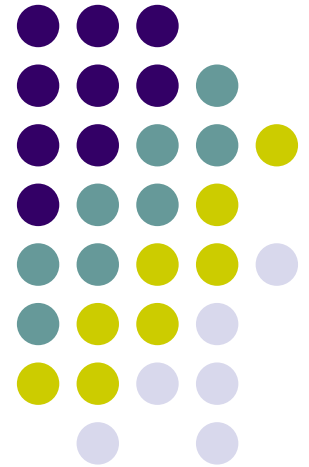
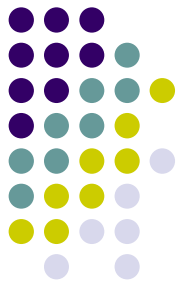


Affordable Passive Solar Housing

Jeff Tiller, PE
Appalachian State University
Southface- NC
tillerjs@appstate.edu

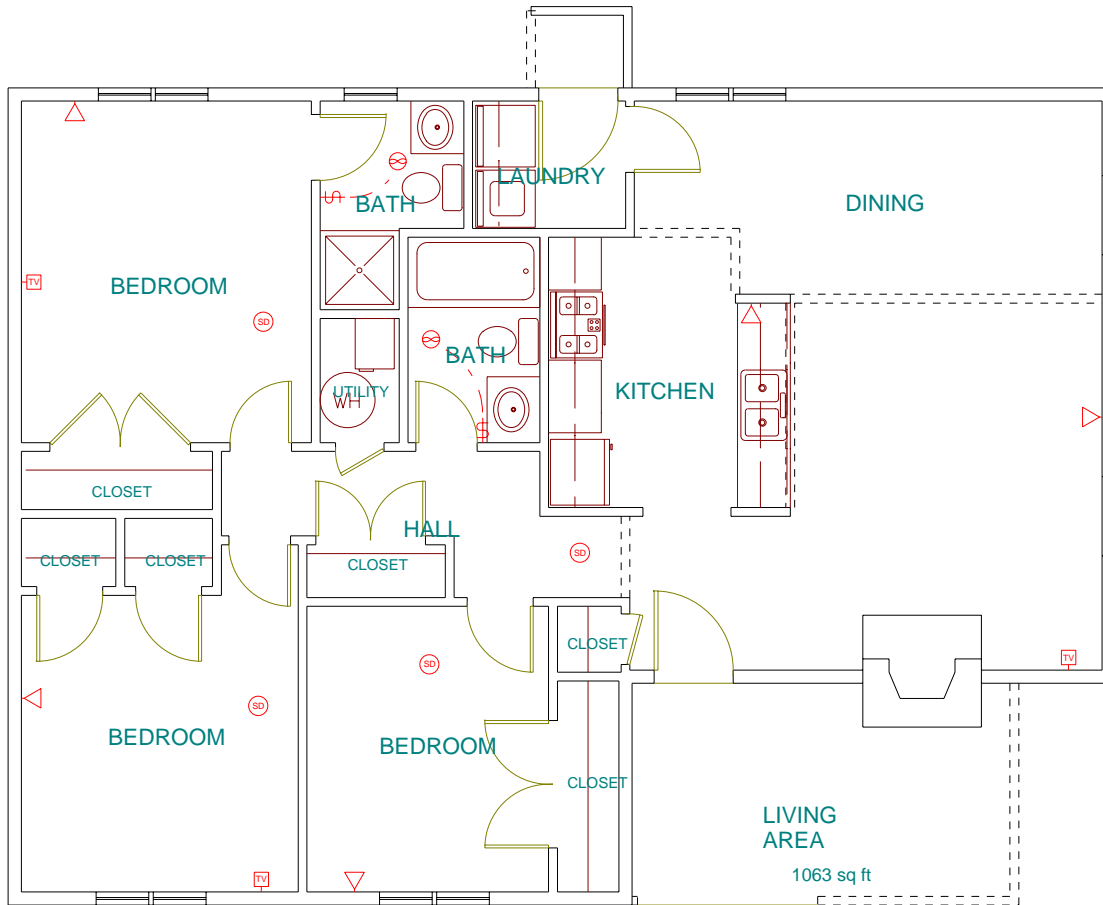


What is Passive Solar Design?



