Window Options

Keeping cool in summer, warm in winter, comfortable all the time,... and saving energy too

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Florida Solar Energy Center

- **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**

Finding the Right Window

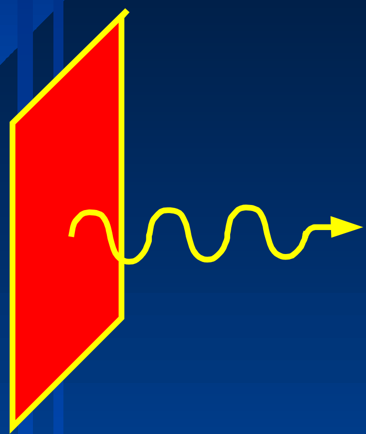
- It is more than just choosing a pretty window.
- We must also deal with the heat and the cold, as well as the glare and overheating of direct sunlight
  - The heat and cold: insulation and shading
  - The glare and overheating of direct sunlight: orientation and shading
- Other issues
  - Choice of window frame and glazing
  - To insulate or not?
  - Impact resistance?
  - Acoustic isolation?
  - Utility concerns

Dealing with the Sun

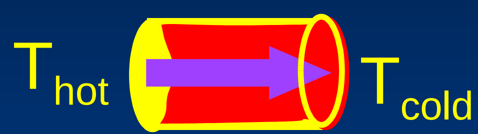
- **The Good**: Big windows provide a bright and open room with great views and good daylight illumination
- **The Bad**: Overheating, fading of furnishings, blocked views
- **The Ugly**: Killer glare from the sun, big energy bills, thermal discomfort
- **Three strategies for dealing with the sun**
  - Know where the sun is
  - Shape and orient the building properly relative to the sun
  - Shade the windows and walls properly

