Window Options for Florida Residences

Keeping cool and comfortable,... and saving energy too

Ross McCluney, Ph.D., Principal Research Scientist
Florida Solar Energy Center

Florida Solar Energy Center
Half-day short course on window energy and illumination performance and background for purchase decisions

- Many factors affect the design and choice of windows for the Florida home.

- After some background information, we’ll take a tour through the options.
Are windows just “holes in the insulation?”

Some are,... but “it ain’t necessarily so!”

- Good windows can out-perform opaque insulated walls, energy-wise.
- Windows provide much more than energy savings!
- A building is there to provide comfort and protection from the elements, not just to save energy.
- If energy can be saved too, that’s even better.

- We’ll start with some basics
- Then we’ll cover energy and economics
- And finish with a summary of window option recommendations
Outline of the presentation

**Background Information**
- Fundamentals of Window Physics
- Sun Position and Shading

**High Performance Window Glazings**
- Spectral Selectivity
- Hot climate versus cold climate coating technology
- Light-to-Solar Gain Ratio

**Energy and Economics**
- Calculating Window Energy and Economic Performance
- Simulation programs - EnergyGauge USA and EnergyGaugeFlaRes®
- Florida Building Code - Mix and match – to the extreme

**There’s more to windows than just energy or energy code compliance**
- The cheapest window is not always best
- Human factors and long term energy and environmental aspects
- What’s really wrong here?

**The Bigger Picture**
- History, the Peak of Oil Production
- We really need higher energy prices

**The Florida Residential Windows Market**
- The circle of failures – A chicken-and-egg problem
- Breaking the circle

**Conclusions and Recommendations**
- Final window shading and window option selection guidelines

**Additional Questions and Answers, Course Evaluation**
What are windows for?

- Views to the outdoors - visual connections to the natural world
- Illumination of the interior with natural daylight
- Acoustic connections to the outdoors
- Routes for emergency escape
- Protection from the discomforts of cold, heat, wind, and rain

Do you see energy anywhere in this list?
Finding the Right Window

- It is more than just choosing a pretty window.
- We must also deal with direct sunlight:
  - **The Good**: Big windows provide a bright and open room with great views and good daylight illumination
  - **The Bad**: Overheating, fading of furnishings, blocked views
  - **The Ugly**: Killer glare from the sun, big energy bills, thermal discomfort
- Three strategies for dealing with the sun
  - Know the sun’s position
  - Shape and orient the building properly
  - Shade the windows and walls properly
- Other issues
  - Choice of window frame and glazing
  - To insulate or not?
  - Impact resistance?
  - Acoustic isolation?
  - Utility concerns
Factors Affecting the Choice of Window Options

- Which way the window faces
- How much it is (or will be) shaded from the sun
- The importance ($) of thermal comfort
- The importance ($) of sound isolation
- The importance ($) of impact resistance
- New construction vs retrofit (replacement)
- Occupant preferences for style and color
- Electric utility company incentives
- Florida Building Code Compliance
Window Fundamentals to be Considered

- Heat transfers (Radiation, Conduction, Convection)
- The path of the sun through the sky
- Orientation and shading
- Electromagnetic spectrum
- The solar spectrum
- Solar radiant heat gain, direct and diffuse
- Illumination — Daylighting, glare, electric lighting
- The “U-factor” — Conductive heat transfer
- Solar Heat Gain Coefficient (SHGC)
- Visible transmittance (VT)
Heat Transfer

The three modes of heat transfer

Radiation

Conduction

Convection

\[ T_{\text{hot}} \quad T_{\text{cold}} \]
Heat Flows Through Windows

- Reflected solar radiation
- Glazing-absorbed solar radiant heat
- Outward flowing fraction of glazing absorbed radiation
- Absorbed solar radiation conducted through the frame
- Directly transmitted solar radiation through the glazings (includes both light & heat)
- Inward flowing fraction of glazing absorbed radiation
- Heat conducted through the glass
- Heat conducted through the frame
Insulated windows reduce conduction, convection, and radiation.

Heat conducted through the frame.

Heat conducted through the glazing system.

Coatings reduce radiation transfer.

Insulating gas reduces conduction.

Proper spacing minimizes convection.

Winter → Cold → Warm → Hot → Cool → Summer

Heat conducted through the frame.
Summer

Sun rises north of due east, sets north of due west, and is high in the sky at noon.

Shade: overhang for noon east to northeast morning, west to northwest afternoon.

Winter

Sun rises south of due east, sets south of due west, and is low in the sky at noon.