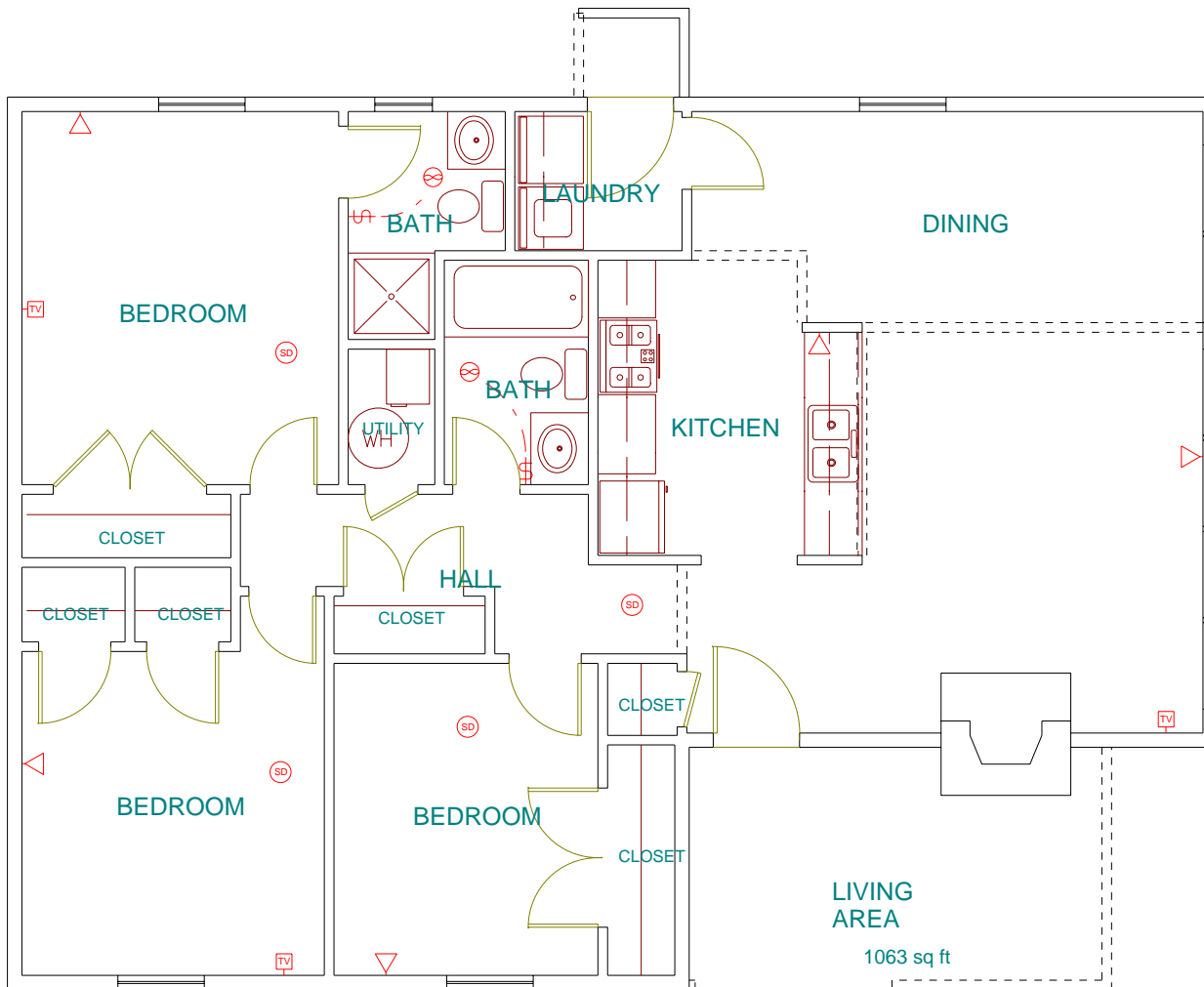
- Most affordable designs
 - Single story
 - Limited window area
 - Simple appearance; low roof pitch
 - No attention to orientation
- Passive solar design effort
 - Reorient rooms and windows
 - Insulated slab floor
 - Insulation, air sealing, duct sealing details
 - High efficiency HVAC