Heat Transfer

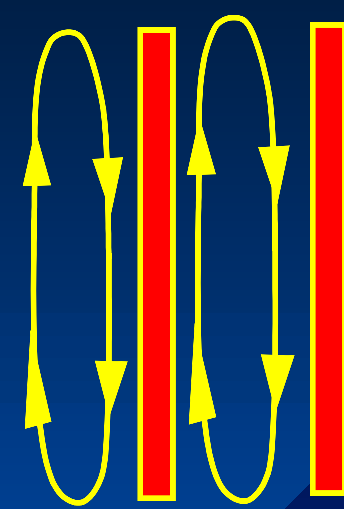
The three modes of heat transfer



Radiation

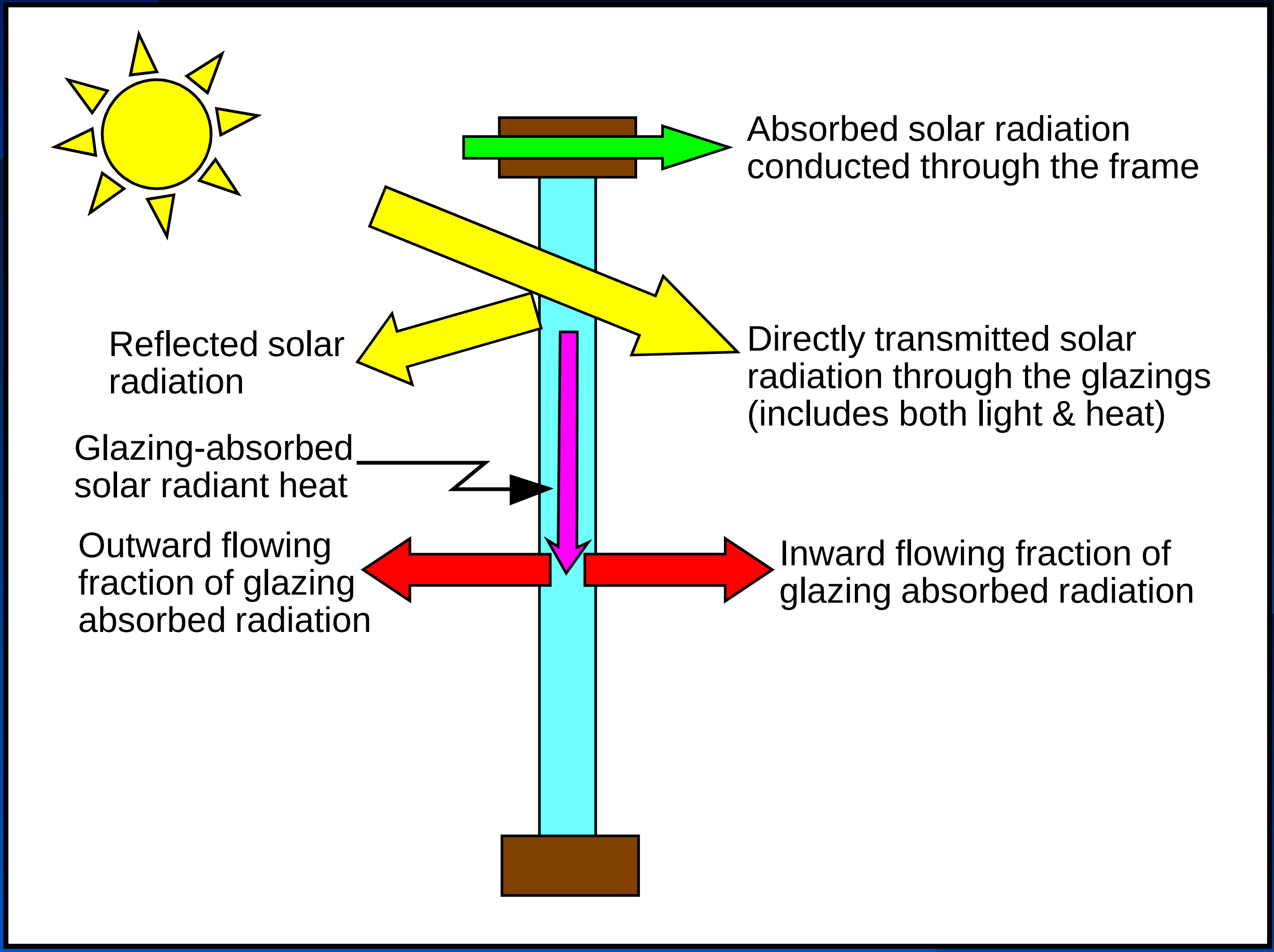


Conduction

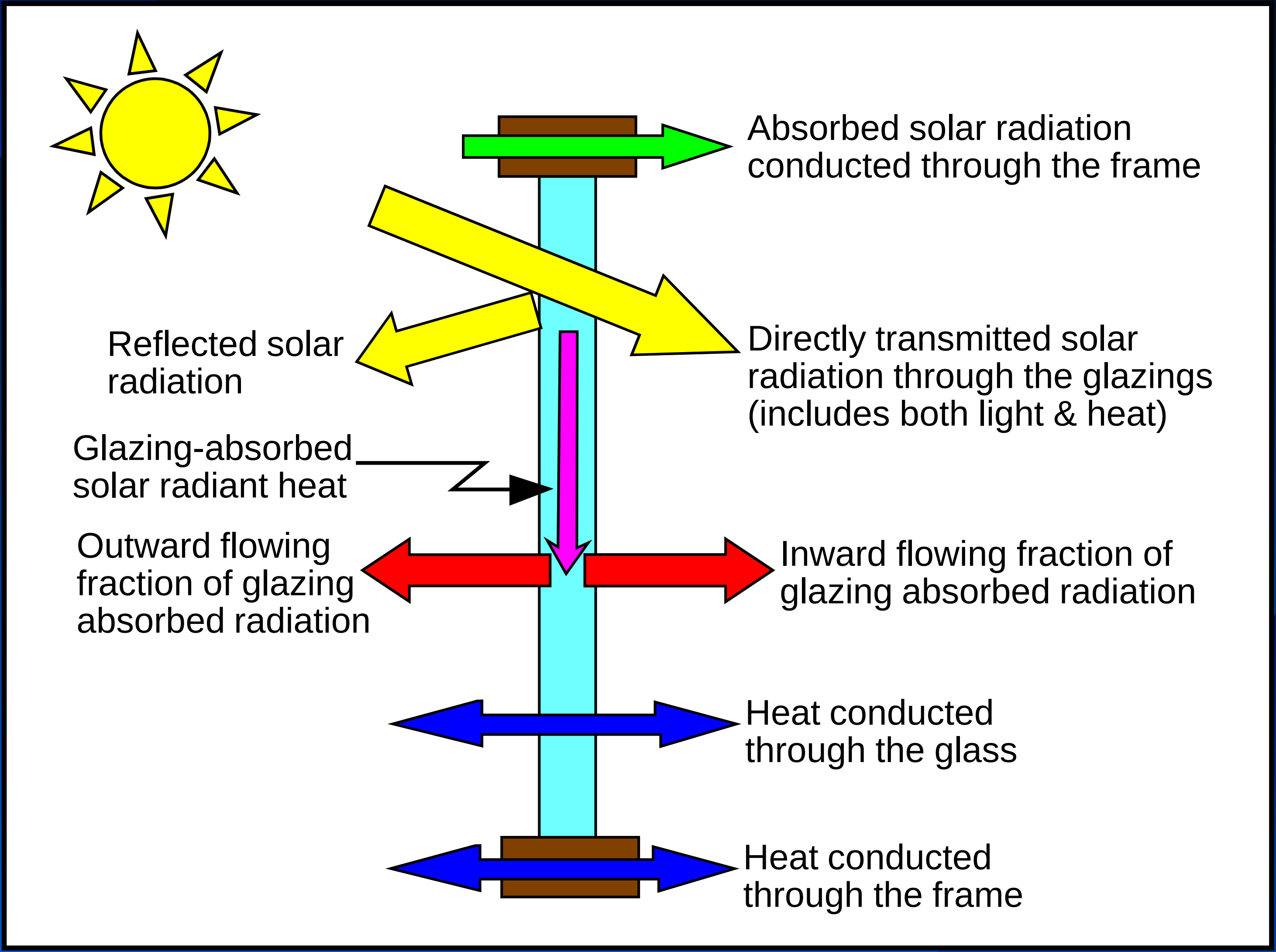


Convection

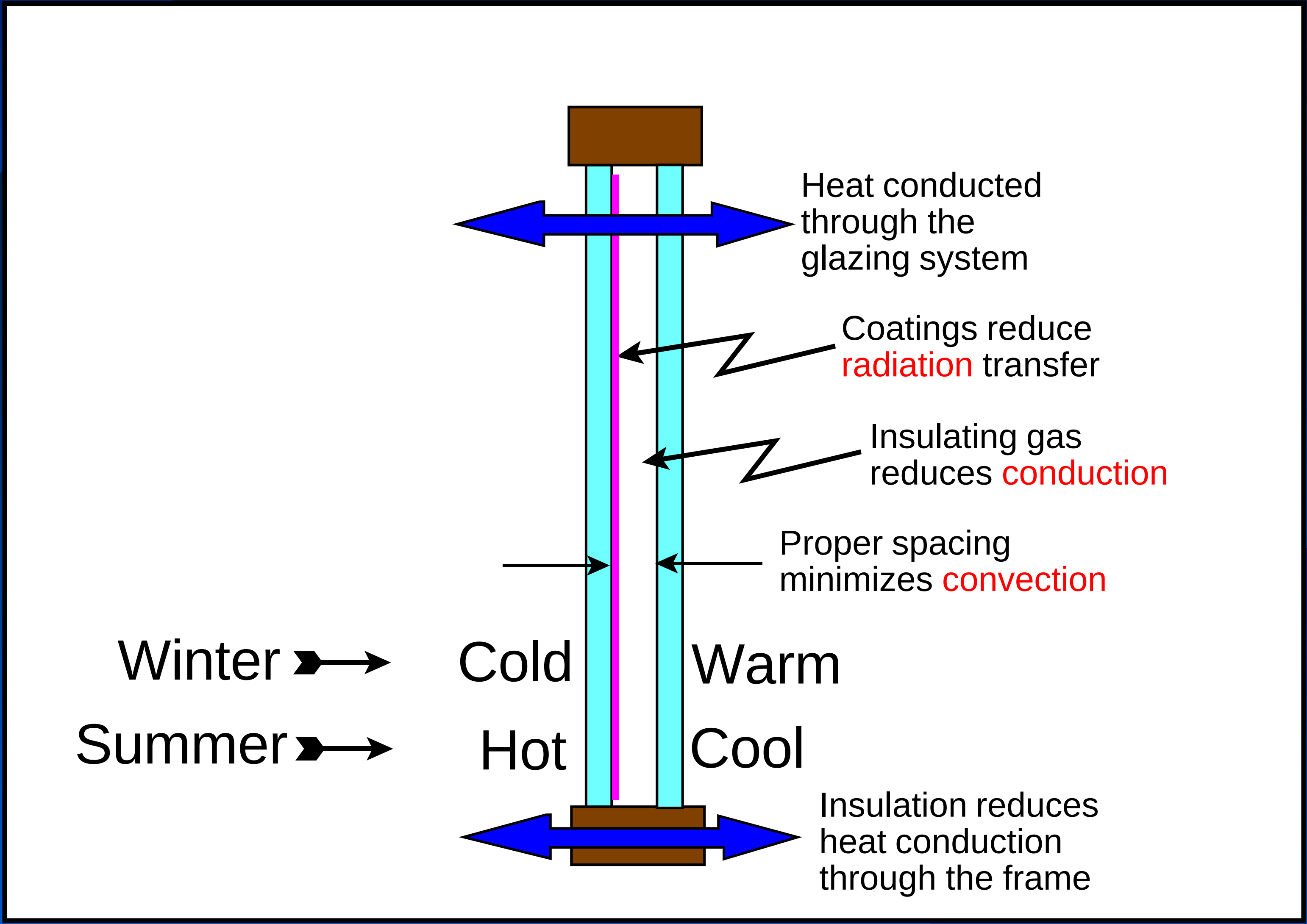
Heat Flows Through Windows



Heat Flows Through Windows



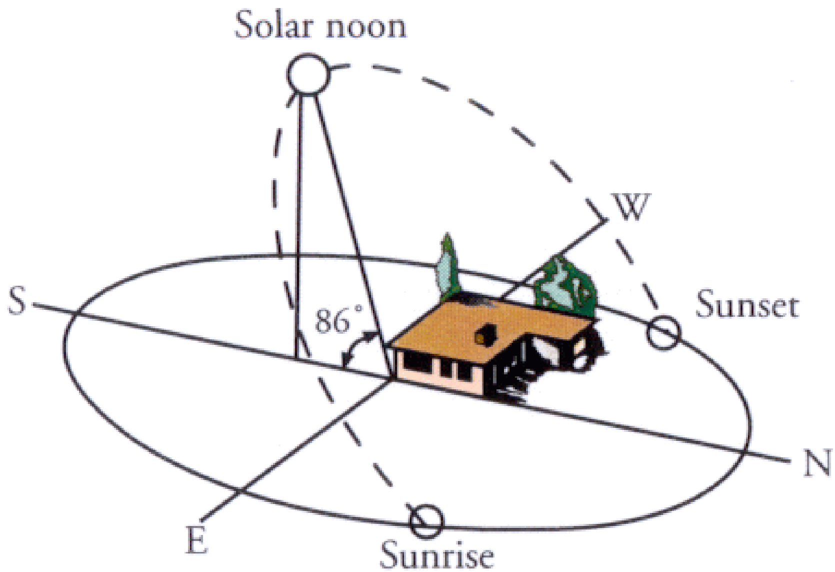
Insulated windows reduce conduction, convection, and radiation



Knowing Where the Sun is

- Radiation from the sun is generally much stronger than that from the sky, except on hazy and partially overcast days
- The sun moves through the sky in a known way each day
- Radiation coming directly from the sun's "disk" is called "direct beam radiation."
- Orienting the building and its windows is important to maximize the benefits and minimize the problems produced by direct beam solar radiation.
- First we look at a generic drawing of the sun's path through the sky on the summer and winter solstices
- Then we consider how to orient a house properly relative to the sun's positions in the sky

