PASSIVE SOLAR DESIGN

MAXIMIZE SOLAR HEAT GAIN IN WINTER AND MINIMIZE IT IN SUMMER
PASSIVE SOLAR HEATING

DIRECT GAIN

INDIRECT GAIN

ISOLATED GAIN
DIRECT GAIN

SOLAR RADIATION OR DIRECT SUN LIGHT THAT PENETRATES AND IS STORED IN THE LIVING SPACE
1000 WATTS PER SQUARE METER

- 1 - 3’ X 5’ SINGLE PANE WINDOW TAKING DIRECT SUMMER SUN
  - FROM 9:00 AM TO 3:00PM
  - FOR 75% OF THE DAYS
  - CAN ADD APPROXIMATELY

135 kWh TO MONTHLY SUMMER ELECTRIC BILL
SUN ANGLES AND SHADING

summer sun

winter sun

summer sun

winter sun

insulation

thermal mass
SUN TEMPERING

Up to 7 percent of floor area in windows...
SOUTH FACING WINDOWS

2800 sq. ft house

X

7\% \times 196 = 196 \text{ square feet}

13 - 3' \times 5' \text{ windows}
SHADING

Calculate the sun angle to determine proper overhang

Mature deciduous trees

Building integrated awnings
INDIRECT GAIN collects, stores, and distributes solar radiation using thermal mass.
3" OVERHANG

OUTSIDE

GLAZING MATERIAL - 2 LAYERS SEPARATED BY 3/8" SPACE
(I used Kalewall brand fiberglass)

WALL PAINTED BLACK

SUN

AIR FLOW

INSIDE

8" X 12" HOLE IN WALL

STUCCO FINISH

8" THICK CONCRETE WALL

AIR FLOW

SOUTH

MYLAR DAMPER ATTACHED AT THE TOP HINGING OUTWARD TO ALLOW AIR TO ENTER THE COLLECTOR

2" X 6" FRAME (APPROXIMATELY 4' X 8')

AIR FLOW

8" X 8" HOLE IN WALL

FLOOR

GRADE

FOOTING

2" THICK CLOSED CELL STYROFOAM ON OUTSIDE OF WALLS WITH SIDING MATERIAL ON THE OUTSIDE OF THAT

MODIFIED TROMBE WALL
ISOLATED GAIN

COLLECT SOLAR RADIATION IN AN AREA THAT CAN BE SELECTIVELY CLOSED OFF OR OPENED TO THE REST OF THE HOUSE
HEAT STORAGE

Thermal mass

Use Brick, Rock, Concrete on the inside of your house
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>VHC</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER</td>
<td>4186</td>
</tr>
<tr>
<td>CONCRETE</td>
<td>2060</td>
</tr>
<tr>
<td>SANDSTONE</td>
<td>1800</td>
</tr>
<tr>
<td>COMPRESSED EARTH BLOCKS</td>
<td>1740</td>
</tr>
<tr>
<td>RAMMED EARTH</td>
<td>1673</td>
</tr>
<tr>
<td>DRYWALL</td>
<td>1530</td>
</tr>
<tr>
<td>BRICK</td>
<td>1360</td>
</tr>
<tr>
<td>EARTH WALL(ADOBE)</td>
<td>1300</td>
</tr>
<tr>
<td>WOOD</td>
<td>350</td>
</tr>
</tbody>
</table>
NATURAL LIGHTING

Use sunlight for daytime interior lighting

5% of room floor area in glass

Skylights are RARELY a GOOD choice
WINDOW SELECTION

Minimize on the West, East and North

Maximize on the South

Proper shading either with overhangs, shutters, vegetation or solar window screens
WINDOW TECHNOLOGIES

ARGON OR KRYPTON GAS: ECONOMICAL CHOICES

LOW E COATING: HAS TRADE OFFS

HEAT MIRROR® and SUPERGLASS® QUAD: THE ULTIMATE WINDOW TECHNOLOGY?