Typical Design

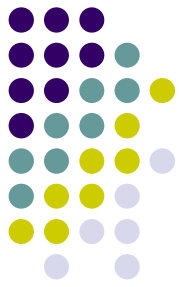
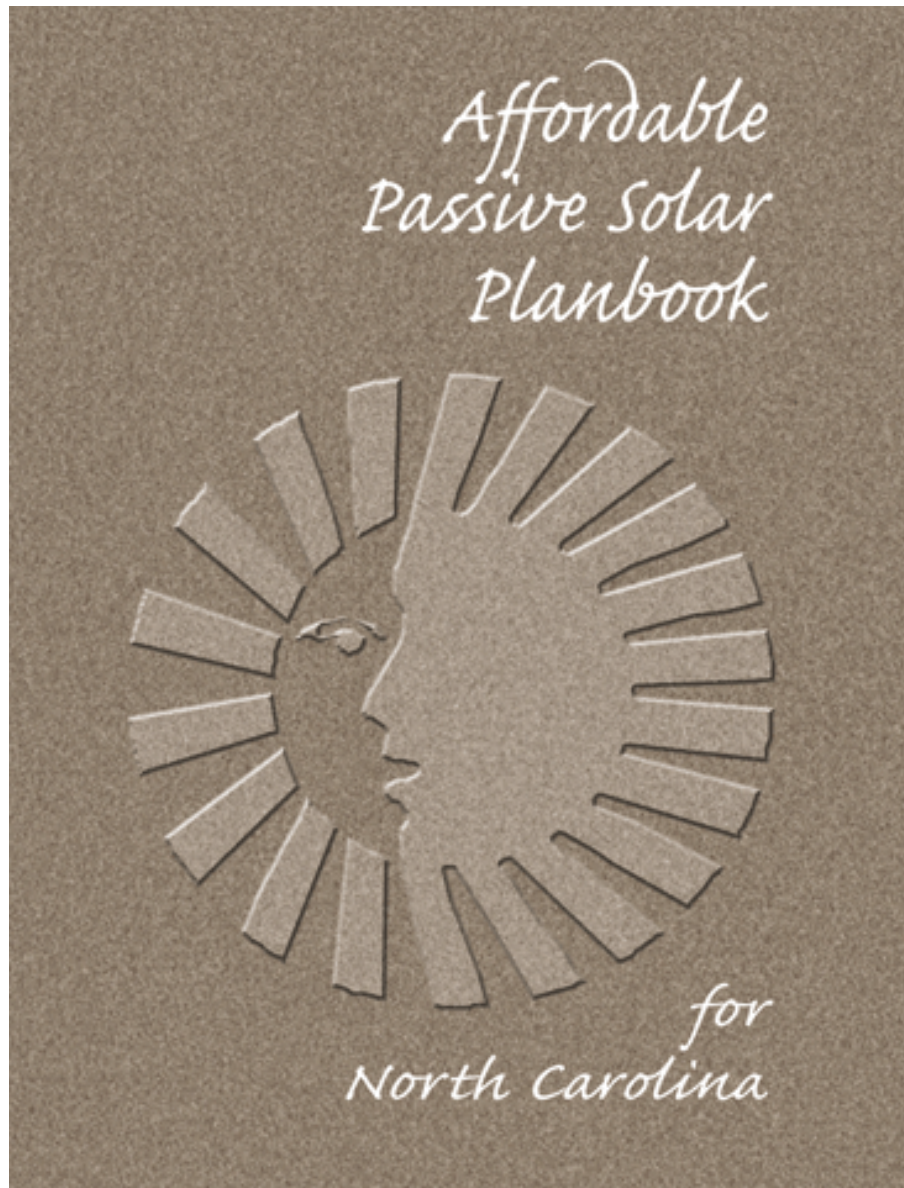


- 1147 sq feet

Passive Solar Option

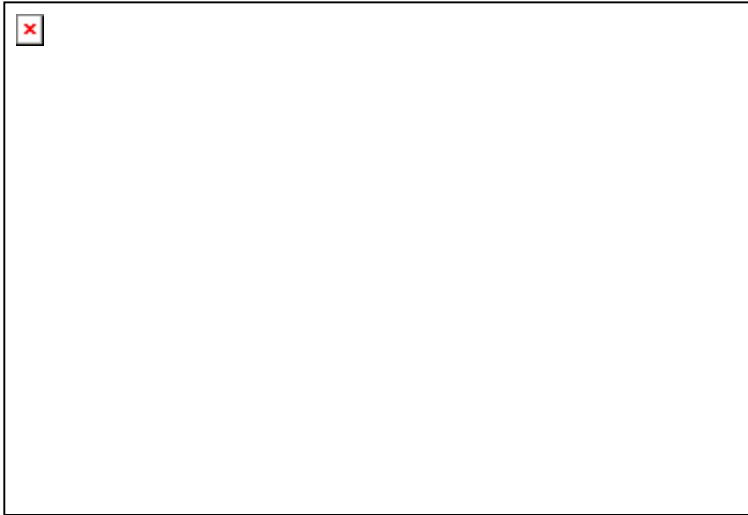
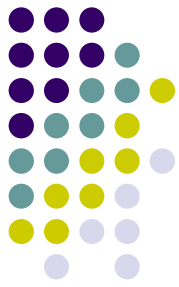


