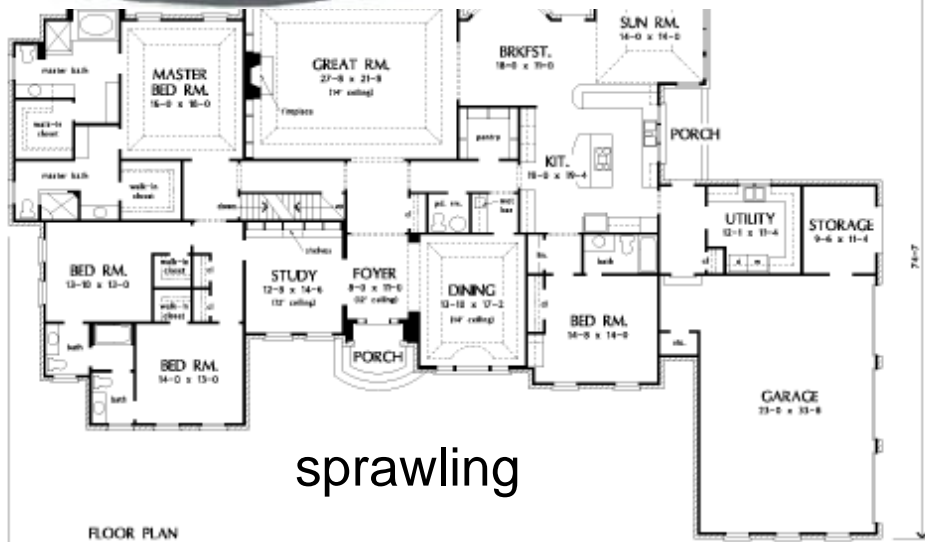
- ❖ Good southern exposure / evergreen trees to the north and west
- ❖ Preferably an east-west street (front of the house facing north or south)
- ❖ Long axis of the house running east-west
 - ◆ maximizes southern solar exposure
 - ◆ minimizes east and west solar exposure





Efficiency First

Which one requires more power to operate?



sprawling

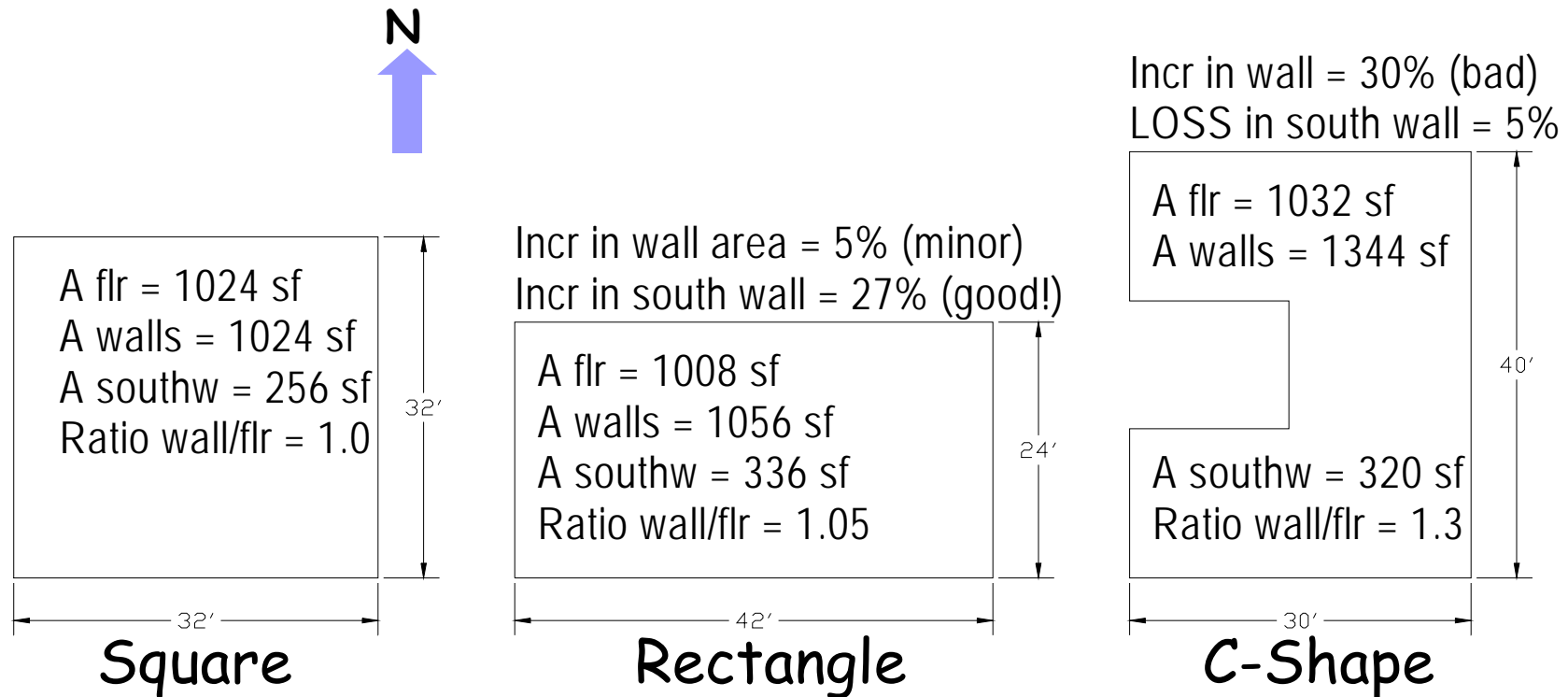


right sized



Structure Shape Comparison

- ❖ The shape and orientation of the house can affect energy use by approximately 30%