SUMMER

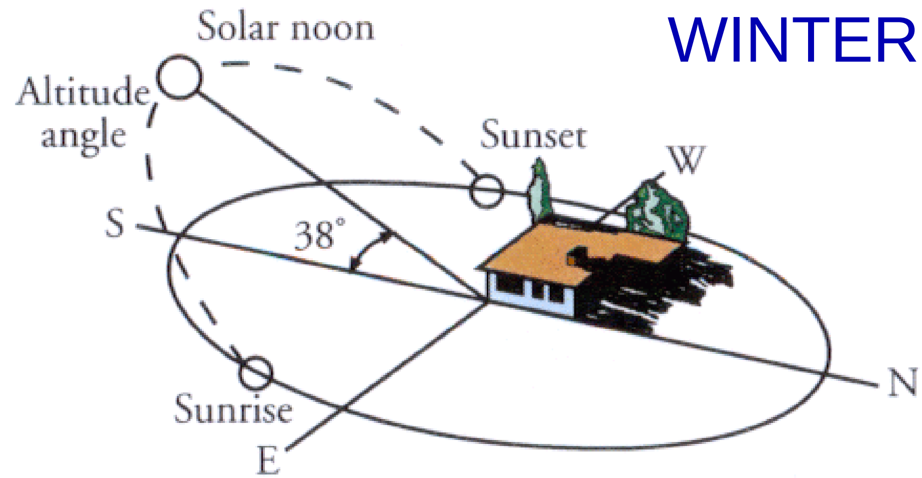


Sunpath on summer solstice at southern latitude

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

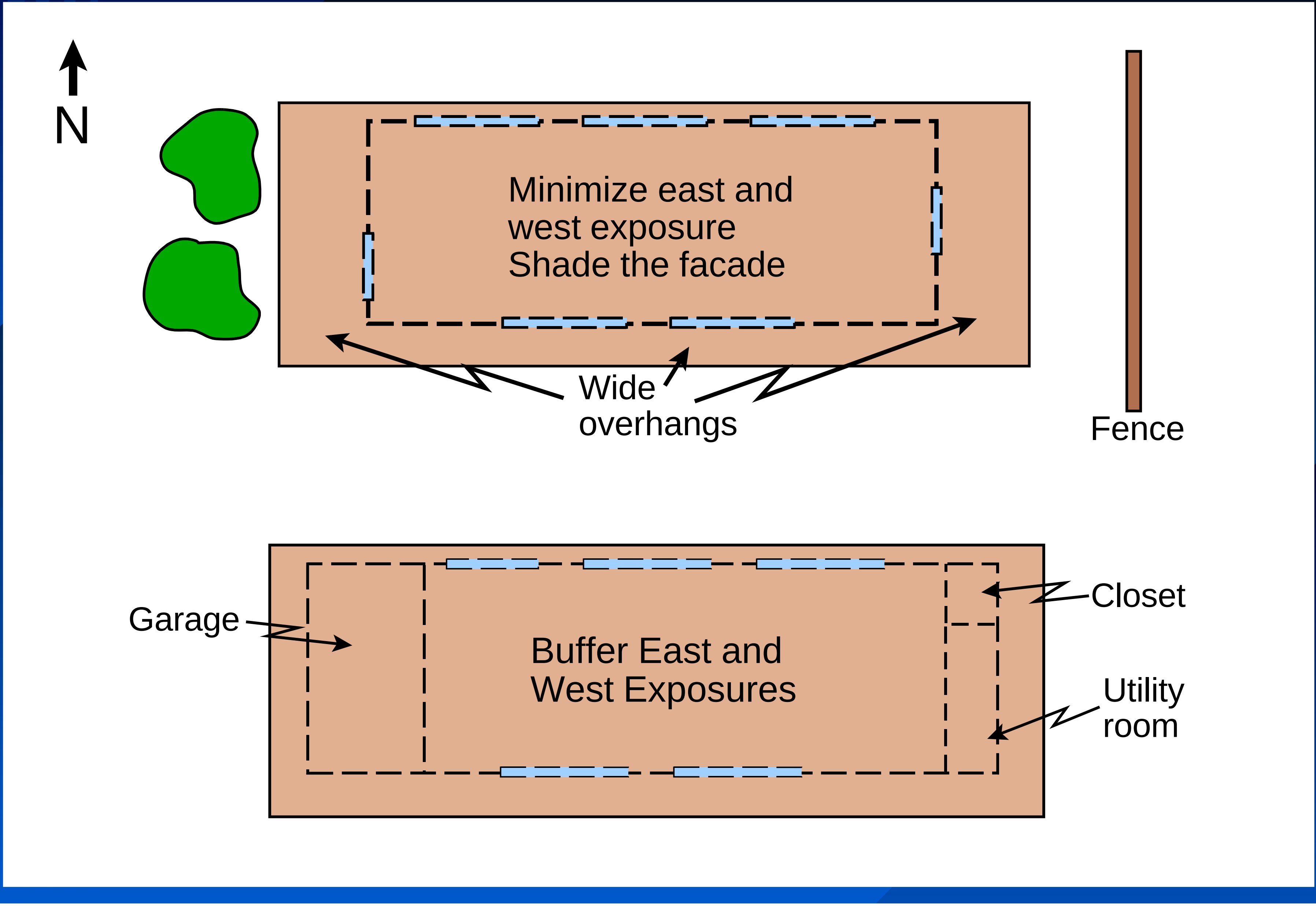


Sunpath on winter solstice at a southern latitude

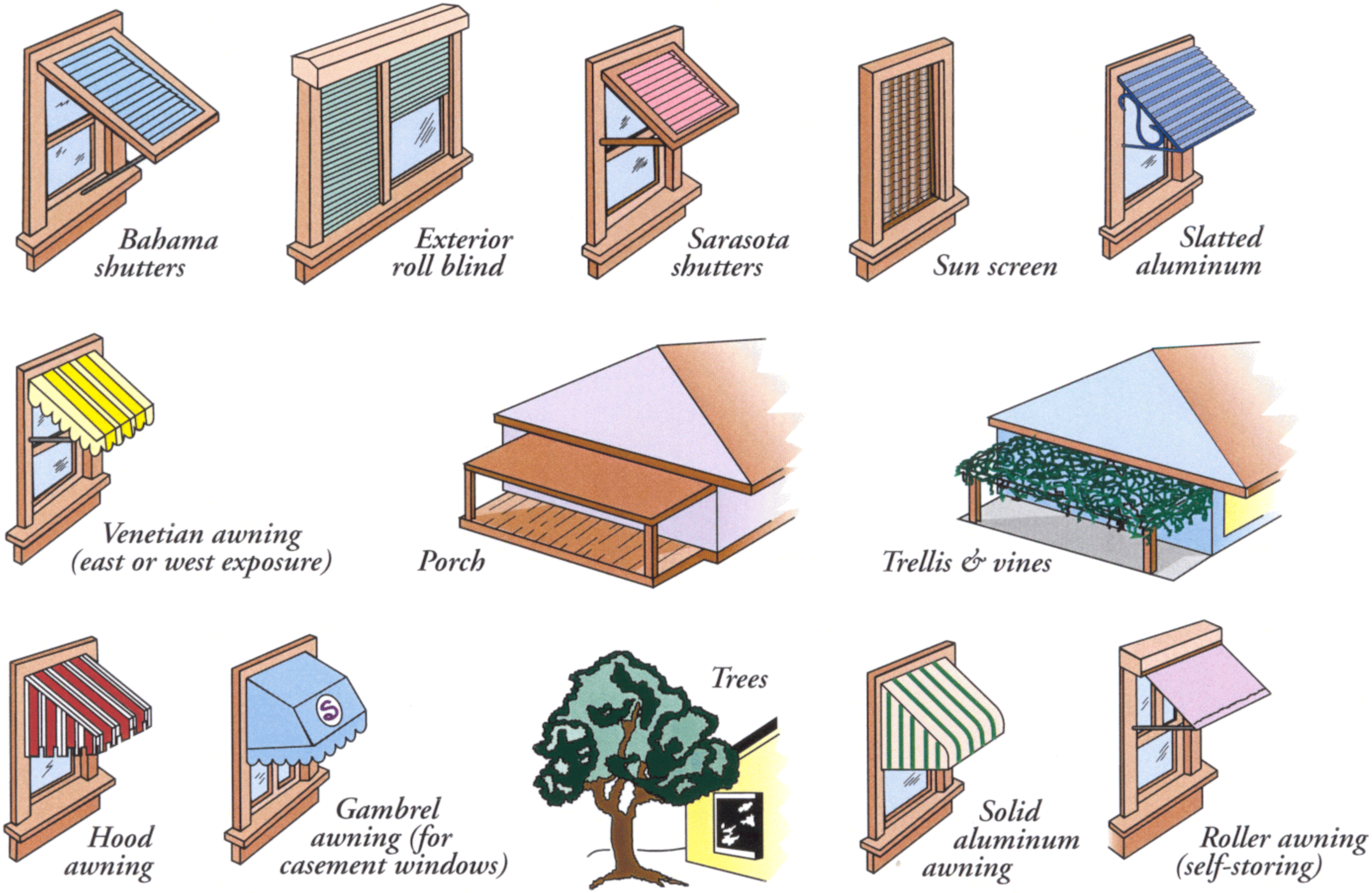
Sun rises south of due east,
sets south of due west,
and is low in the sky at noon