- Same window area
- 90 sq ft face south (8%)
- Savings:
- % heating
- % cooling



Available on-line at www.tec.appstate.edu

Affordable Passive Solar Plans

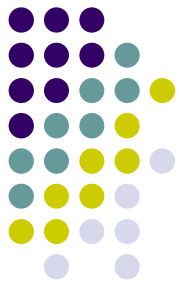




Enthusiastic Response

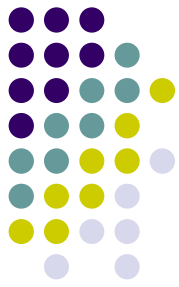
- Habitat for Humanity Chapters
 - Redesigned homes for Avery, Catawba Valley, and Watauga
 - Also working with Asheville, North Charlotte, Caldwell County and Alexander County
- Housing Authorities/ Other Groups
 - NW Housing Authority
 - Watauga Youth Build
 - Mountain Housing

NW Housing Authority

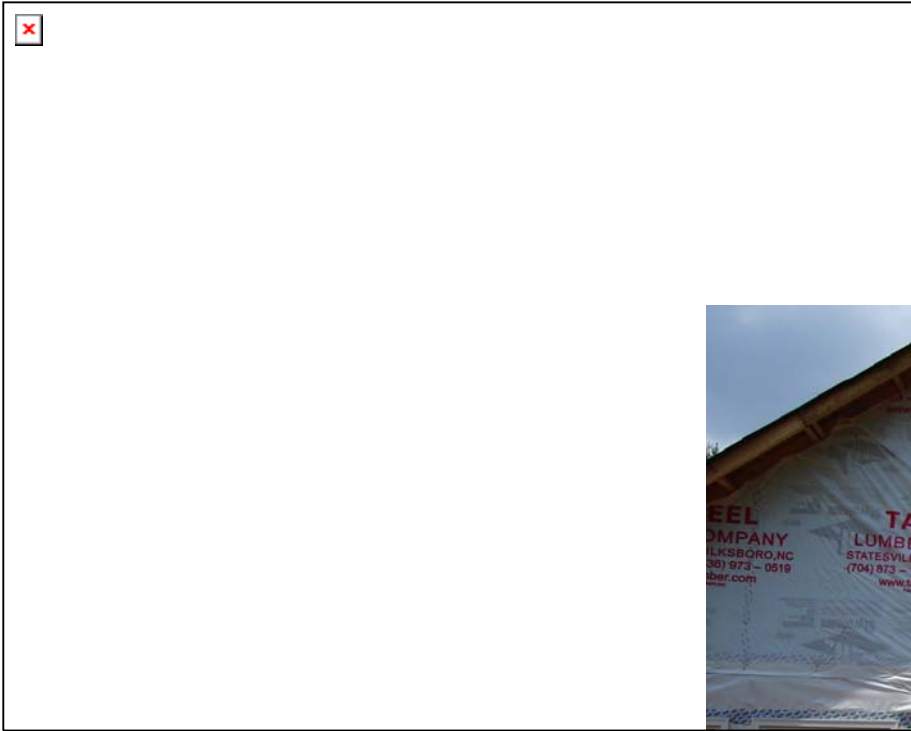
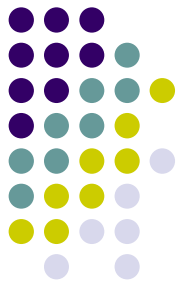


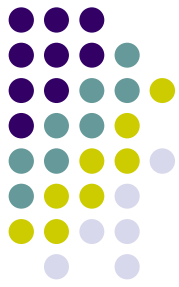
- Currently meeting SystemVision program guidelines
- Agreed to adopt new passive solar designs
- Agreed to meet NC HealthyBuilt Home criteria
- First project: 18-home subdivision in Jefferson, NC – The Oaks