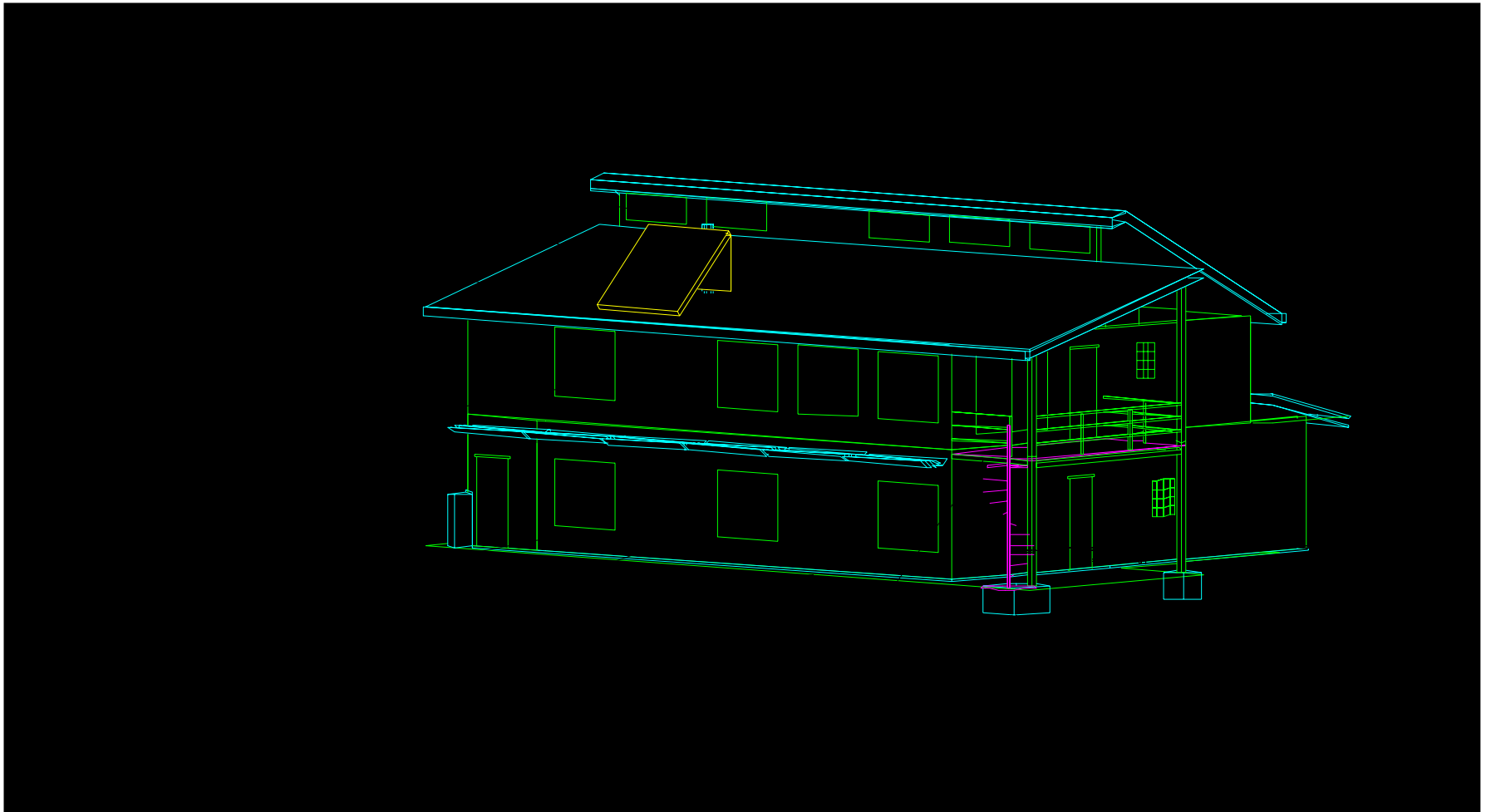
Structure Size/Shape/Material

- ❖ A 2-story rectangle is a space efficient and practical plan
- ❖ Structural Insulated Panels (SIPs) for the walls and roof offer several advantages
 - ❖ Very little air infiltration
 - ❖ Good, consistent insulation value
 - ◆ Thermal bridging is underestimated in stick built construction
 - ❖ Cost effective
 - ❖ 6" wall=R26,
8" roof=R33
 - ❖ Prefabed in large sections off site, minimizing on-site erection time and crew size





