

## The Westbrook House

Efficient and Sustainable Home Design

Paul Westbrook www.enerjazz.com/house



- Sustainability & Efficiency
- Efficient Home Design / Passive Solar
- Mechanical Systems
- Renewable Energy
- Data
- Existing Home Tips

#### It's the right time . . .





#### ... for sustainable development.

Westbrook House enerjazz.com/house

## 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 1/4th the amount of energy and 1/8th 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**



## 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



## 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 enerjazz.com/house

### Westbrook House - Southeast View

Compact, two story stacked



## **SIP Thermal Performance**

# These are infrared pictured of a SIP house and a standard construction house



#### Window & Door

#### Selection/Location/Placement

- Use double-pane, argonfilled, low-E units.
- I prefer vinyl for the lowmaintenance 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.







Photos at solar noon:

•Winter solstice (left)

•Equinox (lower left)

•Summer solstice (below)



## 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 shortcycling 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 14 (as of 2020). The Westbrook House GSHP has an EER of 28.
- There is no noisy outdoor fan unit and we don't reject heat to the already overheated air.



## Energy Recovery Ventilator (ERV)

#### The house is very air tight

- GOOD: energy savings, minimal dust
- BAD: not much fresh air
- An ERV brings in a steady stream of fresh air, but recovers much of the energy from the exhausted air
- Recovers over 70% of the total energy



## Efficient Lighting

- Passive solar design usually results in good natural lighting, decreasing the need for daytime artificial lighting
- Incandescent bulbs and halogen lights convert 80%-90% of the electric energy to heat, which increases your air conditioning load.
- LED lighting is even more efficient than compact fluorescent and has better color temperatures and much longer life.



#### The st Four to Cedars House

## 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



## Water Efficiency

- House designed with all fixtures plumbed to a common water wall - no fixture is far from the water heater
- Low flow fixtures toilets, faucets, and shower heads all contribute

#### 2009 North Texas Municipal Water District Water Genius Award Winner



### Floor Plan - Stacked

#### Common plumbing wall



Living areas upstairs



•1<sup>st</sup> Floor

•2<sup>nd</sup> Floor



- 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 temperature stays between 51 – 86 degrees F
- Enthalpy wheel air to air heat exchanger for fresh air and humidity control
- 100% recycled polypropylene carpet from Image
- Motorized operators on clerestory windows for ventilation
- Efficient indoor appliances (refrigerator) to reduce heat load
- Wood stove with outside air intake for combustion
- Horizontal axis washing machine for efficient water use
- Insulated the concrete slab foundation perimeter
- Ceiling fans in almost every room
- LED bulbs in almost every light fixture
- Recycled plastic / waste cedar shavings for deck board
- Low VOC paint

## Energy Efficiency/Best Investment

- 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)

#### Nice Looking and Nature Friendly











## Utility Usage Comparison

#### Relative Heating / Cooling Energy





## **Payback Information**

#### Payback was one month on a cash flow basis

Electricity Savings (all electric home)										
Average Electric Bill:	\$85.00	avg use: 809 kWh/month								
Highest Electric Bill:	\$170.71	Aug-06								
Westbrook Electric Cost/Yr:	\$1,019.34	809kWh/mo * \$0.105/kWh over 15 year avg								
Average Home Elec. Cost/Yr:	\$3,068.00	Avg use south: 10.77 kWh/sf/yr @ .101/kWh								
Annual Savings:	\$2,048.66									
Monthly Savings:	\$170.72									
Payback										
Cost for Energy Efficiency Items:	\$ 13,000.00	Total cost of all energy efficiency upgrades								
Added to a 15 year mortgage:	\$99	/mo @ 5.5% int + tax deduct on mortgage								
Added to a 30 year mortgage:	\$75	/mo @ 6% int + tax deduct on mortgage								
With a 15 year mortgage, you SAVE:	/month - but get full savings faster.									
With a 30 year mortgage, you SAVE:	/month									
First month I paid \$99 more on the mortgage, but \$171 less to the utility. Net of \$72 in one month.										
After the mortgage is paid, you realize the full savings every month.										
Note that mortgage interest is tax deductib										
Energy bills are not deductible. In fact, energy use is taxed.										
Payback occurred in the first month when we paid more to the mortgage co. but less to the utility.										

### Efficiency First...Then Generation

- Since I have driven the consumption down I started adding on site renewable energy generation
- 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









In 2012 we installed a solar PV system

- Because of the efficiency we needed only a 3.7kW system to meet 80% of our energy needs
- The wind turbine was hampered by my large trees, so I sold it in 2013

Introduction to solar electricity presentation link: https://enerjazz.com/house/files/Solar\_PV\_Basics.pdf



## Solar PV System

- Installed a 3.3kW array in 2012 (expanded in 2014 to 3.75kW)
  - Produces more electricity than we need for 3-4 months a year
  - Produces > 80% of our electrical needs during the year
  - A ~5kW system would have made us an annual net zero site energy home, but our utility rate structure was poor – no payment for excess energy to the grid and a low-use fee penalty for not using enough energy each month.
  - Utility rules finally changed in 2020