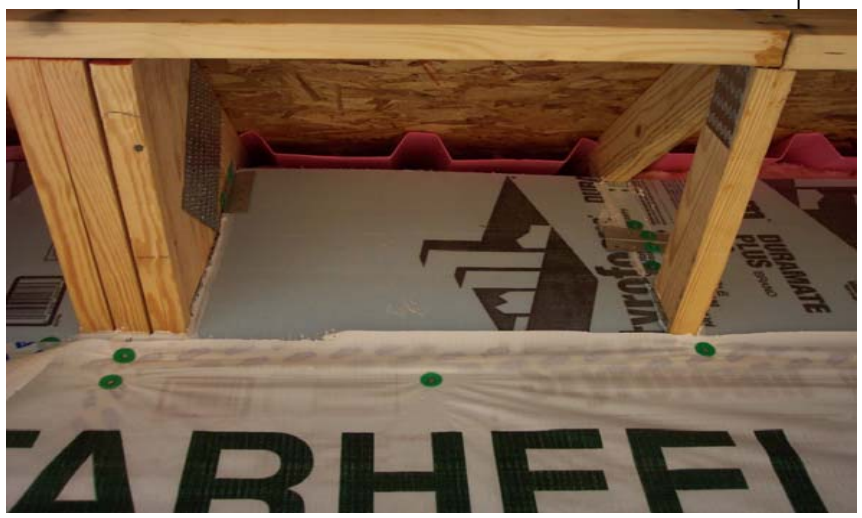
Baby Cape Design



Garden Window Design





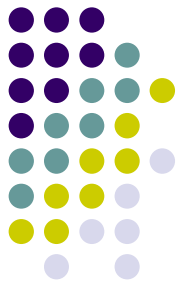




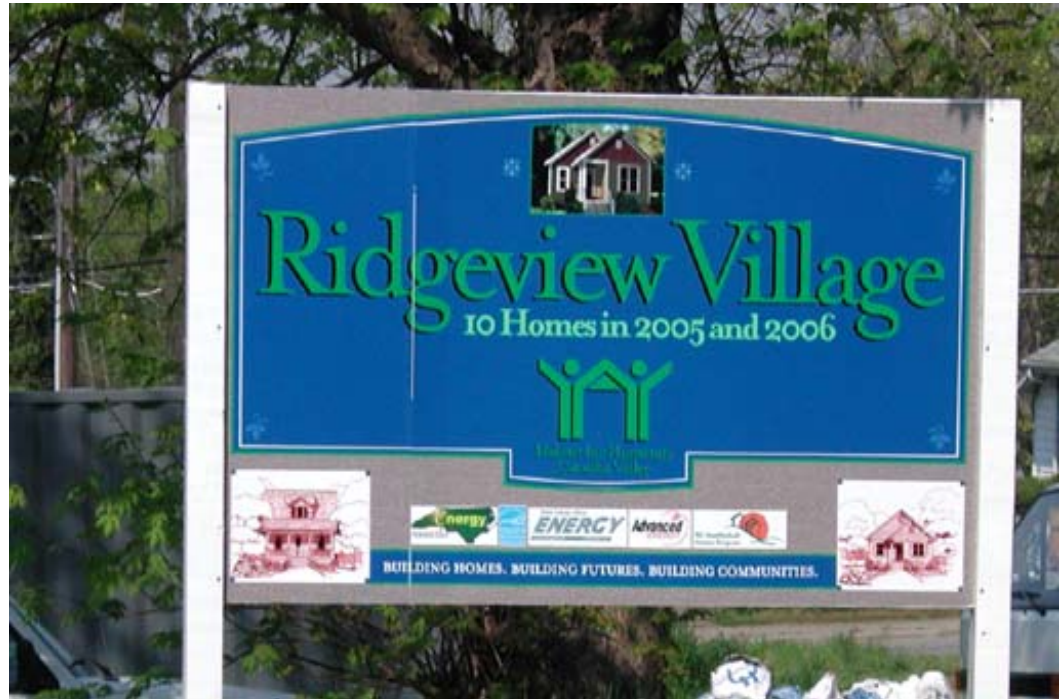
Towards Zero Energy

- Step 1: High Efficiency
 - Insulation systems; high efficiency windows
 - Air sealing
 - Duct sealing
 - HVAC efficiency
 - Appliances and lighting
 - Indoor air quality / ventilation/ moisture control
- Step 2: Passive Solar Design/
Natural Cooling Features
- Step 3: Solar Thermal
- Step 4: Green Building Features
- Step 4: Renewable Electricity