Shade: southwest to west to protect west window on warm winter days

Orientation and shading



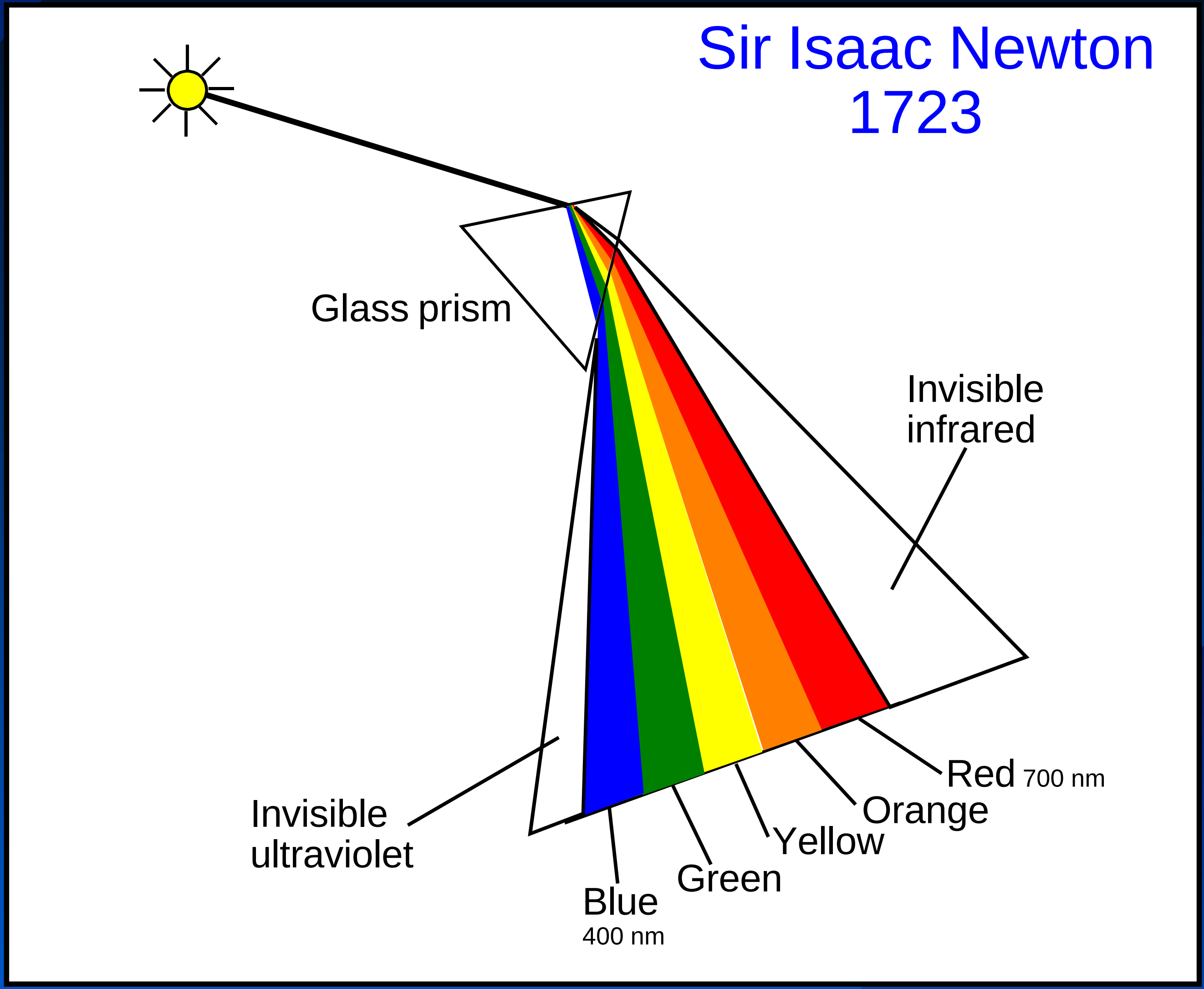
Exterior window shading strategies



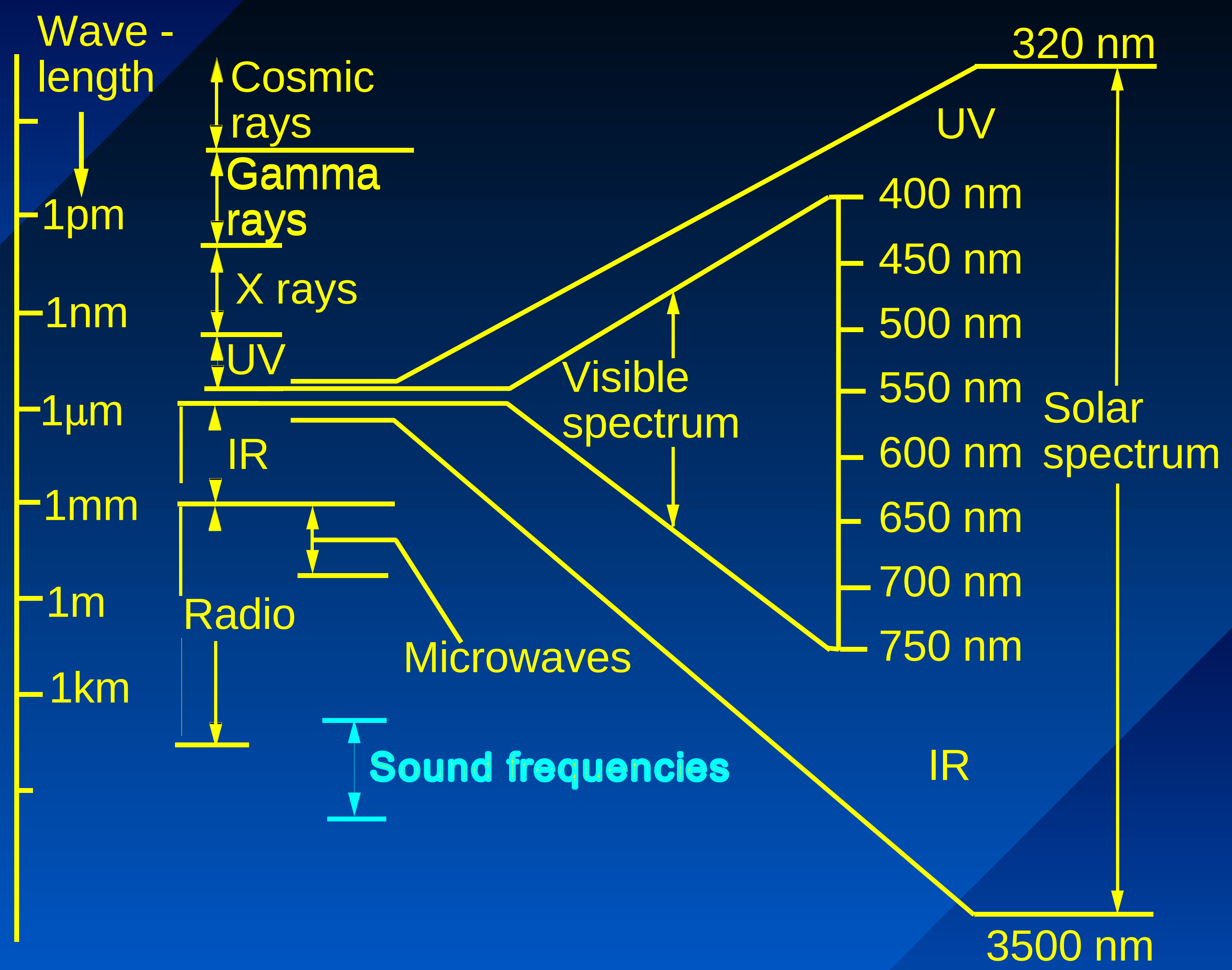
Solar Spectrum Fundamentals

- The sun’s radiation covers a range of colors, and beyond.
- This electromagnetic radiation has important features for the design and performance of windows in different climates.
- We need to know a little more about the physics of solar radiation to fully understand the variety of window products now on the market.
- We begin with the electromagnetic spectrum.

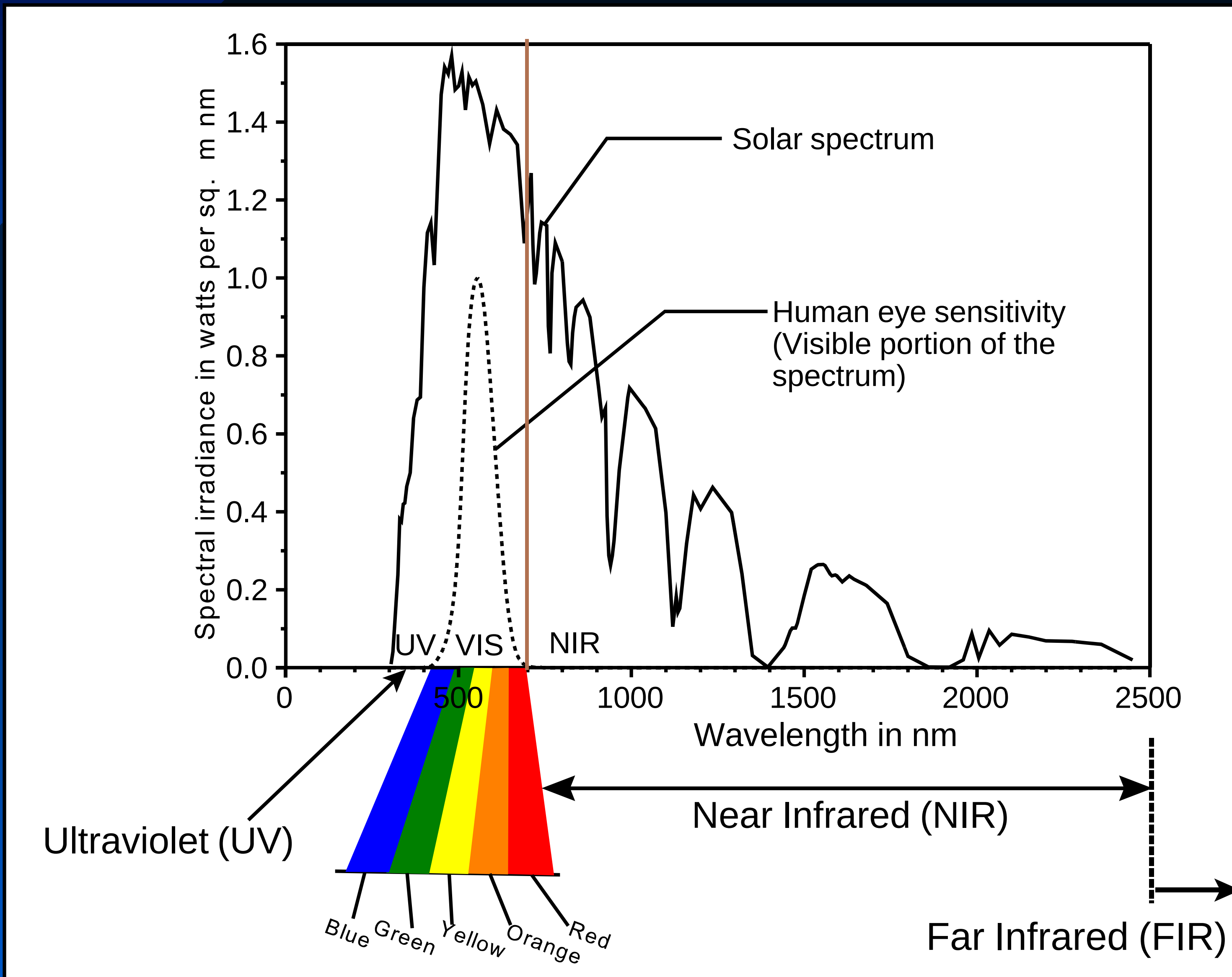
Breaking sunlight into its various colors