Shade: southwest to west to protect west window on warm winter days.
Minimize east and west exposure
Shade the facade

Wide overhangs

Buffer East and West Exposures

Garage

Fence

Closet

Utility room
Exterior window shading strategies

- Bahama shutters
- Exterior roll blind
- Sarasota shutters
- Sun screen
- Slatted aluminum
- Venetian awning (east or west exposure)
- Porch
- Trellis & vines
- Hood awning
- Gambrel awning (for casement windows)
- Trees
- Solid aluminum awning
- Roller awning (self-storing)
Breaking sunlight into its various colors

Sir Isaac Newton in 1723 (or so)
Parts of the solar spectrum

Solar spectrum (all of which produces heat when in the building)

Human eye sensitivity (visible portion of the spectrum), only a small part of the solar spectrum and the only part we can see

Near Infrared (NIR)

Ultraviolet (UV)
Warm Objects Emit Radiation

Blackbody radiation spectra from 80 to 35,000 deg Fahrenheit

This is the only part of the spectrum we can see
Blackbody Spectral Shape on Linear Scale

T = 5.5 x 10^3 K
Spectral Selectivity

- Cold climate glass transmittance

- Room temperature surface emission spectrum

- Solar spectrum

- Human eye response

- Visible light (VIS)
- UV (Ultra Violet)
- NIR (Invisible solar IR)
- FIR (Invisible IR emitted by room temperature surfaces)

- Wavelength range:
  - UV: 200 nm
  - VIS: 380 nm to 760 nm
  - NIR: 3.5 μm
  - FIR: 30 μm
Spectral Selectivity - 2

- Hot climate transmittance
- Cold climate transmittance
- Room temperature surface emission spectrum
- Solar spectrum
- Human eye response

Spectral irradiance vs Wavelength

- UV: 200 nm
- VIS: 380 nm - 760 nm
- NIR: 3.5 μm
- FIR: 30 μm

Visible light

- Visible light spectrum
- Human eye response

Invisible solar IR

- Invisible IR emitted by room temperature surfaces

Visible region from UV to NIR

- Blue, green, red wavelengths

Infrared region from NIR to FIR

- Infrared wavelengths

Ultra Violet

- Ultraviolet wavelengths
Heat flux, \( Q \) in W/m\(^2\)

- Incident solar irradiance: \( E_o \)
- Reflected solar radiation: \( R_s E_o \)
- Transmitted solar radiation: \( T_s E_o = Q_{\text{direct}} \)
- Glazing-absorbed solar radiant heat: \( A_s E_o = Q_{\text{absorbed}} \)
- Outward flowing fraction of glazing absorbed radiation: \( N_i A_s E_o = Q_{\text{inward}} \)
- Visible Transmittance: \( VT \) (%)
- Glazing conduction heat transfer
- Frame conduction heat transfer

\[ Q_g = U_g \times \text{Area} \times \Delta t \]
\[ Q_f = U_f \times \text{Area} \times \Delta t \]
Performance Indices

Primary Indices

Solar Heat Gain Coefficient

\[ T_s + N_i A_s = \text{SHGC} \]

(R-value = 1/U)

Primary Indices

Visible Transmittance

VT

U-factor

U

Ts

Glazing-absorbed solar radiant heat

Rs

Reflected solar radiation

As

Outward flowing fraction of glazing absorbed radiation

Ni As

SHGC

Primary Indices

U

(R-value = 1/U)
Spectrally Selective Glazing Systems

Introduction to the Light-to-Solar-Gain (LSG) Ratio

The optical properties of different glazing systems can be plotted on this chart, to see how they compare with other glazings.
### Light to Solar Gain ratio
- **A measure of spectral selectivity**

<table>
<thead>
<tr>
<th>VT</th>
<th>Visible transmittance:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fraction of incident light transmitted</td>
</tr>
<tr>
<td>SHGC</td>
<td>Solar heat gain coefficient:</td>
</tr>
<tr>
<td></td>
<td>Fraction of incident solar radiation admitted as heat gain</td>
</tr>
<tr>
<td>LSG</td>
<td>Light-to-Solar Gain ratio:</td>
</tr>
<tr>
<td></td>
<td>Ratio of visible transmittance to solar heat gain coefficient</td>
</tr>
</tbody>
</table>
|          | \[
| LSG      | \( \frac{VT}{SHGC} \)                                                                   |
|          |                                                                                       |
Real Spectrally Selective Glazings