Westbrook House - Southeast View

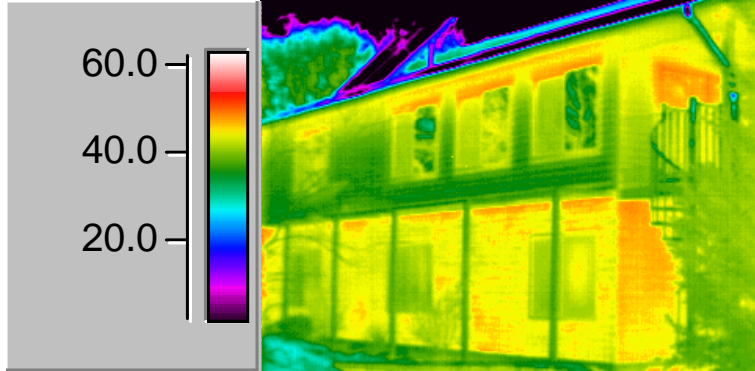




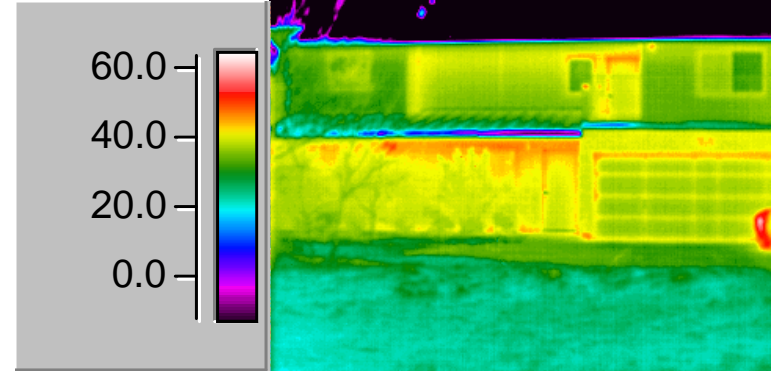
SIP Thermal Performance

These are infrared pictures of a SIP house and a standard construction house

Westbrook House - South Wall

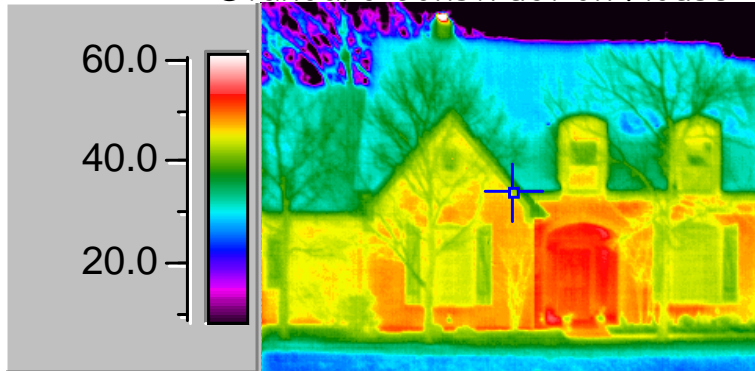


Westbrook House - North Wall

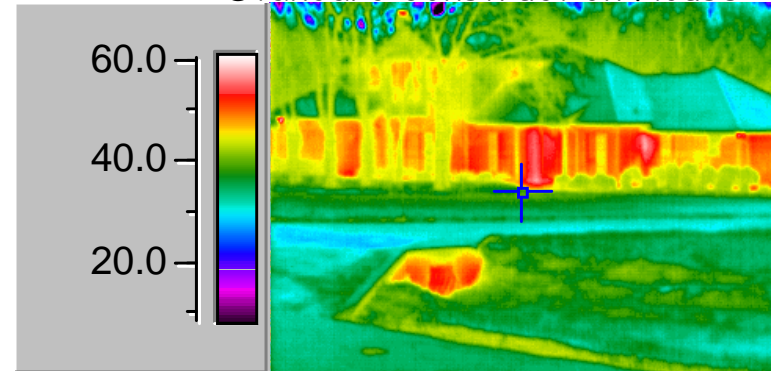


Outside
Temp =
43 deg F

Standard Construction House



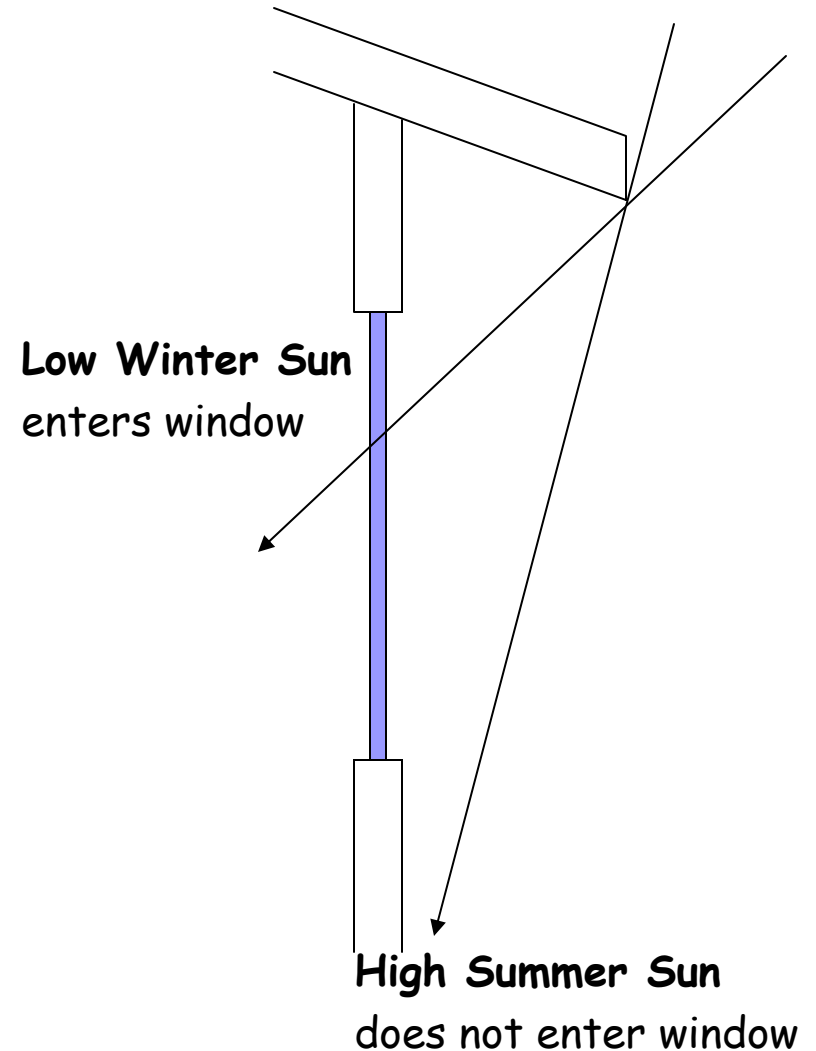
Standard Construction House





Window & Door Selection/Location/Placement

- ❖ Use double-pane, argon-filled, low-E units.
- ❖ I prefer vinyl for the low-maintenance and thermal performance.
- ❖ The majority of the windows should be on the south (60%+), the next most on the north, with as few as possible on the E&W.
- ❖ Placement and overhang size are critical.