BETWEEN GLASS FABRIC SHADES: ADDS TO R AND U VALUE
GLAZING PERFORMANCE TERMS

- **SHGC** – Solar Heat Gain Coefficient – The amount of SH entering a room and becoming heat - Variable
- **U Factor** – The rate of heat transfer – Lower is better
- **VLT** - Visible Light Transmission - the % of light transmitted -Variable
- **RHG** – Relative Heat Gain - the actual amount of heat entering – Variable
- **SC** – Shading Coefficient – the amount of solar heat ÷ amount passing trough 1/8” glass – Variable
- **LBL DF** - Lawrence Berkley Labs Damage Function – predicts UV light fading damage – Lower is better
UNSHADED WINDOW

NORTH
SHGC/U Factor/RHG/LBL DF – LOWER
VLT/SC – HIGHER

EAST/WEST
SHGC/U Factor/RHG/SC/LBL DF – LOWER
VLT/SC – LOWER

SOUTH
SHGC/U Factor/LBL DF – LOWER
VLT/RHG/SC - LOWER
SHADED WINDOW

NORTH
SHGC/U Factor/RHG/LBL DF – LOWER
VLT/SC – HIGHER

EAST/WEST
SHGC/U Factor/RHG/SC/LBL DF – LOWER
VLT/SC – HIGHER

SOUTH
U Factor/LBL DF – LOWER
SHGC/VLT/RHG/SC - HIGHER
ADDED INSULATION

R value = A measure of resistance to heat flow

ICF: Insulated Concrete Form up to R 50 in an 11” thick wall
SIP: Structural Insulated Panel up to R 22.32 in a 7” thick wall

URETHANE FOAM up to R 20.65 in a 3.5” application (5.9 p/i)
ICYNENE® up to R 12.6 in a 3.5” application (3.6 p/i)
BIOFOAM up to R 13.4 in a 3.5” application (3.8 p/i)
CELLULOSE up to R 14 in a 3.5” application (4.0 p/i)
FIBERGLASS up to R 12.6 in a 3.5” application (3.6 p/i)

EXPANDED POLYSTYRENE up to R 12.6 in a 3.5” application (3.6 p/i)
RIGID FOAM up to R 17.5 in a 3.5” application (5.9 p/i)
POLYISOCYANURATE up to R 6.25 in a 1” application (6.25 p/i)
RETROFITTING INSULATION

- EIFS: $8.00 per s/f (old or new exterior wall)
- Icynene®/Bio foam: $1.20 per s/f (new wall)
- Wet blown cellulose: .50¢ - .65¢ per s/f (new wall)
- Dry blown cellulose: $1.00 per s/f (old wall)
- Dry blown cellulose: .50¢ per s/f (attic)
- Blown fiberglass: .65¢ per s/f (attic)
- Fiberglass batting: .45¢ per s/f (wall)
- Fiberglass batting: .60¢ - .65¢ per s/f (attic/floor)
HELPFUL WEBSITES

- energystar.gov – Home Energy Audit
- efficientwindows.org – Window information
- toolbase.org – Technical Information
- nrel.gov – Energy-10™ software
- eere.energy.gov – RESFEN software, EE and RE
- buildinggreen.com – Design/Build information
- coloradoenergy.org – R Value tables
- southwall.com – Heat Mirror® Windows
- pella.com – New and replacement windows
SOLAR\textsuperscript{10}

23,000 TWy/year

2009 World energy consumption 16 TWy/year

2050: 28 TWy

© R. Perez et al.
There's plenty of sun to go around

Enough sunlight strikes Earth every 104 minutes to power the entire world for a year.

The United States has the space and sunlight to provide 100 times its annual power demand with solar.

Mother Jones

3.797 million mi² 8,100 miles²
Mainstream Forecasts: Linear – despite evidence

- Mainstream Forecasts:
  - Linear
  - Backwards-looking
  - Siloed

- They don’t take into account
  - Technology cost curves
  - Product Innovation
  - Business Model Innovation

- Reality: evidence of exponential nature of technology adoption

Annual PV additions: historic data vs IEA WEO predictions


Image Source: PV Magazine
We have all the technologies we need to solve all the challenges facing humanity.

“There are no technological or economic barriers to converting the entire world to clean, renewable energy sources. It is a question of whether we have the societal and political will.”

Mark Jacobson
Director, Atmosphere/Energy Program
Stanford University
Solar on Fire
As prices have dropped, installations have skyrocketed.

Price of a solar panel per watt

Global solar panel installations

*Estimate. Sources: Bloomberg, Earth Policy Institute, www.earth-policy.org

Down to $0.447 in August 2016
WATTS YOUR ANGLE

2002 - Net-metering rules and procedures promulgated at PSC.

2007 - Net-metering improved by extending forfeiture rule to end of calendar year.

2010 - Governor launches Renewable Technology Rebate Plan.


2013 - Net-metering improved slightly by new formula extending forfeiture period to April of following year.