Spectral Transmittances of Various Window Glazings

- Clear plate
- Bluegreen #1
- Bronze coated
- Bluegreen #2
- Spectrally sel.-1
- Spectrally sel.-2

Wavelength in nanometers

Transmittance

Lower VT, higher LSG

Similar IR spectra

VIS
Cold climate glazings
Admit and trap solar heat

Cold climate low-e coating. Transmits solar, doesn’t emit FIR

Low-emissive configuration

One way to do the job

Total solar spectrum

Insulated gas space (air, argon, krypton)
Cold climate glazings
Admit and trap solar heat

Low-emissive configuration

Cold-climate low-e coated windows

High-reflective configuration

Two ways to do the job

1. FIR not emitted
2. FIR reflected

Cold climate low-e coating.
Hot Climate Glazings
Admit visible, reject invisible solar

Hot-climate coated windows

One way to do it

By rejecting nearly half the incident solar radiation by reflection, the SHGC is nearly half as great

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Solar near IR
Visible light

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Hot-climate near-IR reflective coating
(Also called “hot-climate low-e coating”)
Hot Climate Glazings
Admit visible, reject invisible solar

Hot-climate coated windows

Two ways to do it

1. Hot-climate near-IR reflective coating
2. Cold-climate low-e coating
Putting them all together

Cold-climate low-e coated windows

Absorptive longwave conversion

Low-emissive configuration

High-reflective configuration

Cold Warm Cold Warm

Or

Hot Cool Warm Cool Warm Cool

Hot-climate coated windows

Absorptive longwave conversion

Solar direct reflection

Cold-climate low-e coating

Hot-climate solar near IR reflective coating

Cold Warm Cold Warm

Or

Hot Cool Warm Cool Cool

Or

Warm Cool Warm Cool

*Second pane optional in principle
Daylight Illumination

- Cool, natural daylight has good color rendering
- Daylight is healthy
- Daylighting can displace electric lighting
- Electric utility interactions
- The occupancy schedule is critical
  - Florida residential occupancies — are they different?
- Direct beam and diffuse daylight
- Glare
  - Disability glare – Disables the ability to see a visual task clearly
  - Discomfort glare – Produces extraneous light and discomfort and headaches
Disability Glare

Light from overhead or behind you reflects from a shiny task. The reflected light is so bright as to greatly reduce the contrast of the task, making black letters, for example, almost as bright as the white page surrounding them. The result is a “veiling” of the task, a washing out or masking of the target, thereby disabling your ability to see the task. This is why it is called disability glare.
Discomfort Glare

Bright light from the side enters the eye and bounces around in there. The neural system is confused by the presence of this light brighter than the task you are trying to see. The contrast of the task is not directly reduced but the brain has to work hard to see and recognize the task. This kind of glare is like “light pollution” since it is unwanted and mainly annoying. It can produce headaches when in prolonged exposure to it. The problem is mitigated by reducing the comparative brightness of the glaring source or moving it behind you where the light cannot enter your eye.
Direct Beam Solar Radiation

Either direct or reflected, it can be a powerful glare source.
Avoiding Direct Beam
Orientation & Shading Strategies

Minimize East and West Exposures

Wide overhangs

Buffer East and West Exposures

Garage

Fence

Closet

Utility room
Window Shading Strategies

Outdoors

Between the panes

Indoors
Exterior window shading strategies

- Bahama shutters
- Exterior roll blind
- Sarasota shutters
- Sun screen
- Slatted aluminum
- Venetian awning (east or west exposure)
- Porch
- Trellis & vines
- Hood awning
- Gambrel awning (for casement windows)
- Trees
- Solid aluminum awning
- Roller awning (self-storing)
High Performance Glazing Systems

When shading is not permitted, desired, or possible

- To minimize solar heat gain, use **hot-climate low-e coated** glazings with **high LSG ratio**

- Choose VT to fit the situation
  - **VT high** for north-facing and exposures already shaded fairly well
  - **VT low** for east- and west-facing exposures inadequately shaded

- To reduce peak load, enhancing comfort and allowing smaller air conditioners, use **double pane windows**
  - **Impact resistant** for coastal zone
  - **Insulated frames** to reduce condensation and improve comfort further
Different window options have different energy consequences

**Instantaneous** versus **long term hourly** performance

For instantaneous perf., get the NFRC label information:
- U-factor
- SHGC
- VT

But how do you know good values of these parameters for your application?