Electromagnetic Spectrum



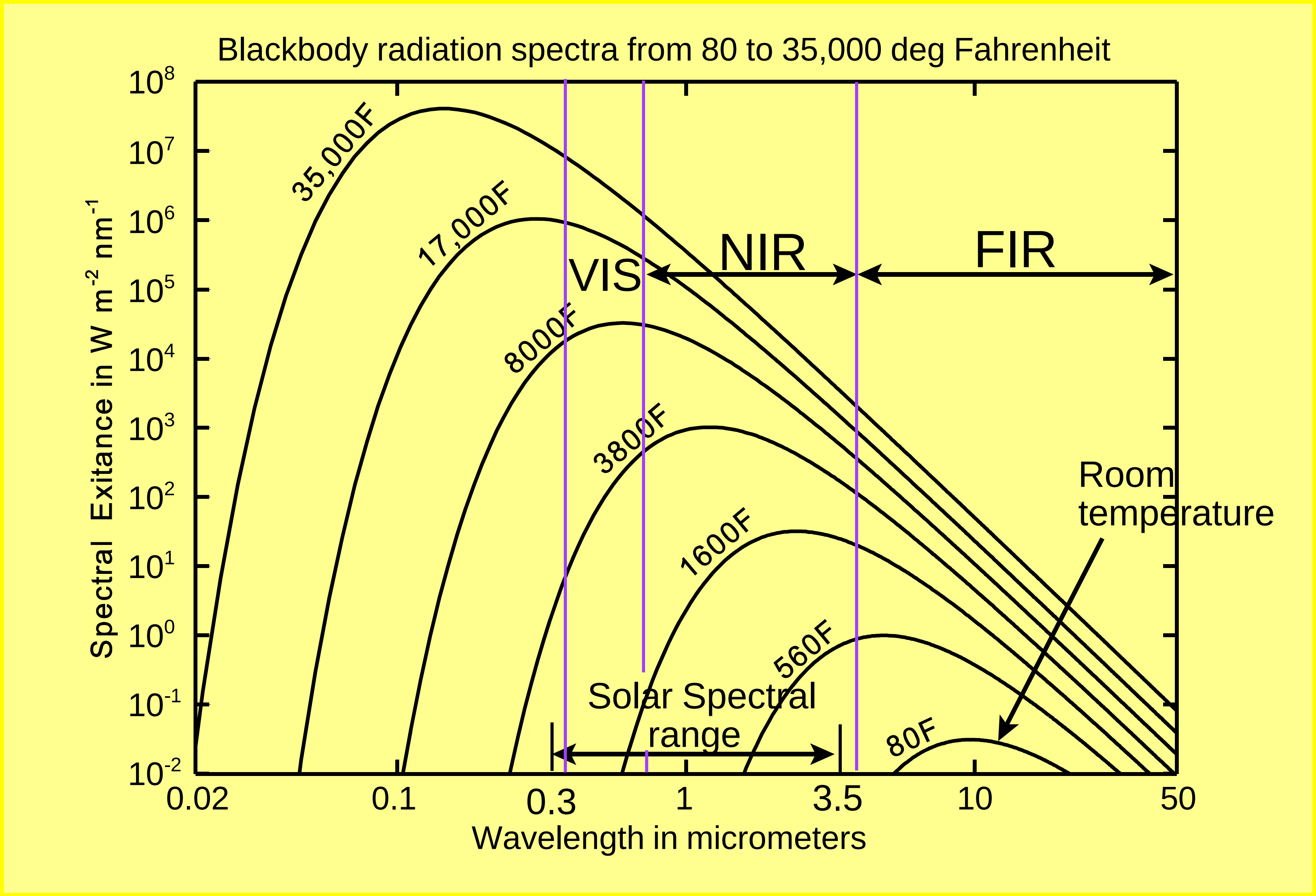
Parts of the solar spectrum



Emission of Heat Radiation

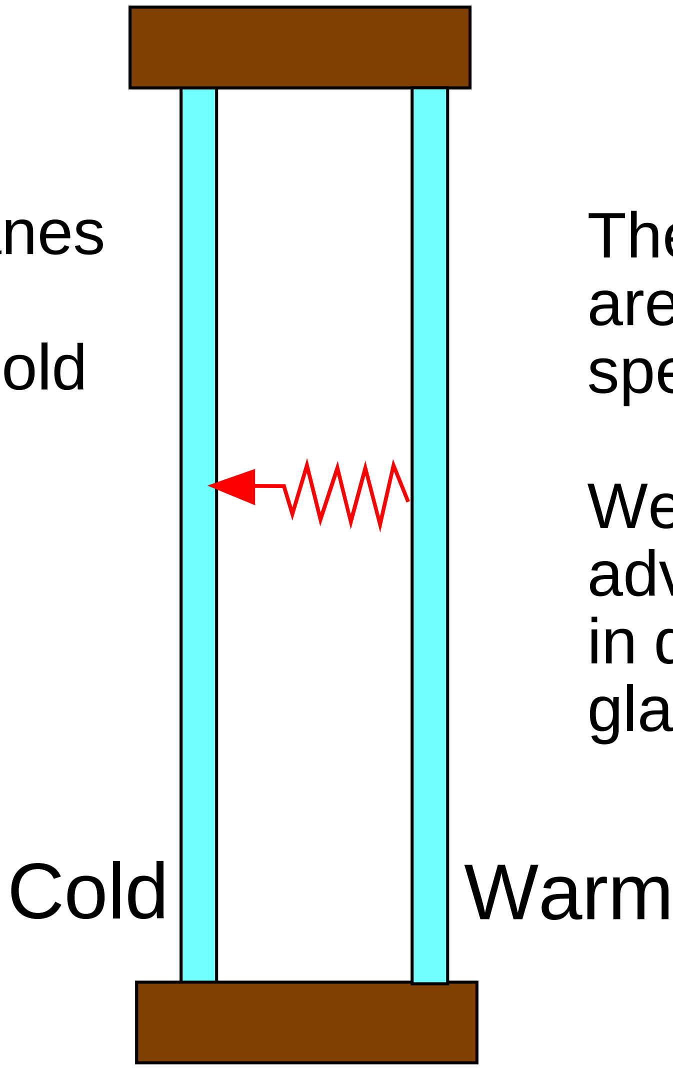
- Warm objects emit radiation
- The hotter they are, the more they emit
- As their temperature increases, the spectral distribution shifts as well, as shown on the next slide