2013 - PSC opens docket addressing impediments to net-metering.

2013 - PSC removes mutual indemnification clause for entities with sovereign immunity.

2013 - PSC adds meter-aggregation to net-metering rules.
2015 - HB 1885 The Arkansas Distributed Generation Act fails in Joint Energy Committee.

2015 – HB 1633 becomes Act 1088 Allowing a utility to enter into a Power Purchase Agreement and receive additional sum if PPA is not with an affiliate of the utility. Does not apply to an electric cooperative corporation or electric utility customers.
2015 – HB 1004 becomes Act 827. Net-metering improved by allowing indefinite carry over of unused kWh generation with option to cash out at avoided cost rate after a twenty four month period.
Act 827 also increased the size limits for residential and commercial installations to the size necessary to create 110% of highest monthly usage.
The Act also directed the PSC to determine if the costs of net-metering policy outweigh the policy's electrical system benefits, public benefits and environmental benefits. Language allowing utilities to charge net-metering customers extra fees, if costs outweigh benefits, has been in AREDA since its passage in 2001. The difference is that Act 827 allowed cover for the utilities to be able to say it was the legislatures idea not theirs.
2016 – PSC opened docket 16-027-R to satisfy the requirements of Act 827.

2016 – PSC opened docket 16-028-U without a direct requirement from the legislature to investigate policies related to renewable distributed generation.

2107 – PSC rules that existing NMC’s will be grandfathered under existing rules for next twenty years. Additionally, the ruling states that any NM installation completed before final ruling regarding rate changes are also grandfathered for next 20 years.
30% Federal Income Tax credit
1 Year Accelerated Depreciation On 85% Of Installed Cost
Arkansas’ first solar garden allows interested citizens to “plant” solar modules and grow electricity. Arkansas customers of Entergy simply register a new electric meter in their name and attach a solar array that produces kilowatt hours of electricity. Monthly kWh production is credited against monthly kWh consumption on existing meters at another home or business location.

Through a program called meter-aggregation, Entergy customers can sight their array here at Bearskin Solar Center and create kWh generation which will offset usage from another Entergy meter anywhere else in Arkansas.

If your home or business does not have suitable solar access or you just want to have your array sighted elsewhere, you can purchase a minimum of 20 modules at Bearskin Solar Center and apply the generation to any other number of existing electric meters.

The purchase price includes an initial 20 year land lease and a 25 year performance warranty with daily web access monitoring of solar modules in each individual array. A modest annual maintenance fee is assessed to keep the grass mowed and the modules clean.
### Overview

<table>
<thead>
<tr>
<th>Current Power</th>
<th>Energy today</th>
<th>Energy this month</th>
<th>Lifetime energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>863 W</td>
<td>39.11 kWh</td>
<td>2.15 MWh</td>
<td>2.17 MWh</td>
</tr>
</tbody>
</table>

### Power and Energy

<table>
<thead>
<tr>
<th>Week</th>
<th>Month</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>01/01/2016 - 01/31/2016</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Solar Production: **2.16 MWh**

### Site summary

- **Name**: Bearskin Lake Loop 126
- **Country**: United States
- **State**: Arkansas
- **City**: Scott
- **Address**: Bearskin Lake Loop 126
- **Installed**: 12/31/2015
- **Last updated**: 01/31/2016 17:00
- **Peak power**: 21.2 kW

### Weather

- **Temperature**: 73.4 °F
- **Feels like**: 73.4 °F
- **Wind SSW**: 13.79 MPH
- **Humidity**: 50%
- **Sunrise**: 07:03
- **Sunset**: 17:37

- **Sunday**: 66.8 - 60 °F, Party Cloudy
- **Monday**: 62.6 - 56.4 °F, Party Cloudy
- **Tuesday**: 66.2 - 37.4 °F, Party Cloudy
Solar Beats Natural Gas Peak Power Today

Gas peakers pollute 3 times more than natural gas power plants.

Sources: 2011 gas price is the mid-point of the LCOE range given by Lazard, version 5.0. 2016 gas price is illustrative, calculated assuming 7% annual escalation; 2011 & 2016 PV Prices from DOE, Advanced Research Projects Agency - Energy, $1/Watt Photovoltaic Systems, May 2011 (further validated by prices bid by solar developers into the California market).
THE TRIPLE BOTTOM LINE

- People
- Planet

- Profit
- Viable
- Sustainability

- Bearable
- Equitable