You need a tool that tells you about the long-term energy and peak load consequences of a given choice

And you would like a way to convert energy efficiency information into economic information, such as payback time

Before describing the options, we need some background on how energy programs work and on economic indicators
Hourly Building Energy Simulations

Building **thermal properties**
- Thermal mass & location
- Wall, roof, & floor insulation
- Infiltration models
- Window SHGC & U-factors
- HVAC efficiency data

**Weather data** for each hour
- Air temperature & humidity
- Wind speed
- Direct beam solar
- Global horizontal solar

**Assumed internal heat loads**
- Equipment
- Humans & animals
- Occupancy

**Loads** on HVAC system
- Conduction through envelope
- Internal loads
- Fenestration Solar Gain

**Energy use** by energy type
- Electric energy
- Electric demand
- Gas energy
- Fuel oil

**Other energy** consumed
- Equipment
- Electric lighting

**Costs of energy-efficiency**
- Building envelope
- HVAC system
- Other features

**Dollar costs** to operate the building each hour and for a year
- Annual energy
- Demand charges
- Economic performance indicators
Window Energy Software

- **DOE-2** — Large & complex, needs an engineer to run it
- **RESFEN** — Easier to run, and based on DOE-2, but you must be somewhat computer savvy to run it
- **EnergyGauge USA** — Requires licensing and training
- **EnergyGauge FlaRes** — Used mainly for code compliance
- Energy performance for a typical house can be determined from [www.efficientwindows.org](http://www.efficientwindows.org) but this treats shading only minimally
- Sample results from DOE-2 on next slide
  (Note: Shading coefficient = 0.87 SHGC)
DOE-2 Results for Miami - 1

MIAMI – YEARLY ENERGY CONSUMPTION

WEST ORIENTATION

- No shade, No overhang
- No shade, With overhang
- With shade, No overhang

Relative Energy Use (kWhr/ft²)

Shading Coefficient

Single glazing, U = 1.3
Double glazing, U = 0.3
(Slightly less energy efficient)

Lower is better
DOE-2 Results for Miami - 2

MIAMI - PEAK COOLING LOAD

WEST ORIENTATION

Single glazing, U = 1.3

Double glazing, U = 0.3

RELATIVE PEAK LOAD (W/ft²)

0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1

SHADING COEFFICIENT

No shade, No overhang
No shade, With overhang
With shade, No overhang
Conclusions from Miami Study

- U-factor is not that important for annual energy in South Florida
- Preventing solar gain is more important
- Thus low solar gain single pane, uninsulated windows would appear a good choice for Southern Florida
- At least one glass company offers “hard-coat” high LSG glass
- But there is more to the study than this.
- Further north, insulated windows become more attractive
- And there are other benefits of double pane windows:
  - Lowered Peak loads
  - Smaller, less expensive HVAC equipment
  - Acoustic isolation
  - Greater comfort and happiness
  - Motherhood and apple pie
What Can the Homeowner Do to Get Energy Performance/Information?

- Use Florida Building Code energy provisions — Minimal
- Insist on NFRC ratings — Instantaneous values only, but still important to know that the numbers are correct
- Obtain Florida Green Home Certification — Great environmentally, but modest for window energy
- Use only Energy Star windows — Good but not best
- Information customized for your home, use RESFEN: http://windows.lbl.gov/software/resfen/resfen.html
Where to find these resources
Florida Building Commission

http://www.floridabuilding.org/BCISOld/bc/default.asp

FSEC commentary on the new Florida Building Code
http://energygaug.com/FlaRes/new_code.htm

Florida Building Code Online

View The Florida Building Code Online at SBCCI's website:
http://www2.iccsafe.org/states/2004_florida_codes/
How to Select an Energy Efficient Window

1. Look for the Energy Star
   Look for a product that qualifies for the Energy Star in the Northern, Central, or Southern Climate Zone. To distinguish between Energy Star products, go to Step 2.

2. Look for Energy Efficient Window Properties on the NFRC Label
   The key window properties are U-factor, Solar Heat Gain Coefficient (SHGC), and Visible Transmittance (VT). The NFRC label provides the only reliable way to determine the window properties and to compare products. For typical cost savings from efficient windows in specific locations, go to Step 3.