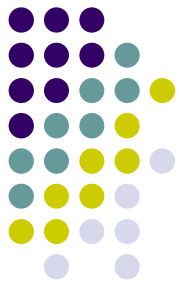
Zero Energy Plan design



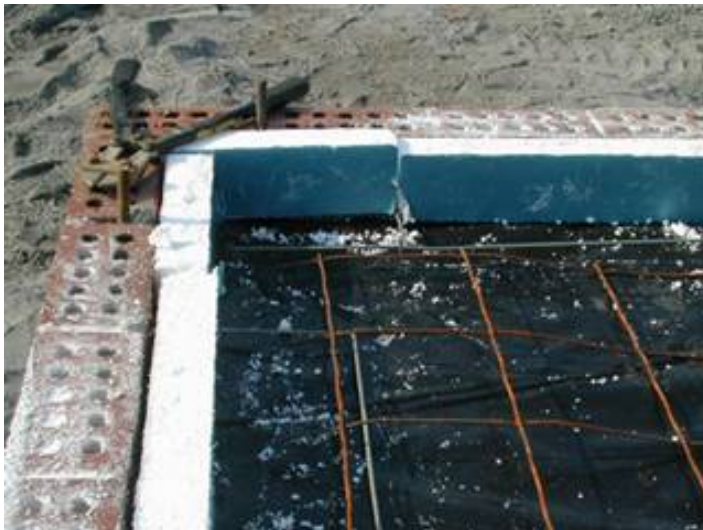
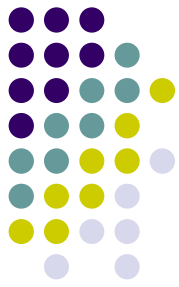
- Catawba Valley Habitat for Humanity
- Project in Hickory, NC



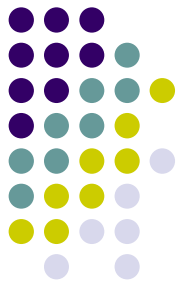
The Zero Energy Home



Insulated Foundation



Framing



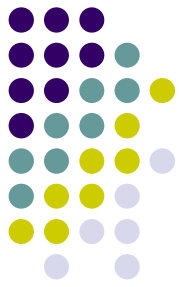
Framing Details



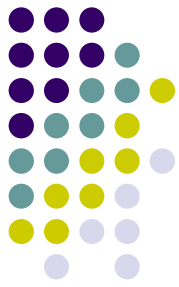
Framing Details



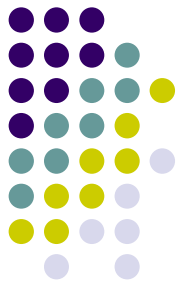
Icynene Insulation



Truss Design



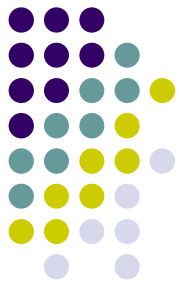
HVAC System



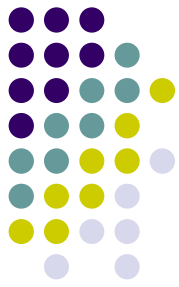
- Total cooling load – less than 1 ton
- Geothermal HVAC
- Typical cfm to bedrooms – less than 75 cfm
- Most of ductwork – in conditioned space



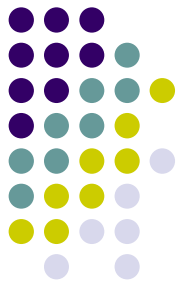
Ventilation Strategies



Passive Solar Design



Energy Efficient Appliances and Fixtures



Appliances and Lighting



- Thor washer-dryer combination
 - No dryer vent, runs on 110 V, liquid water drain
- Energy Startm refrigerator and dishwasher
- Compact fluorescent lighting
- Low sone, effective Panasonic exhaust fans
- Enthalpy Recovery Ventilation system
- Insulated window blinds

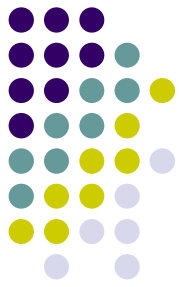
Problems Along the Way



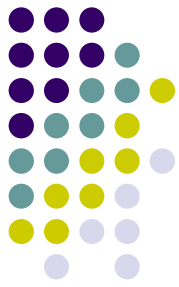
- South window design
 - Corner structure
 - Quest for high SHGC; Window delivery
- Truss delivery
- HVAC – loads
- Solar water heating
 - Cost
 - Installation
- Photovoltaics
 - UL-listing
 - Interconnection
 - Meter Fee
 - The Freezer