Window Shading

Summer Shade



Winter Sun

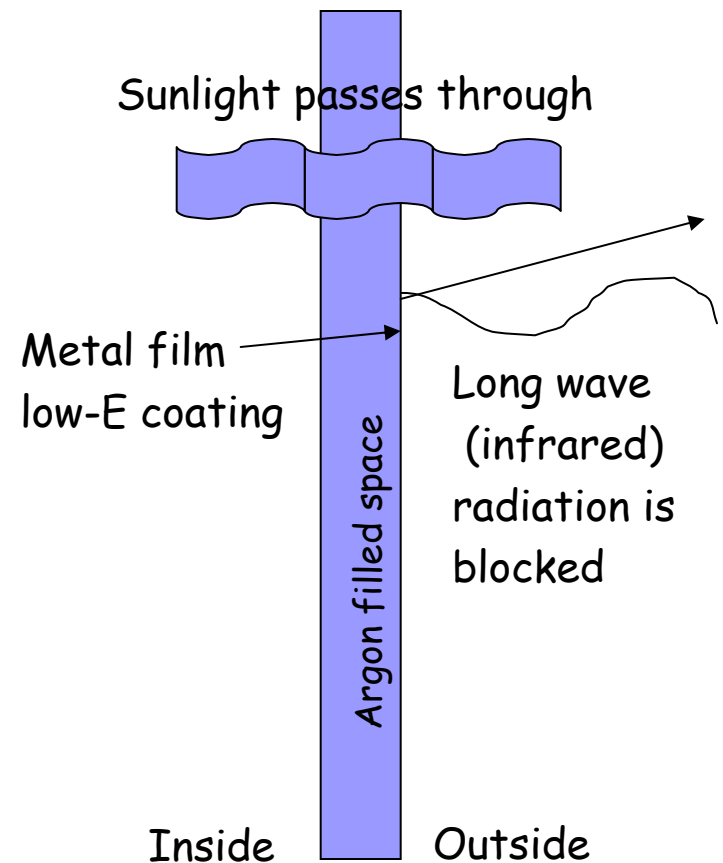


Passive Solar - taking advantage of the earth's tilt



Window Science

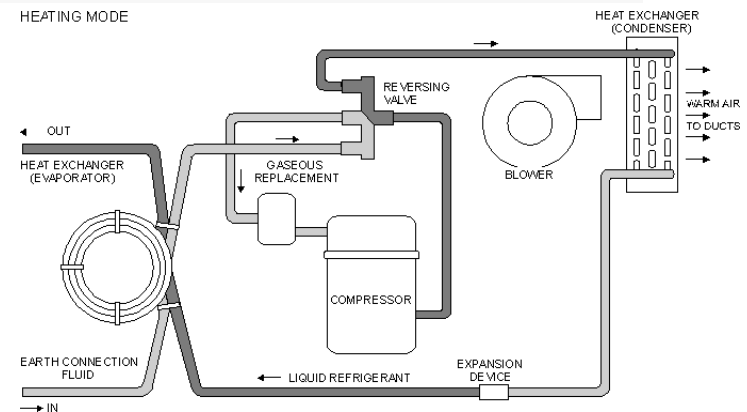
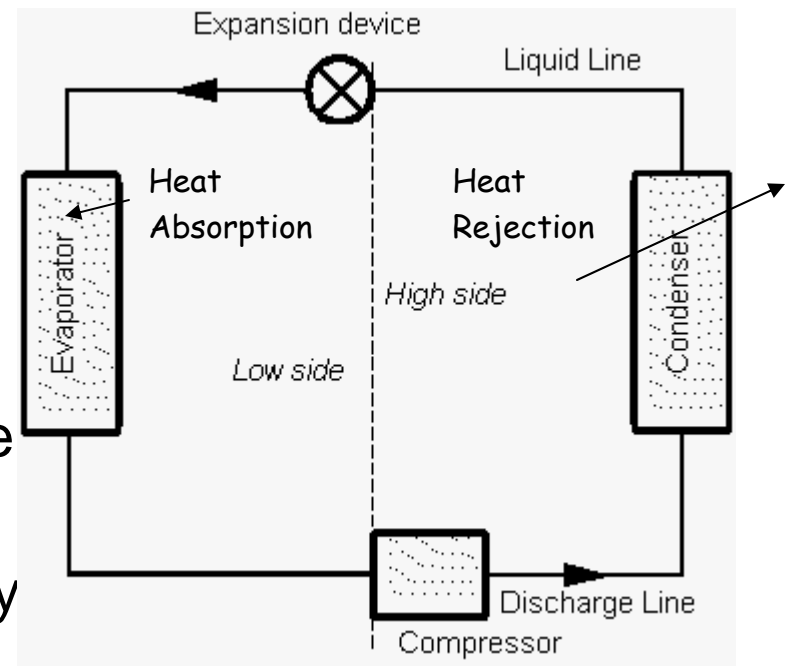
- ❖ Double pane provides an insulating air space
- ❖ Argon is denser than air (38% more), and does not conduct heat as readily (19% reduction)
- ❖ Low-E coatings block infrared (long wave) radiation and contribute to the comfort level of the home
- ❖ Radiation loss accounts for 2/3 of the losses by a window





HVAC - Load Calculation

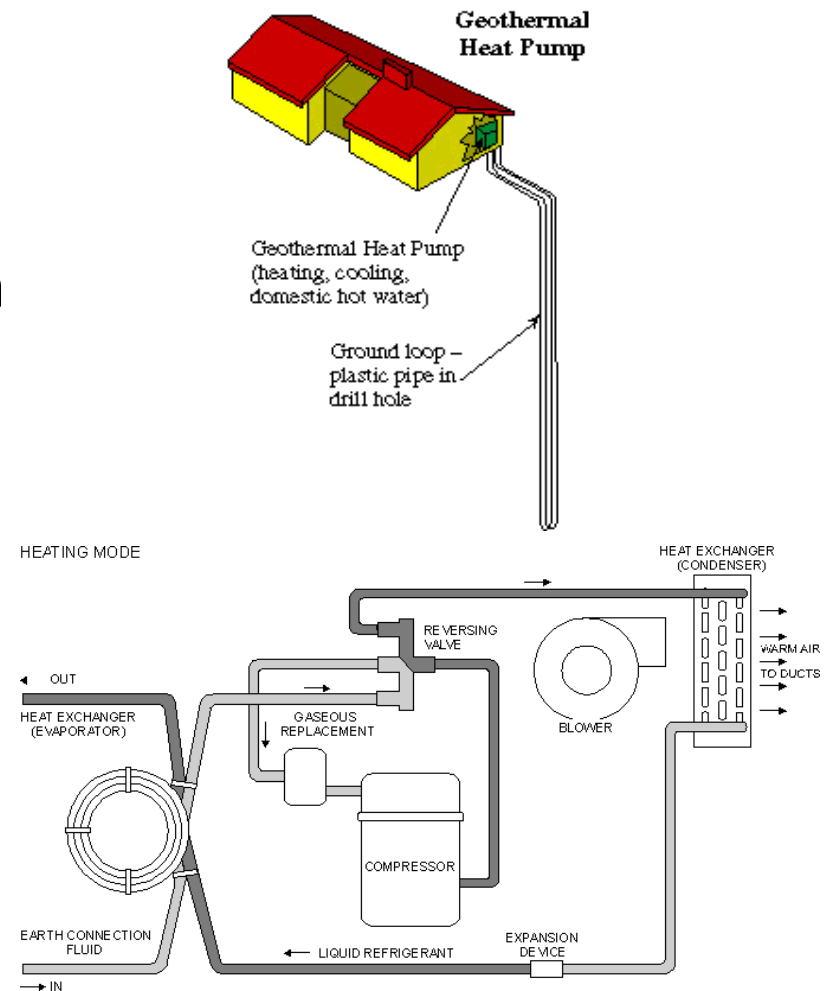
- ❖ Oversizing an HVAC system increases the initial cost and decreases the comfort. A short-cycling unit does not fully dehumidify.
- ❖ Two-speed units meet the variable loads more efficiently.
- ❖ Zoned duct is helpful in a two story home.
- ❖ Good design choices can greatly minimize the HVAC system size. The Westbrook House only needs 2 1/2 tons of cooling (2713 SF).





Ground Source Heat Pump (GSHP)

- ❖ The GSHP uses the relatively constant temperature of the earth as a heat sink or source.
- ❖ A GSHP can also be used as an efficient method of water heating.
- ❖ The minimum efficiency unit has a SEER of 13 (as of 2006). The Westbrook House GSHP has a SEER of 22.
- ❖ There is no noisy outdoor fan unit and we don't reject heat to the already overheated air.