3. Compare Annual Energy Costs for a Typical House
   Compare the annual energy use for different window options for a typical 2000-square-foot house in your state or region.
Energy Star Homes must meet a performance standard: Have a HERS energy rating of 86 or above

Energy Star Windows must meet a prescriptive standard: In the hot climate zone:

<table>
<thead>
<tr>
<th>Windows &amp; Doors</th>
<th>Skylights</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U-Factor</strong></td>
<td>0.75 or below</td>
</tr>
<tr>
<td><strong>Maximum Solar Heat Gain Coefficient</strong></td>
<td>0.40 or below</td>
</tr>
</tbody>
</table>

Climatic Zones

[Image of a map showing climatic zones]

[Image of an Energy Star Labeled Home]

[Image of Energy Star logo]

[Image of EPA logo]

[Image of Department of Energy logo]

http://www.energystar.gov/index.cfm?c=windows_doors.pr_windows
None of the previous web sites offers much guidance on selecting window shading. The next one at least gives credit for tree shading, and a variety of other environmental sound practices.
Florida Green Home Certification

Florida Green Building Coalition, Inc., www.floridagreenbuilding.org

- Green Home Standard Certification based on a points rating
- "Green Home Designation Standard Checklist" publication
- Checklist includes points for Energy, Water, Site, Health, Materials, Disaster Mitigation, and a General category
- For new homes each category has a minimum number of points. The sum of the minimums (default case) is 160.
- Total points requirement is 200.
- More points required if the minimum cannot be met in a category
- Window points given for daylighting, east and west tree shading, and exceeding the Florida Energy Code HERS rating of 80
To Double-pane or not?

- For energy savings only, double pane is generally not needed in Florida (except possibly for north Florida)
- It is more important to put your money into preventing solar gain —
  **On the other hand:**
  - The highest LSG glass is only available in double pane
  - Double pane is more comfortable
  - Double pane allows smaller A/C, saving dollars
  - Double pane gives better acoustic isolation
  - The electric utility might *pay you* to use double pane (if you ask them nicely)
Guidance for the Average Homeowner

- Purchase the best window you can afford for your situation, considering:
  - Direction the window faces
  - Degree of existing shading of that window

- Shade east- and west-facing windows from direct sunlight
  - Trees
  - Trellis vines
  - Shrubs and plants
  - Awnings and shade screens
  - Shutters

- Use double-pane glass and insulated frames to
  - Maintain thermal comfort
  - Reduce peak A/C size required
  - Save energy and electricity costs
  - Protect against possible future peak demand charges
I could stop here,

leaving you with the previous slide of recommendations,

but this is only part of the story.

What about the dollar consequences?
Are my choices cost-effective?

Here’s how we tell: economic performance measures

- Payback time
- Return on Investment
- Cash flow analysis
- Life cycle costs
- Net energy analysis
- External costs
First are the dollar costs of “extra” features in the home, compared with the alternative.
- Extra cost of double pane
- Extra cost of hot-climate low-e coatings for reducing solar heat gain
- Extra cost of insulating gas fill
- Extra cost of insulated frames
- Extra cost of external shading devices or vegetation

Let $C$ be the total of all the extra costs you incur, in dollars

Then you have to know the dollar value of the energy savings in a typical year generated by these extra costs.

This comes from an energy computer program for both the “base-case” home and the one with the extra features.

Let $S$ be the savings, the reduced energy cost attributable to the extra features over the year, in dollars per year.
The Simple Payback Time SPT is

\[ SPT = \frac{C}{S} \]

Since C is in $ and S is in $/yr, the units of SPT are years.

SPT is the time it takes for the dollar savings to equal the extra costs of the energy-saving measures, assuming no change in energy prices over the years.

With a little effort and some complicated mathematics, you can figure out the effective payback time or discounted payback time in years, accounting for changes in the price of energy (and hence your yearly dollar savings) in the future.

As energy prices increase, your dollar savings do as well, and the payback time shortens.
Return on Investment

- Return on Investment (ROI) is the annual percentage rate of dollars earned, or in this case, saved, in response to an initial expenditure (the investment) in an energy-saving technology.

- If $C$ is the cost of the investment and $S$ is the savings, both defined on the previous slide, then the return on the investment is the ratio of the savings $S$ each year to the initial investment $C$, expressed as a percent.

  \[ \text{ROI} = 100\% \left( \frac{S}{C} \right) \]

- ROI is $1/PBT$ times 100%.

- The shorter the payback time, the greater the economic return on the investment.