Warm Objects Emit Radiation



Why black body radiation is important

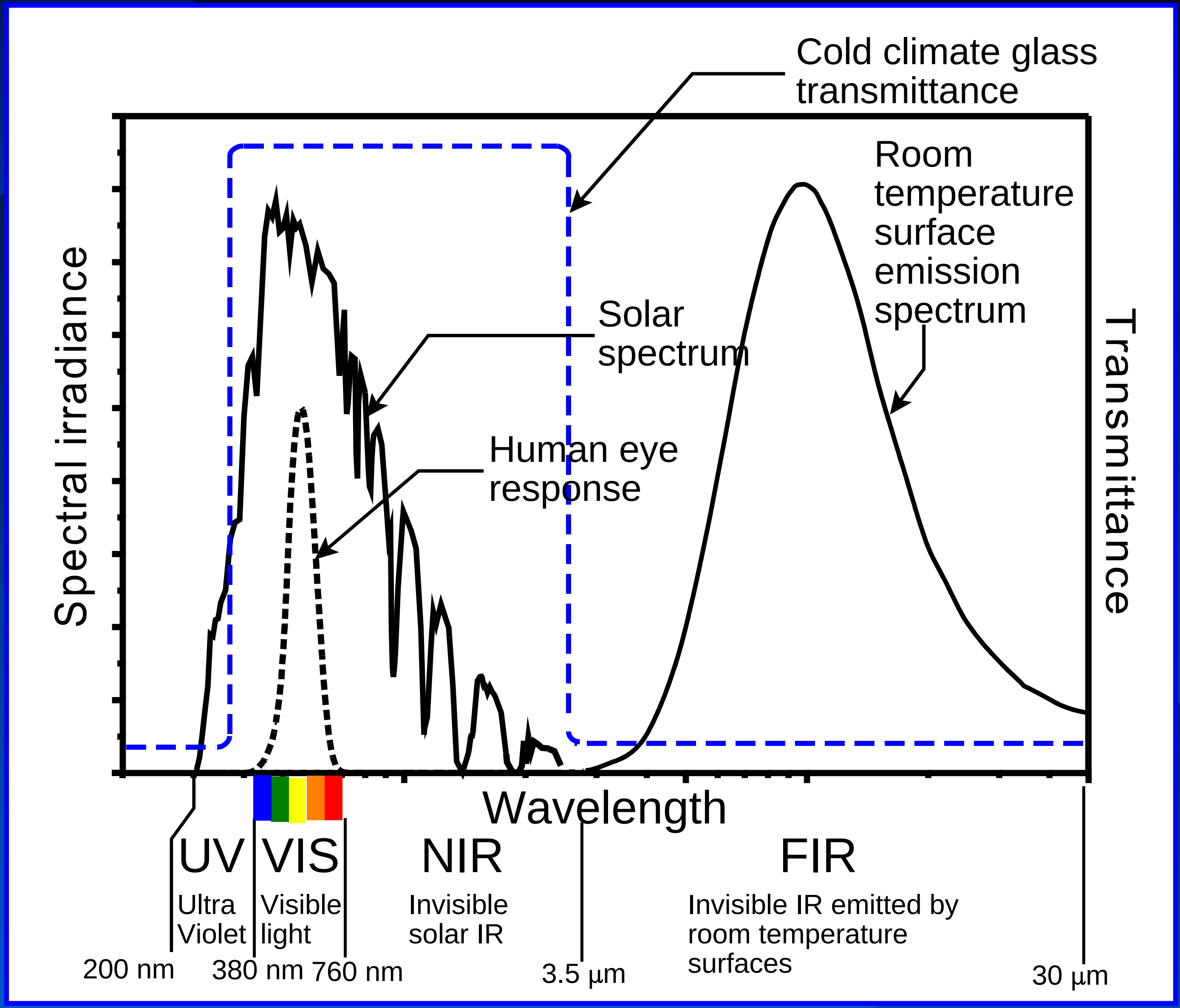
Warm panes radiate toward cold ones



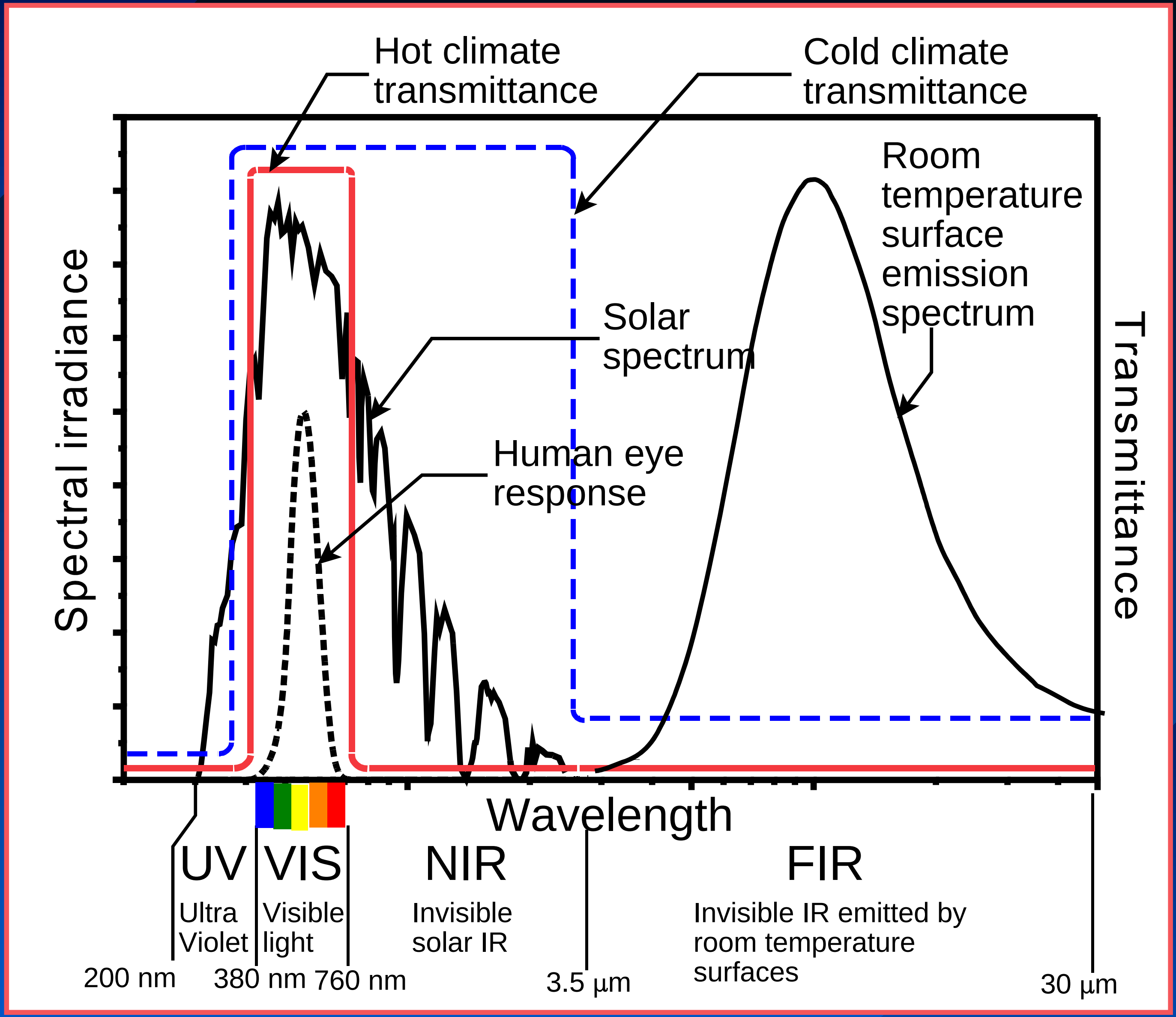
The wavelengths are in the far IR spectral range