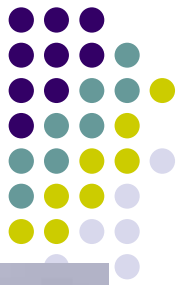
Wall Framing Issue



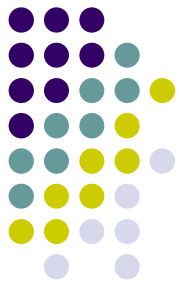
Truss Issue



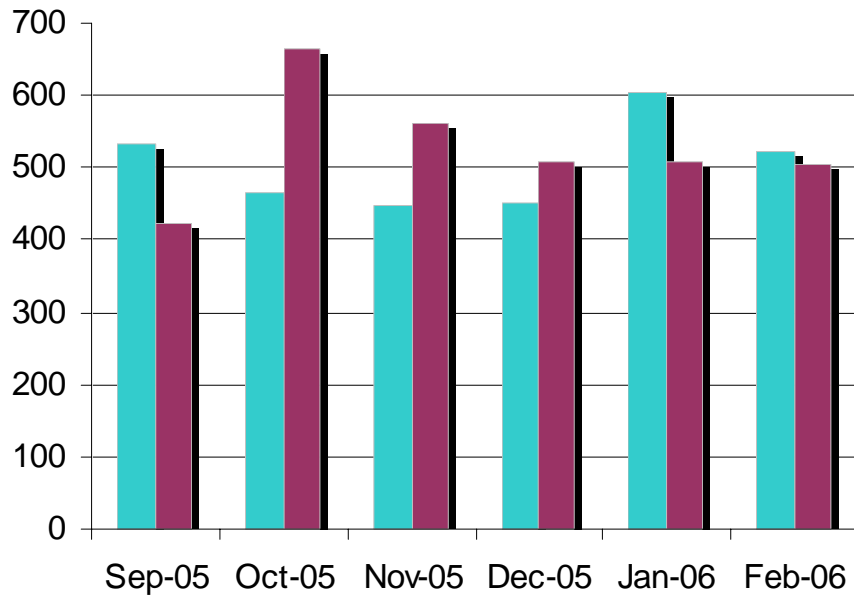
Solar Energy Systems



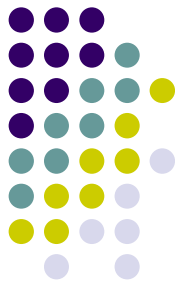
The Finished House



The power bills...



The power generation "bills" ...



Duke Power



Duke Power

HABITAT FOR HUMANITY CATAWBA PO BOX 9475 HICKORY, NC 28603		Account #: 1579819182 For Service At: 446 S CENTER ST HICKORY, NC 28603	
Bill Date:	10/06/2005	Past Due After:	10/20/2005
Service From:	08/31/2005 To: 09/30/2005	Days Of Service:	30
		Rate Schedule:	FP- N (NC)
MONTHLY SUMMARY			
Capacity Commitment	0 KW	Power Factor	0.9785
Actual Maximum Capacity	4 KW	Adjustment Factor	0.9913
Total Energy	663 KWH		
PURCHASED POWER CREDITS DUE SUPPLIER			
Capacity Credit		253 KWH ADJ	\$ -2.58
On-Peak Energy Credit		253 KWH ADJ	\$ -6.96
Off-Peak Energy Credit		410 KWH ADJ	\$ -8.65
TOTAL CREDITS			\$ -18.19
MISCELLANEOUS			
Interconnection Charge			\$ 25.00
SUBTOTAL			\$ 6.81
TOTAL AMOUNT DUE DUKE POWER			\$ 6.81

HABITAT FOR HUMANITY CATAWBA PO BOX 9475 HICKORY, NC 28603		Account #: 1579819182 For Service At: 446 S CENTER ST HICKORY, NC 28603	
Bill Date:	11/09/2005	Past Due After:	11/23/2005
Service From:	09/30/2005 To: 10/31/2005	Days Of Service:	31
		Rate Schedule:	PP- N (NC)
MONTHLY SUMMARY			
Capacity Commitment	0 KW	Power Factor	0.9642
Actual Maximum Capacity	4 KW	Adjustment Factor	1.0000
Total Energy	560 KWH		
PURCHASED POWER CREDITS DUE SUPPLIER			
Capacity Credit		153 KWH	\$ -1.71
On-Peak Energy Credit		153 KWH	\$ -6.26
Off-Peak Energy Credit		407 KWH	\$ -13.35
TOTAL CREDITS			\$ -21.32
MISCELLANEOUS			
Interconnection Charge			\$ 25.00
SUBTOTAL			\$ 3.68
TOTAL AMOUNT DUE DUKE POWER			\$ 3.68