- The escalated return on investment takes account of changing future values, but a good straight ROI, as defined above, is still a good indicator of the return on the investment.
Cash Flow Analysis

- With cash flow analysis, we assume that no money is directly invested in an energy-saving technology.
- Instead the money, the principle $P$, is borrowed at an interest rate $I$, and the dollar value of the energy savings is used to pay off the loan.
- If the technology saves more than the loan payment, then the cash flow is positive each month (or each year).
- If the technology saves less than the loan payment, then the cash flow is negative.
- Alert business managers are easy to convince, if offered a technology they don’t pay for (the loan pays for it) that pays them a little extra each year.
- When interest rates are low, it is easier to have positive cash flow with such a scheme.
Life-cycle Costs

- Life-cycle cost analysis seeks to consider all the costs and benefits of an energy-saving technology over the lifetime of the equipment involved.
- An investment is made.
- There are annual maintenance and service costs to add in.
- There are annual savings which may be subtracted from the costs.
- The costs and savings are projected over the system’s lifetime.
- The net, end-of-life, cost is totaled up and compared with the life-cycle costs of alternative investment.
- The *least* life-cycle cost technology is generally the one to use.
- This approach is well-tailored to adding in a variety of societal and other costs associated with the investment, if dollar values can be placed on them.
Net Energy Analysis

- Seeks to determine the total energy costs of production of an energy-saving technology.
- Then it estimates the amount of energy to be saved over the lifetime of that technology.
- If the net energy savings exceed the energy costs to manufacture, then the investment is considered to be a good one.
- The concept is most often used to compare the fossil fuel costs to manufacture and operate a system to the saved fossil fuel costs to operate over the system’s lifetime.
- The investment is a good one if less nonrenewable energy is spent than the technology saves in its lifetime.
External Costs

- External costs are the environmental and human health costs of a business operation that are not included in the business’s profit and loss statement.
- External costs are “off the books” and not considered a normal cost of doing business.
- People and the environment pay these external costs—in tax dollars to clean up messes and in health care dollars and diminished health.
- External costs are not usually included in the price of a product. This sends misleading price signals to purchasers and perverts a free-market economy.
- Internalizing costs is the process of pulling external costs back into the corporations generating them, forcing them to include them in their prices offered to customers.
Aren’t these economic measures overkill just for a couple of windows?

- The window market in Florida is large
- Often a selection decision applies to many windows in a home, apartment building, or high-rise condominium, not just two
- In spite of this, yes they are overkill, however: see next slide
There’s More to a Window Than Just Energy or Code Compliance

Economic indicators don’t express the total value of an energy-saving technology

- Cheapest is not always best
- Peak load savings are often not included
- Reduced equipment sizing is often left out
- Human factors of comfort and aesthetics are often ignored
- Acoustic isolation is another often ignored benefit

- Other Factors
  - Human health, environmental viability, economic security

- How do you put a price on these?
While you take a break, please think about all the many environmental, health, comfort, and societal benefits of very energy efficient, well-insulated, well-built windows. Then ask yourself where you can purchase such good windows.
Window Market Problems in Florida

The perils of being smarter than the salesperson

- The sales person doesn’t know what you are talking about
- The window you want they don’t stock
- The window you want requires special order & costs more
- Double-pane warranties may not be long enough
- The building code doesn’t stimulate the market enough for high-performance windows
- The architect doesn’t know enough
- The builder doesn’t know enough
- Even I don’t know enough
- It’s a chicken-and-egg problem in a dog-eat-dog world
Least-cost is a powerful driver

Think of the Bigger Picture

- Choosing the least cost window and other energy-consuming building system is still too prevalent: And can be environmentally disastrous.
- One reason is relatively low energy prices.
- Energy codes work, but only minimally.
- Markets often fail to see the bigger picture, until rather late in the game, especially if they are biased in the wrong direction by government policy (such as subsidizing fossil energy).
- Let’s take a larger view ....
Earth History

Age of Fossil Resources
Coal: 250-350 million years
Oil: 150 million years old
(This is approximate. Deposits vary in age.)

Historical Earth Events
- Earth formed
- Life begins
- Multicellular organisms
- Vertebrates
- Dinosaurs
- Time in billions of years

Coal & oil formation
-3 million yrs
Year 2000
**Seeing the Big Picture**

**Human History**

- First humans - Pop 10,000
- 125,000 humans 1 million yrs. ago
- 500 million Year 1500
- 800 million Year 1800
- Pop 10 million Year 3500 BCE
- 10,000 BCE
- 6 Billion Year 2000

Oil deposit formations nearly complete
History of Civilization

(Oil is still being generated, but at the same very slow rate)

Year 2000

Year 1970

2.5 billion

Year 1950

800 million

Year 1800

500 million

Year 1500

10 million people

Year: 3500 BCE

Agriculture

10,000 BCE

World Population in Billions

Time in thousands of years BCE

6 Billion

Year 2000

2
Exponential Growth

The Bigger Picture Revealed
Exponential growth of world oil and coal production

The bigger picture revealed


Exponential Growth of World Coal and Oil Production

What do you think happened in the next 40 years?