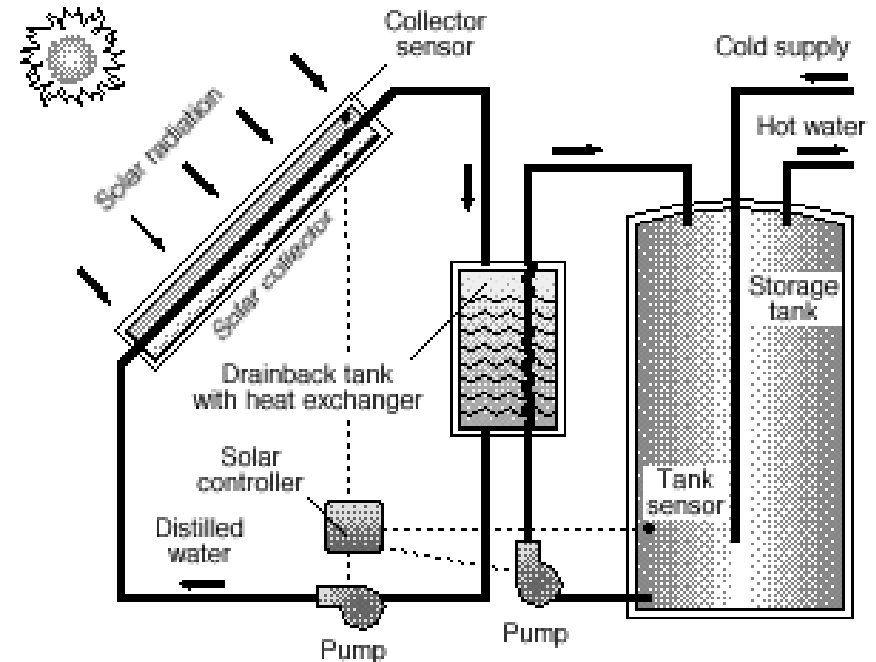
Efficient Lighting

- ❖ Passive solar design usually results in good natural lighting, decreasing the need for daytime artificial lighting
- ❖ Use of compact fluorescent lighting uses only $\frac{1}{4}$ th the energy of incandescent bulbs.
- ❖ Incandescent bulbs and halogen lights convert 80%-90% of the electric energy to heat, which increases your air conditioning load.
- ❖ Compact fluorescent lights last significantly longer than incandescent bulbs - each CF has a higher initial price, but the energy savings and long life give each bulb a net \$50 savings.



Water Heating

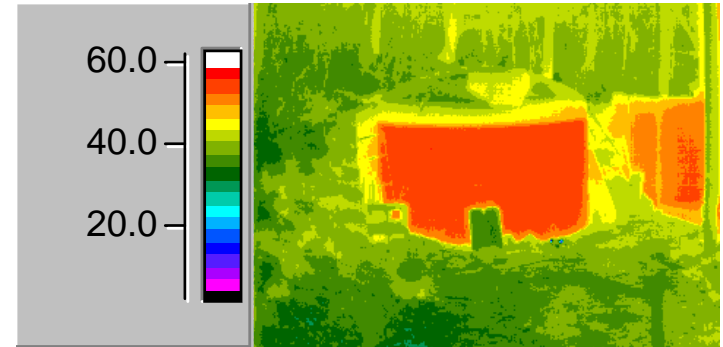
- ❖ Water heating can account for up to 30% of the electric use in a home.
- ❖ Solar Flat Plate water heating is very cost effective in the Dallas area.
- ❖ A side benefit of ground source heat pumps is the hot water recovery option which provides free hot water during the summer.
- ❖ R-25 polybutylene water heater / storage tank provides for long storage.





Water Efficiency

- ❖ Rain water collection from the roof can be used to:
 - ◆ provide water for outdoor use.
 - ◆ reduce urban runoff.
 - ◆ significantly lower your water bill.
- ❖ The first approach should be a native, low-maintenance lawn to reduce need.
- ❖ Rain water can also be used for human consumption.
- ❖ Our aerobic septic system uses our “waste” water to water the lawn.



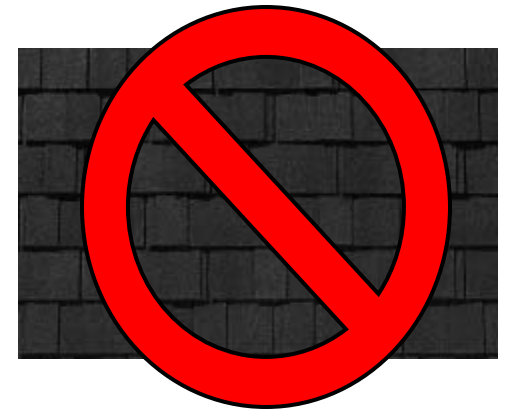
1600 gallon rain water storage tank





Roof

- ❖ In hot climates, exterior colors should be light for reflectivity.
- ❖ The roof material is a major heat absorber and should be light colored. Look for a roof material with high reflectance and high emissivity.
- ❖ A Galvalume metal roof reflects heat, provides a clean surface for rain collection, and reduces homeowners insurance rates (hail resistance). It also has a 50year + life.
- ❖ A coated metal roof is an even better reflector