#### Results: Energy Efficiency



## Annual Utility Costs

The off

Texas average = 41kBtu/sf

Westbro	ok Hous	e Annua	al Utilit	2,713 sf, 3>2 people							
											Water
	kWh		kWh	kWh	Elec		Average	kBtu/	kWh/	kWh/	Use/Yr
Year	house	kWh util	wind	solar	Cost/Yr		Cost/Mo	sf	sf/yr	DD	(gallons)
1997	8,952	8,952	0		\$ 739	\$	61.55	11.3	3.3	1.8	34,700
1998	10,195	10,195	0		\$ 781	\$	65.09	12.8	3.8	1.9	27,900
1999	9,309	9,309	0		\$ 644	\$	53.63	11.7	3.4	2.0	45,500
2000	9,966	9,966	0		\$ 684	\$	56.99	12.5	3.7	2.0	38,400
2001	9,875	9,875	0		\$ 753	\$	62.79	12.4	3.6	2.1	36,000
2002	10,404	10,404	0		\$ 893	\$	74.45	13.1	3.8	2.1	28,000
2003	10,257	10,257	0		\$ 934	\$	77.87	12.9	3.8	2.1	38,000
2004	10,624	10,624	0		\$ 988	\$	82.37	13.4	3.9	2.4	25,000
2005	11,205	11,205	0		\$ 1,177	\$	98.08	14.1	4.1	2.3	37,000
2006	10,633	10,555	78		\$ 1,443	\$	120.28	13.4	3.9	2.2	35,000
2007	9,916	9,770	146		\$ 1,305	\$	108.79	12.5	3.7	2.0	28,000
2008	9,661	9,419	242		\$ 1,364	\$	113.65	12.2	3.6	1.9	38,000
2009	8,403	8,118	285		\$ 1,247	\$	103.92	10.6	3.1	1.8	29,000
2010	9,034	8,788	246		\$ 1,222	\$	101.84	11.4	3.3	1.7	34,000
2011	8,571	8,238	333		\$ 1,137	\$	94.73	10.8	3.2	1.5	42,000
2012	7,573	7,137	228	208	\$ 1,033	\$	86.07	9.5	2.8	1.6	29,000
2013	7,791	2,625	216	4,950	\$ 590	\$	49.21	9.8	2.9	1.5	33,000
2014	8,742	3,472	7	5,263	\$ 698	\$	58.14	11.0	3.2	1.7	28,000
2015	8,670	3,976	0	4,694	\$ 735	\$	61.27	10.9	3.2	1.7	27,000
2016	6,817	1,786	0	5,031	\$ 462	\$	38.51	8.6	2.5	1.5	22,000
2017	6,326	1,437	0	4,889	\$ 465	\$	38.72	8.0	2.3	1.5	21,000
2018	6,932	2,019	0	4,913	\$ 486	\$	40.50	8.7	2.6	1.4	20,000
2019	5,603	972	0	4,631	\$ 361	\$	30.08	7.0	2.1	1.1	25,000

### New for 2020 – Utility Changes

- In January, our utility started allowing us to carry over excess monthly production
- In July, they introduced new rate plans, including a free nights and weekends plan
- We analyzed our use data and switched and had zero energy cost during the two hottest months of the year

			Total	Day	N/WE		Pwr		Low				Base		
	Bank	Bank	Net	Net	Net	Elec	Cost	Base	Use	Franch.	Sales	Elec	Fees	Energy	Energy
Date	Used	Bal.	kWh	kWh	kWh	Cost (\$)	Factor	Cost (\$)	Fee (\$)	Fee (\$)	Tax (\$)	Total (\$)	(\$/mo)	Total (\$)	\$/kWh
1/14/20			283			\$ 27.45	\$ 2.83	\$ 18.00	<b>\$</b> -	\$ 1.93	\$ 1.00	\$ 51.22	\$ 19.10	\$ 32.12	\$ 0.113
2/14/20			367			\$ 35.60	\$ 3.67	\$ 18.00	\$ -	\$ 2.29	\$ 1.19	\$ 60.75	\$ 19.10	\$ 41.65	\$ 0.113
3/14/20			145			\$ 14.07	\$ 1.45	\$ 18.00	\$ -	\$ 1.34	\$ 0.70	\$ 35.56	\$ 19.10	\$ 16.46	\$ 0.113
4/14/20			104			\$ 10.09	\$ 1.04	\$ 18.00	<b>\$</b> -	\$ 1.17	\$ 0.61	\$ 30.90	\$ 19.10	\$ 11.80	\$ 0.113
5/14/20	-	77	(77)			<b>\$</b> -	\$ -	\$ 18.00	\$ 5.00	\$ 0.92	\$ 0.48	\$ 24.40	\$ 24.40	\$ (0.00)	\$ 0.113
6/14/20	3	74	-			<b>\$</b> -	<b>\$</b> -	\$ 18.00	\$ 5.00	\$ 0.92	\$ 0.48	\$ 24.40	\$ 24.40	\$ (0.00)	\$ 0.113
7/17/20	74	-	100			\$ 9.70	\$ 0.50	\$ 18.00	<b>\$</b> -	\$ 1.13	\$ 0.59	\$ 29.92	\$ 24.40	\$ 10.81	\$ 0.108
8/14/20	-	63	197	(63)	260	<b>\$</b> -	\$ -	\$ 23.00	\$ -	\$ 0.92	\$ 0.48	\$ 24.40	\$ 24.40	\$ (0.00)	\$ 0.108
9/14/20	-	104	243	(41)	544	\$-	\$ -	\$ 23.00	\$ -	\$ 0.92	\$ 0.48	\$ 24.40	\$ 24.40	\$ (0.00)	\$ 0.108

### More Information

How to live and work better with less PAUL WESTBROOK

EFFICIENCY

The

I published a book with general efficiency tips, details on my house, and details on industrial efficiency

#### joyofefficiency.com

Paul Westbrook

Radical Efficiency, LLC

## Tips for Existing Homes

- Consider an energy audit to help prioritize your efforts
- Change all your light bulbs to 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
- Tune up your systems
  - Change the air conditioner filter
  - Clean the exterior coils
  - Insulate your water heater
- Appliances

1505

- Purchase Energy Star appliances
- Measure your appliances energy use
- Put your energy "vampires" on a plug strip
- Windows are another place to look
  - Double pane, low-e
  - Properly shaded



#### 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