And what will happen 30 years after that?

FLOW OF OIL starts to fall from any large region when about half the crude is gone. Adding the output of fields of various sizes and ages (green curves at right) usually yields a bell-shaped production curve for the region as a whole. M. King Hubbert (left), a geologist with Shell Oil, exploited this fact in 1956 to predict correctly that oil from the lower 48 American states would peak around 1969.

The Peaking and Decline of World Oil

U. S. production peaked in 1972, only 3 years after 1969, the year Hubbert predicted (in 1956) it would happen.

World Oil Depletion Estimate

World Production
Modeled on an ultimate 2000 Gb


Current estimates of the date of peak world oil production:
“We may have already passed it.” made by Campbell in 2002, private communication.
Like the flame of a candle in the long dark night

“The brevity of this in human history can best be appreciated if we plot [the above graph].” “The epoch of the fossil fuels ... is responsible for the development of our modern industrial civilization....”

The following are my views

To some extent they reflect the interests of the U.S. Department of Energy in reducing fossil energy use.

For example, DOE’s zero energy home program. And the President’s pronouncement that global warming is real and of human origin.

They are the views of neither the Florida Solar Energy Center nor the University of Central Florida.
Some Possible Future Consequences of Declining World Oil Production

- Transportation fuel prices will increase
- Prices for transported commodities will increase
- Electricity and fuel oil prices will increase, along with the prices of the foods most heavily dependent upon fossil fuel
- A rush to conserve petroleum for more durable uses
- A push to relocate places of work closer to homes and vice versa
- Pressure on the “have-not” nations to develop on a much lower energy model than the current industrialized world one
- Pressure on the industrialized nations to use less, leaving more for developing nations to consume as they develop
- How long until this starts happening? — Middle of this decade
- How long does a good window last? — Several decades
- So what kind of window did you say you wanted for your home?
The World Economy’s Response

Many people have proposed various scenarios

- Amory Lovins suggests that radical resource efficiency will dominate the market for energy-consuming systems.
  - It will happen faster than the decline in world oil production.
  - There will be no crisis as we run out of oil.
  - Energy efficiency and substitute fuels will rule the day.

- Suggested substitutes include
  - liquid fuel from renewable biomass such as corn
  - hydrogen derived from solar-powered electrolysis of water
  - other renewable sources.

- World population growth will continue. The per capita use of energy is also growing, especially in China, India, and other parts of the world. But radically increased energy efficiency will save the day. Plus increased renewable energy sources.

- Both of these will occur on a massive scale. Some say it will be enough to keep ahead of growing demand.
But there may be some limitations

- Some renewable energy systems may not pan out, due to:
  - Technological problems
  - Cost problems
  - Limited resource availability
  - Adverse environmental consequences

- Public policy currently fails to offer strong incentives for energy efficiency or renewable sources. This may not change fast enough.

- As China, India, Africa, and South America grow and demand more energy-consuming technologies, new energy demand can outstrip improved energy efficiency and more use of renewables.

- What about the base of existing, already installed energy-consuming systems? They can’t become efficient overnight.
Throughout [the 1990s] China’s real gross domestic product (GDP) has grown an average of over 11% each year.

To help fuel her unprecedented growth, in 1993 China became a net importer of oil for the first time in history.

The impact of China’s total fossil fuel consumption also dominates the politics of global environmental change.

Chinese oil imports could reach 7 to 8 million barrels per day by 2015 and 13 to 15 by 2025.

Together with projected global declines in oil production in 20 years, these demands on the global oil market pose a serious threat to future global energy security.
Shouldn’t we buy the *most* energy-efficient windows available?

However, in the face of coming oil shortages, we continue to purchase what is cost-effective only in a narrow monetary sense. When energy prices are low, *more* energy consumption results, not less.

So vendors have trouble stocking and selling better products.

There is an inherent conflict between what the “free market” wants and what DOE and the concerned public want. And there is the natural human reluctance to change, a failure to anticipate future pressures and respond ahead of time.

Market consequences
"A chicken and egg problem in a dog eat dog world."
Perhaps we need to restructure the market toward more efficient products.
How to encourage energy efficiency in new buildings?:

- **A market-based approach** utilizes education, technical information, design assistance, financial incentives — to accelerate voluntary adoption of energy efficient building practices.
- **The regulatory approach.** Energy codes are arguably the most cost-effective and permanent mechanism.