All the Little Things

- ❖ Insulated hot water lines in the walls.
- ❖ Consolidated all plumbing to one area - no line loss.
- ❖ Earth bermed the west wall of the attached garage and insulated it - lowest garage winter temperature = 51 degrees F.
- ❖ Installed enthalpy wheel air to air heat exchanger for fresh air and humidity control.
- ❖ Used 100% recycled polypropylene carpet from Image.
- ❖ Installed motorized operators on clerestory windows for ventilation.
- ❖ Used efficient indoor appliances (refrigerator) reduce heat load
- ❖ Installed glass doors and outside air intake for fireplace combustion.
- ❖ Installed horizontal axis washing machine for efficient water use.
- ❖ Insulated the concrete slab foundation perimeter.
- ❖ Installed ceiling fans in almost every room.
- ❖ Compact fluorescent bulbs in almost every light fixture.



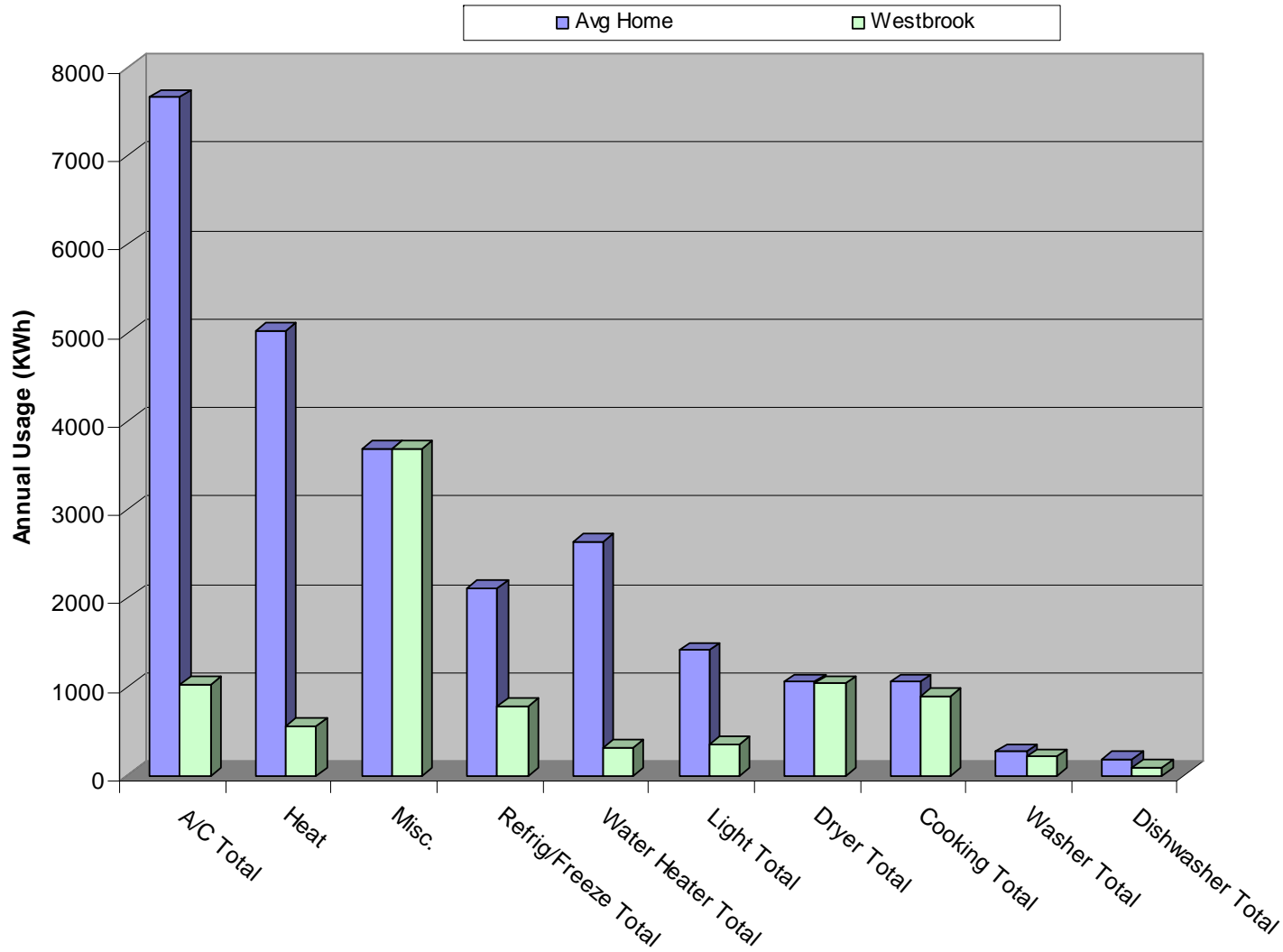
Energy Efficiency MAKES money

- ❖ Several items with large payback have little initial cost:
 - ◆ Design - orientation, window and overhang placement
 - ◆ Material color
- ❖ Some items pay back in other ways:
 - ◆ Well insulated shell reduces mechanical system size
 - ◆ Space efficient design reduces construction material cost
 - ◆ Metal roof reflects heat and provides a large discount on homeowners insurance (hail-resistant)