NC GreenPower Payment



NC GREENPOWER

OUR REF NO	YOUR INVOICE NO	INVOICE DATE	INVOICE AMOUNT	AMOUNT PAID	DISCOUNT TAKEN	NET CHECK AMOUNT
000171	051018	10/18/2005	195.48	195.48	0.00	195.48

FORM : HABITAT FOR HUMANITY 1161

FAX NO. : 8883289283

NC GREENPOWER
 909 CAPABILITY DRIVE, SUITE 2100
 RALEIGH, NC 27606
 PHONE: (919) 857-9000

BANK OF AMERICA
 02992 NC
 66-19-5301

CHECK DATE	CONTROL NUMBER	AMOUNT
10/31/2005	001161	\$*****195.48

1161

PAY One Hundred Ninety-Five and 48/100----- US Dollars

TO THE ORDER OF HABITAT FOR HUMANITY CATAWBA
 P O BOX 9475
 HICKORY, NC 28603

TWO SIGNATURES REQUIRED FOR AMOUNTS OVER \$10,000

Margaret A. Juma

NOV. 03 2005 02:11

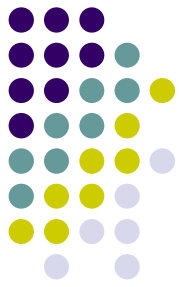
82899099000 0530001964 000691099828

Solar Water Heating



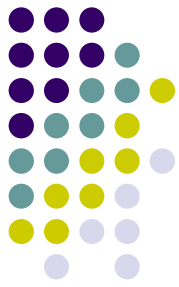
- Installed: \$4,500 (maxes out tax credit)
- Decided to hire installer (or self install)
- Three bids (Two collectors, 80-gallon storage with built-in heat exchanger, pumps, all key parts)
 - \$2,900
 - \$2,500
 - \$2,200

Solar Hot Water Economics



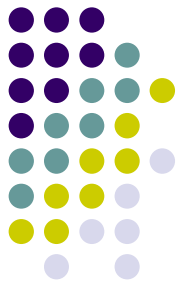
System materials	\$2,500
<u>Installation</u>	<u>1,500</u>
Total	\$4,000
<u>Federal tax credit (30%)</u>	<u>-1,200</u>
Subtotal	\$2,800
NC tax credit (35%)	-1,400
<u>Taxes on NC credit (typical)</u>	<u>+ 392</u>
<u>Net total</u>	<u>\$1,792</u>
Annual savings	\$ 300/ yr
Payback period (years)	6
Mortgage pmts (20 yr, 7%)	\$ 170/ yr

PV Renewable Electricity System



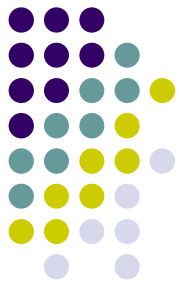
- 4.5 kW array designed to balance home's electricity demand
- Connected to grid via Duke Power
- Generator on NC GreenPower Program

Photovoltaic Economics

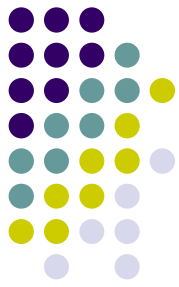


Economic Analysis		
System cost		30,000
Federal tax credit		(2,000)
State tax credit		(10,500)
Total tax credit		(12,500)
Tax on State Income		2,940
Net cost		20,440
Mortgage Principal		20,440
Interest	0.07	
Term	30	
Annual Mortgage Payments		1,632

Photovoltaic Economics (cont)



Income		
Hours per day		4.5
kWh per day		20.25
kWh per year		7,391
Average avoided cost rate	0.04	\$ 296
NC GreenPower rate	0.18	1,330
Total income		\$ 1,697
(currently, have to pay \$300 annual meter fee, but		
proposed new rate structure would eliminate it)		
Payback period (years)		
Net cost after tax credits		21,250
Annual income (without meter fee)		1,697
Payback period (years)		12.5



Energy Stars of All Sizes