Energy codes — the purest form of market transformation:

- They affect all buildings
- They give clear signals to manufacturers and distributors
- They are persistent

Only **you** can influence energy code revisions

It is a political act
FSEC information resources

- Information and educational tools
  - Publications
  - Web site
  - Short courses
  - Technical assistance

- Contribute to market transformations through:
  - Education
  - Technical information
  - Design assistance

- Purpose: accelerate voluntary adoption of energy efficient building practices

- We do not set public policy.

- That’s the public’s job and its political leaders.
Failures of understanding, of education, of leadership, of investigative journalism, and of individual responsibility can keep us from moving to radical resource efficiency

What you seldom hear in the media or from politicians:

- **Energy should cost more**, better reflecting its true cost
- Government should stop subsidizing fossil fuels, keeping energy prices arbitrarily low and sending wrong price signals

If prices were **higher**,

- First cost would be less important
- Life-cycle costing would be more widely used
- Transportation energy use would decrease
- Petroleum would be saved and conserved as the precious commodity that it is
- Extreme energy efficiency would be universal
- Renewable energy would be pushed to the environmental limits

And both the demand for and the supply of high performance windows would be much greater!
“We’re looking for security in all the wrong places.”

“Did we put our young people in 0.6 mile per gallon army tanks because we did not put them in 32 mile per gallon cars?”

“Real security begins at home and is built on communities that are self-sufficient and sustainable.”

— Amory and Hunter Lovins
“Strategic planners...have tended to focus almost exclusively on the military threat. They have largely ignored equally grave vulnerabilities in vital life-support systems such as our energy, water, food, data processing, and telecommunications networks.” To be more resilient to mishaps, Americans must decentralize. “The most resilience per dollar invested comes from using energy very efficiently.”
Substantial increases in efficiency of fossil energy use are essential

- Designing buildings *down* to a minimal energy code
  - represents failed opportunities for slowing the growth of energy demand
  - ignores comfort, produces more pollution, contributes to global warming
  - in some cases is not cost-effective even in the traditional economic sense

- Designing *up* to greater energy efficiency is a patriotic act—a commitment to the future of humanity and of the Earth.
  - It leads to higher quality homes, that are more comfortable and have lower energy bills.
  - It reduces pollution, lessens global warming, reduces dependence on foreign oil.
  - It directly contributes to a sustainable future.

- Better homes attract more customers, permit higher prices, and lead to greater profits for sellers.

- Designing *up* not only helps us enjoy our new homes but makes us feel good about ourselves and our future.
The last thing we want is to design down to the least common denominator, just barely meeting the Florida Energy Code. Achieving only the minimum necessary energy performance represents failures in
- Understanding
- Responsibility
- Policy
- Leadership

Our goals should be
- Disconnect from the electric utility grid to the greatest extent possible.
- Install high performance windows, and very well insulated walls, ceilings, and floors
- A home in Florida can drastically reduce its energy requirements and be more comfortable and enjoyable as well.
- If you are not yet ready to disconnect, at least strive for maximum fossil energy use efficiency.
Final Recommendations on Windows

- **All windows:** Insist on high-LSG glazings and double-pane, insulated windows throughout the house—-for energy savings, comfort, reduced peak load, and smaller A/C capacity (and cost).

- **North-facing:** Use a side-wall, or a deep window reveal to block low rising and setting sun on hot summer days.

- **South-facing:**
  - Use a modest overhang if you like winter sun
  - Use a wide overhang to avoid sun year round
  - High-LSG glazings are especially important if shading’s inadequate

- **East- and West-facing,** a menu of choices:
  - Dense tree shading where possible
  - Awning shade
  - Exterior shade screen
  - Exterior roller shutters
  - Highest-LSG glazing system, VT between 0.2 and 0.4
  - Interior reflective operable shade

- Laminated glass for impact resistance if exterior shade is not enough for this
Getting the Products

- Pressure window sellers, wholesalers, manufacturers, and builders to specify, manufacture, sell, and install high-performance windows

- Since we may already have passed the peak in world oil production . . . .

- And if you value security, freedom, motherhood, and apple pie . . . .

- Work to lessen U.S. dependence on foreign oil through more energy efficient window systems (and energy efficient building designs).

- Work to exceed Energy Star requirements and stringent energy codes by wide margins.
Any Questions?
Additional Information & Resources

- For more information visit our windows web sites:

- A short, relatively easy to read tutorial on windows is at

- This presentation is at

- Energy Crisis: www.dieoff.org

- Please fill out your evaluation questionnaires