Utility Usage Comparison

Electric Usage - Average Home vs. The Westbrook House





Annual Utility Costs

Westbrook House Annual Utility Data

2,713 sf, 3 people

Year	kWh sum	kWh util	kWh wind	Cost/Yr	Average Cost/Mo	Elec Rate (\$/kWh)	kBtu/ sf	kWh/ sf/yr	kWh/ DD	Water Use/Yr (gallons)
1997	8,952	8,952	0	\$ 739	\$ 61.55	\$ 0.083	11.3	3.3	1.8	34,700
1998	10,195	10,195	0	\$ 781	\$ 65.09	\$ 0.077	12.8	3.8	1.9	27,900
1999	9,309	9,309	0	\$ 644	\$ 53.63	\$ 0.069	11.7	3.4	2.0	45,500
2000	9,966	9,966	0	\$ 684	\$ 56.99	\$ 0.069	12.5	3.7	2.0	38,400
2001	9,875	9,875	0	\$ 753	\$ 62.79	\$ 0.076	12.4	3.6	2.1	36,000
2002	10,404	10,404	0	\$ 893	\$ 74.45	\$ 0.086	13.1	3.8	2.1	28,000
2003	10,257	10,257	0	\$ 934	\$ 77.87	\$ 0.091	12.9	3.8	2.1	38,000
2004	10,624	10,624	0	\$ 988	\$ 82.37	\$ 0.093	13.4	3.9	2.4	25,000
2005	11,205	11,205	0	\$ 1,177	\$ 98.08	\$ 0.105	14.1	4.1	2.3	37,000
2006	10,633	10,555	78	\$ 1,443	\$ 120.28	\$ 0.137	13.4	3.9	2.2	35,000
2007	9,916	9,770	146	\$ 1,305	\$ 108.79	\$ 0.134	12.5	3.7	2.0	35,000
Sums and Averages	kWh sum	kWh util	kWh wind	Cost		Elec Rate (\$/kWh)	kBtu/ sf	kWh/ sf/yr	kWh/ DD	Water Use (gallons)
Total>	111,336	111,112	224	\$10,343						310,500
Annual>	10,121	10,101		\$ 940		\$ 0.083	12.7	3.7	2.1	34,500
Monthly>	843	842			\$ 78.35					2,875



Payback Information

Westbrook House Payback Information		
Electricity Savings		
Westbrook House Average Electric Bill:	\$61.00	/mo
Westbrook House Highest Electric Bill:	\$98.90	Jul-98
Westbrook House Electric Cost/Yr:	\$732.00	
Average Home Elec. Cost/Yr:	\$2,082.00	similar size house, source TU electric
Westbrook House Annual Savings:	\$1,350.00	
Westbrook House Monthly Savings:	\$112.50	
Payback		
Cost for Energy Efficiency Items:	\$13,000.00	total spent on energy efficiency improvements
Monthly payment added to a 15 year mortgage:	\$113.24	/month @ 6.5% int
Interest on \$13,000 over the life of the loan:	\$7,714.27	
Tax deductible interest:	\$1,311.43	assume effective 17% tax rate
Actual monthly tax savings:	\$7.29	
Actual monthly cost for efficiency improvements:	\$105.96	MORTGAGE COST - TAX SAVINGS
Net SAVINGS /month in year one:	\$6.54	MONTHLY SAVINGS - MONTHLY COST
Net SAVINGS over the life of the loan:	\$1,177.51	
Energy Efficiency SAVES money		
Environmental Benefit of Energy Efficiency		
Our electricity savings/year:	16000	KWh
Annual reduction in CO2 emissions:	22700	lbs/yr
Annual reduction in SO2 emissions:	100	lbs/yr
Annual reduction in NOx emissions:	100	lbs/yr



Efficiency First...Then Generation

- ❖ Since I have driven the consumption down I'm now investigating generation with solar and wind energy
- ❖ In 2006 I was selected by Southwest Windpower as a test location for their new 1.8kW wind generator

Wind Generator



- ❖ Developed with the National Renewable Energy Lab (NREL)
- ❖ Designed to be a simple, quiet, efficient, and clean power source for residences



Skystream Wind Turbine





Tips for Existing Homes

- ❖ Consider an energy audit to help prioritize your efforts
- ❖ Change all your light bulbs to compact fluorescent or even LED
- ❖ The attic is usually a good place to start
 - ◆ Adequate insulation
 - ◆ Check ductwork for leaking connections and proper insulation
 - ◆ Provide good ventilation – exit AND intake
 - ◆ Radiant barrier



Tips for Existing Homes

- ❖ Plug leaks in walls – caulk and weatherstrip
- ❖ Windows are the next place to look
 - ◆ Double pane, low-e
 - ◆ Properly shaded
- ❖ Tune up your systems
 - ◆ Change the air conditioner filter
 - ◆ Clean the exterior coils
 - ◆ Insulate your water heater
- ❖ Appliances
 - ◆ Purchase Energy Star appliances
 - ◆ Measure your appliances energy use
 - ◆ Put your energy “vampires” on a plug strip





A Few Final Thoughts

- ❖ Optimize – don't compromise
- ❖ Everything is connected and related – recognize the connections
- ❖ Simple solutions are usually the best

Visit my web site for tips and links:
www.enerjazz.com/house