We can take advantage of this in designing the glass panes

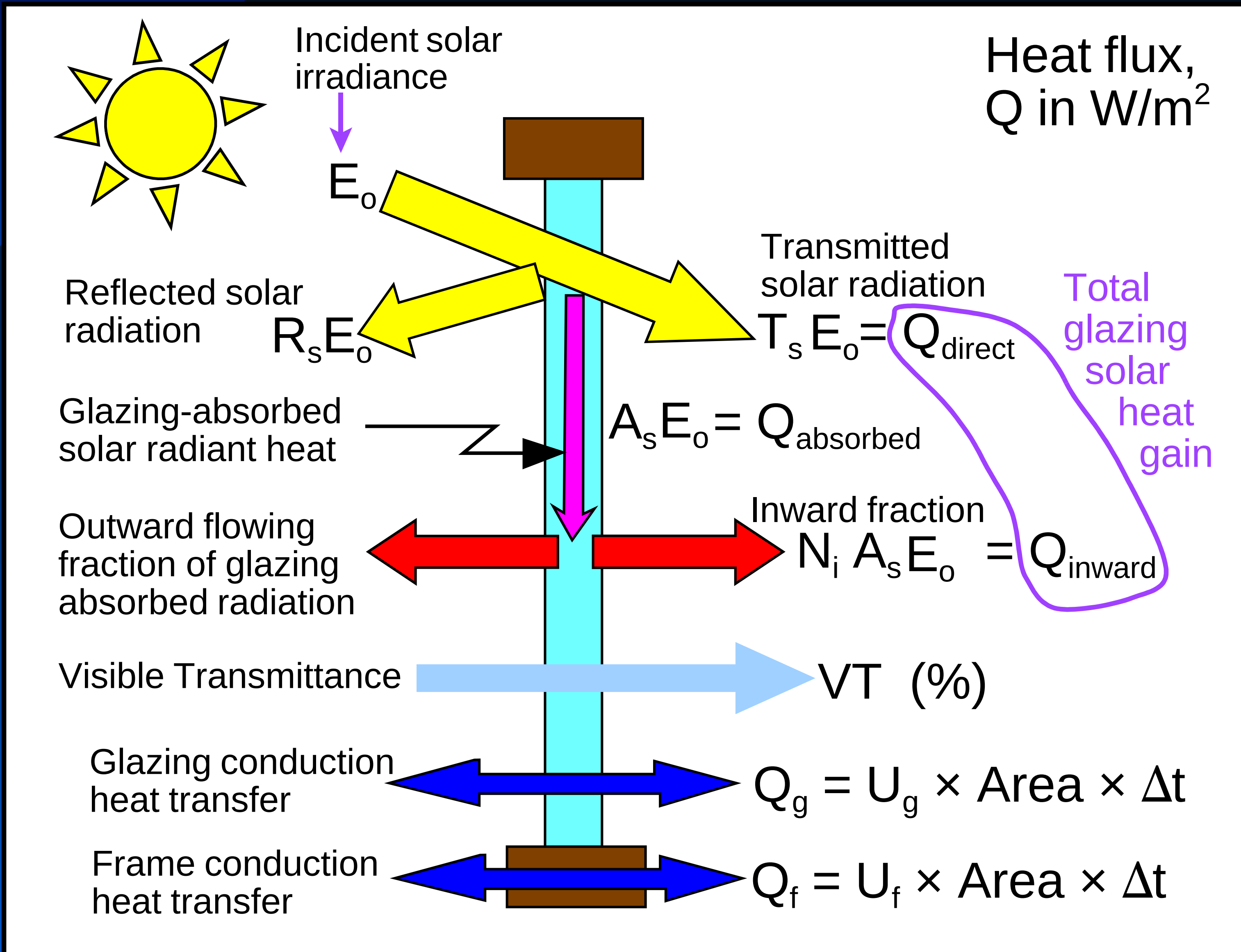
Spectral Selectivity for Cold Climates



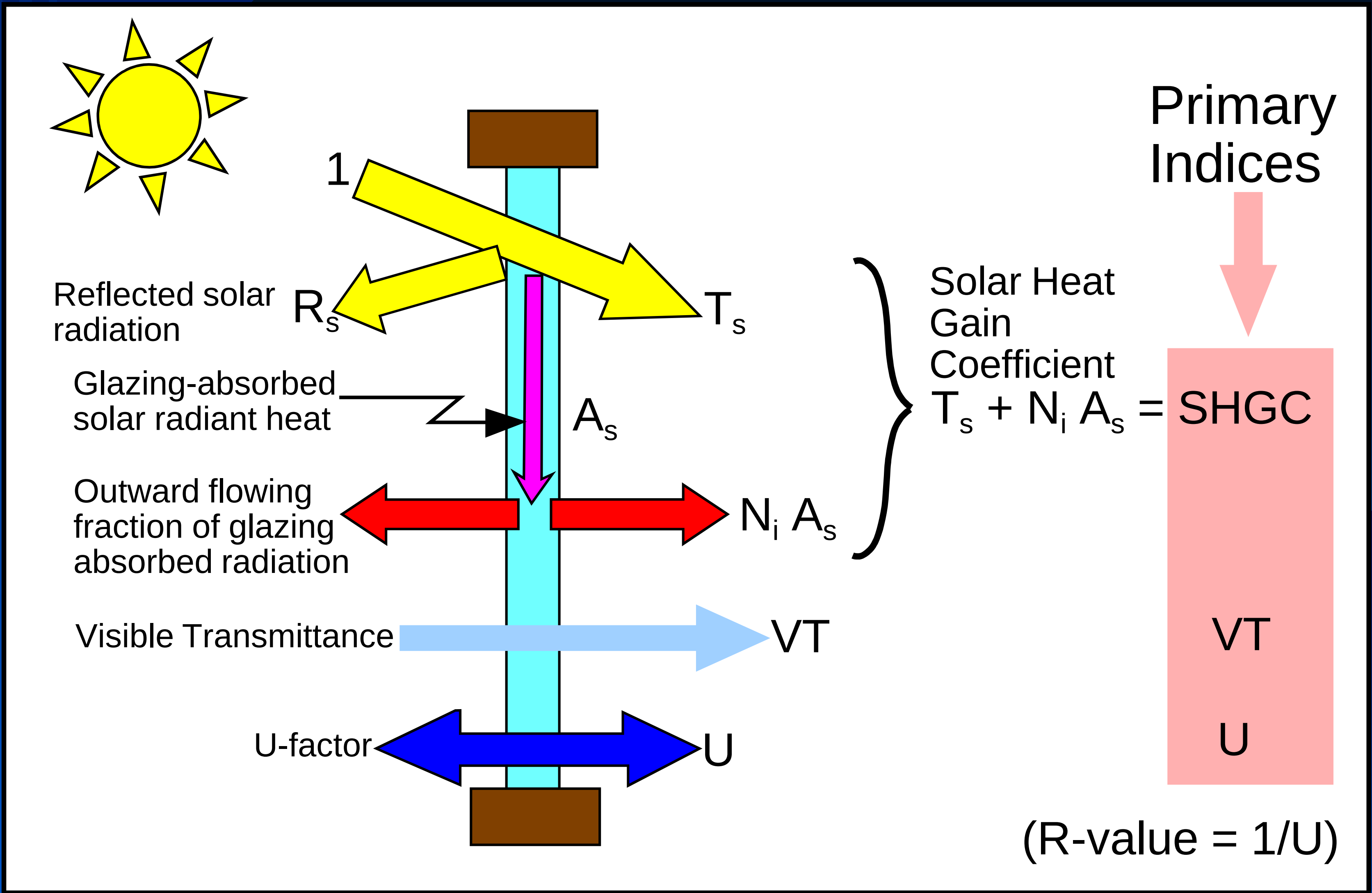
Spectral Selectivity for Hot Climates



Quantifying Heat Flows



Performance Indices

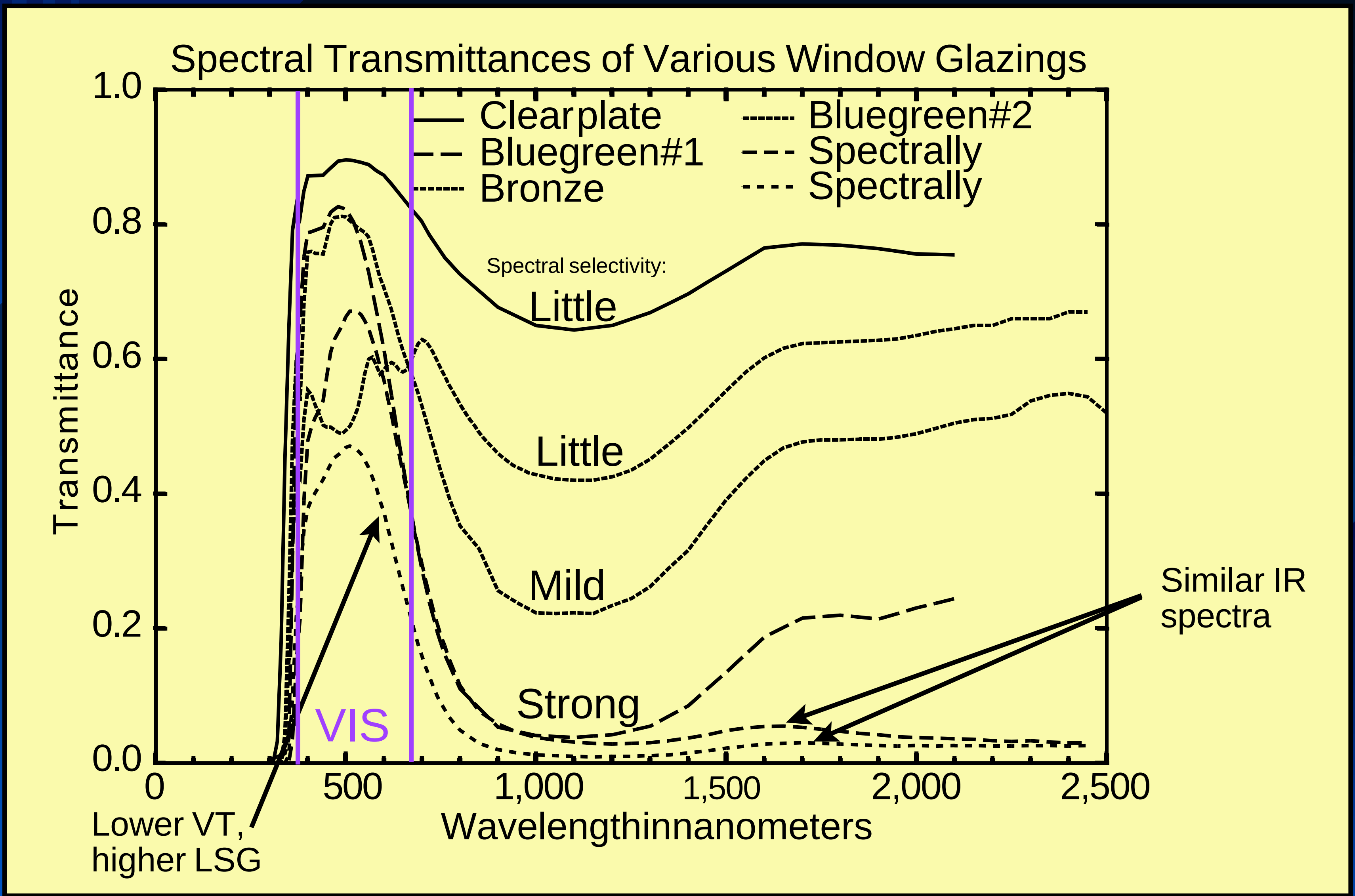


Light to Solar Gain ratio - A measure of spectral selectivity

VT	Visible transmittance: Fraction of incident light transmitted
SHGC	Solar heat gain coefficient: Fraction of incident solar radiation admitted as heat gain
LSG	Light-to-Solar Gain ratio: Ratio of visible transmittance to solar heat gain coefficient

$$\mathbf{LSG} = \frac{\mathbf{VT}}{\mathbf{SHGC}}$$

Spectral Selectivity of Real Glazings

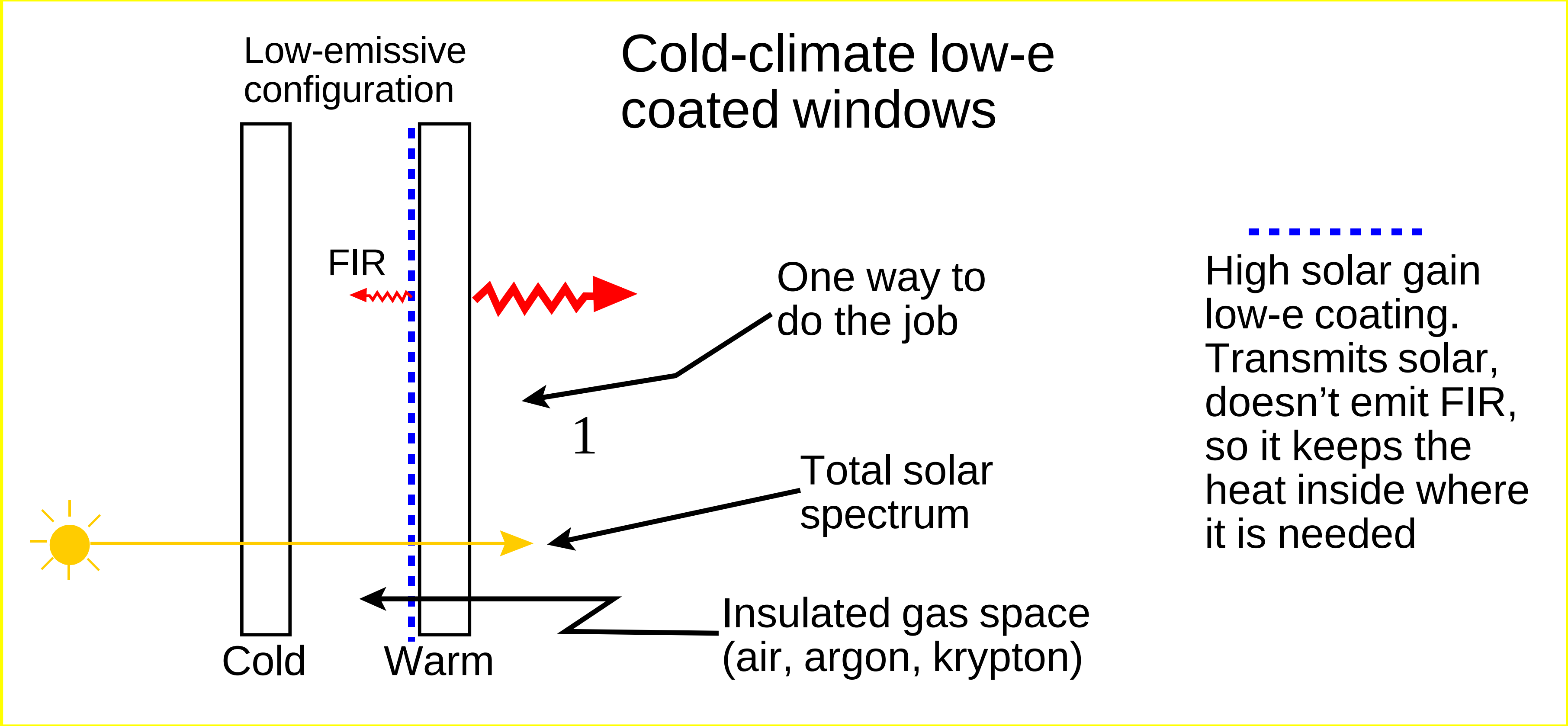


Coatings and Tints

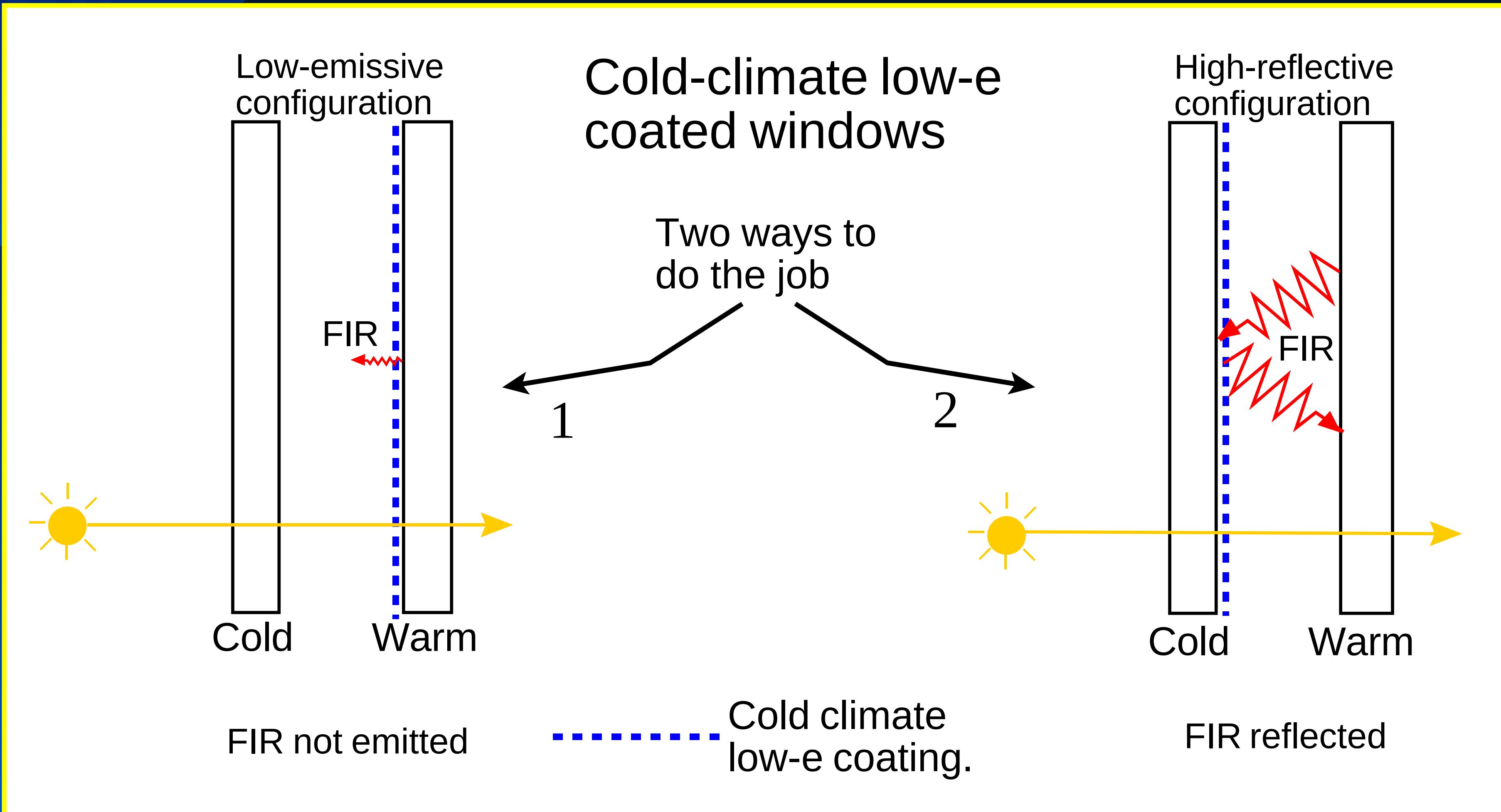
One can use

- High solar gain low-e coatings for cold climates
- Low solar gain low-e coatings for hot climates
- IR-absorbing glass for hot climates
- A variety of ways to coat and tint glass

Cold climate glazings
Admit and trap solar heat

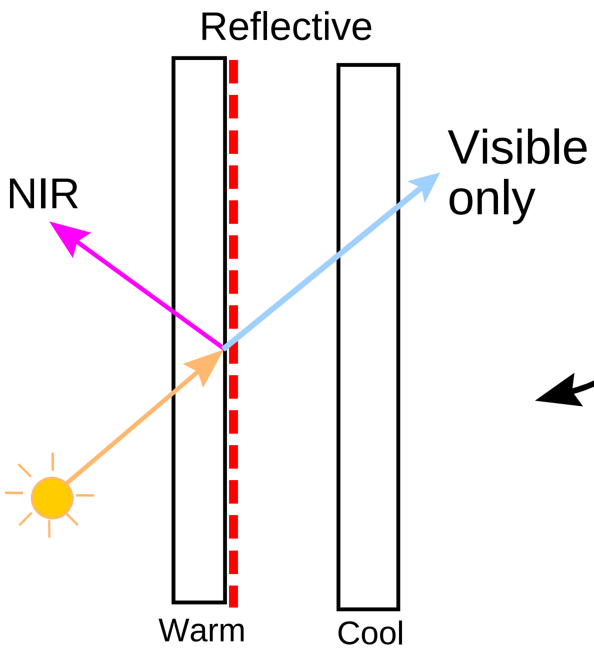


Cold climate glazings
Admit and trap solar heat



Hot Climate Glazings
Admit visible, reject invisible solar

Hot-climate coated windows



One way
to do it

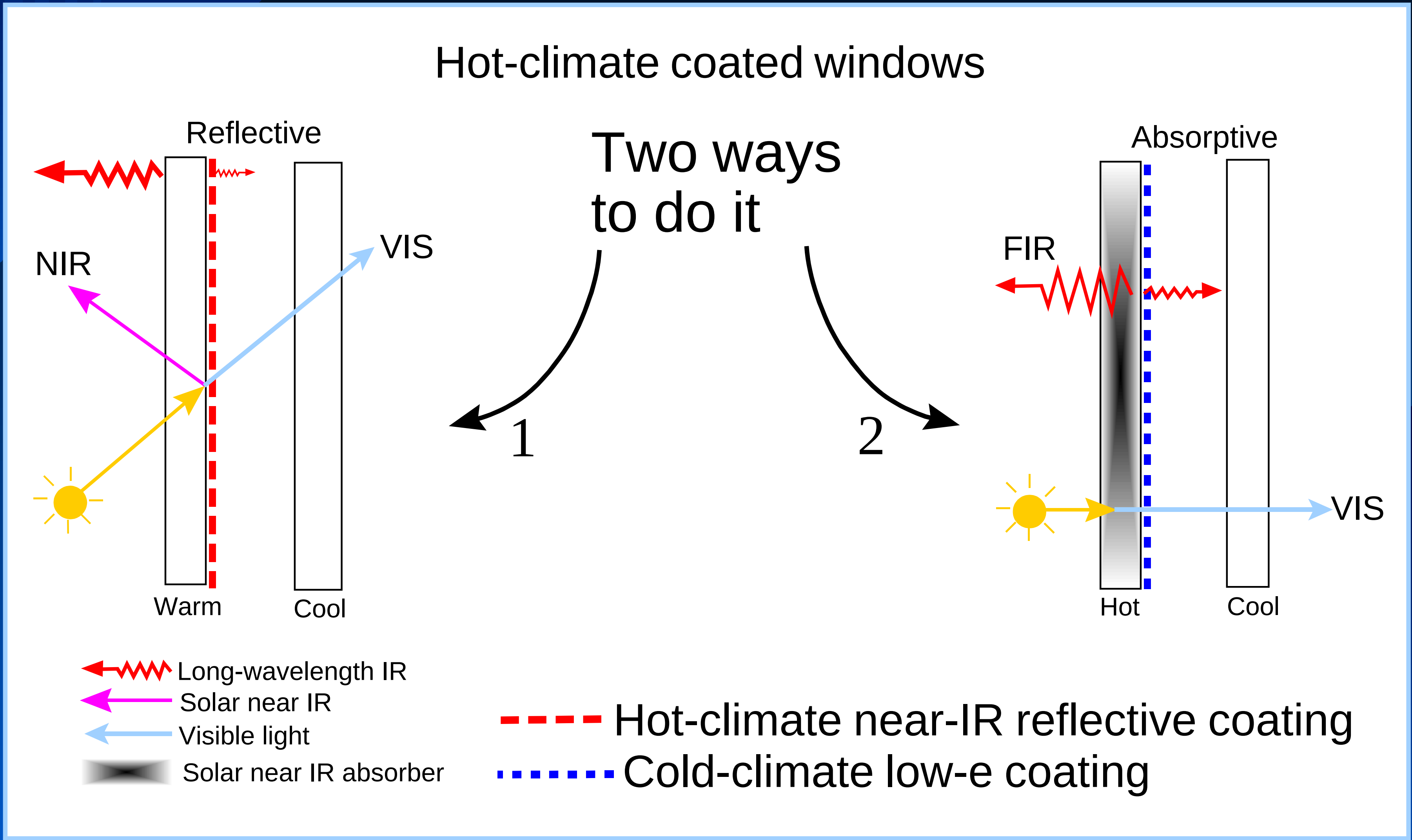
1

By rejecting nearly half the incident solar radiation with reflection, the SHGC is nearly half as large

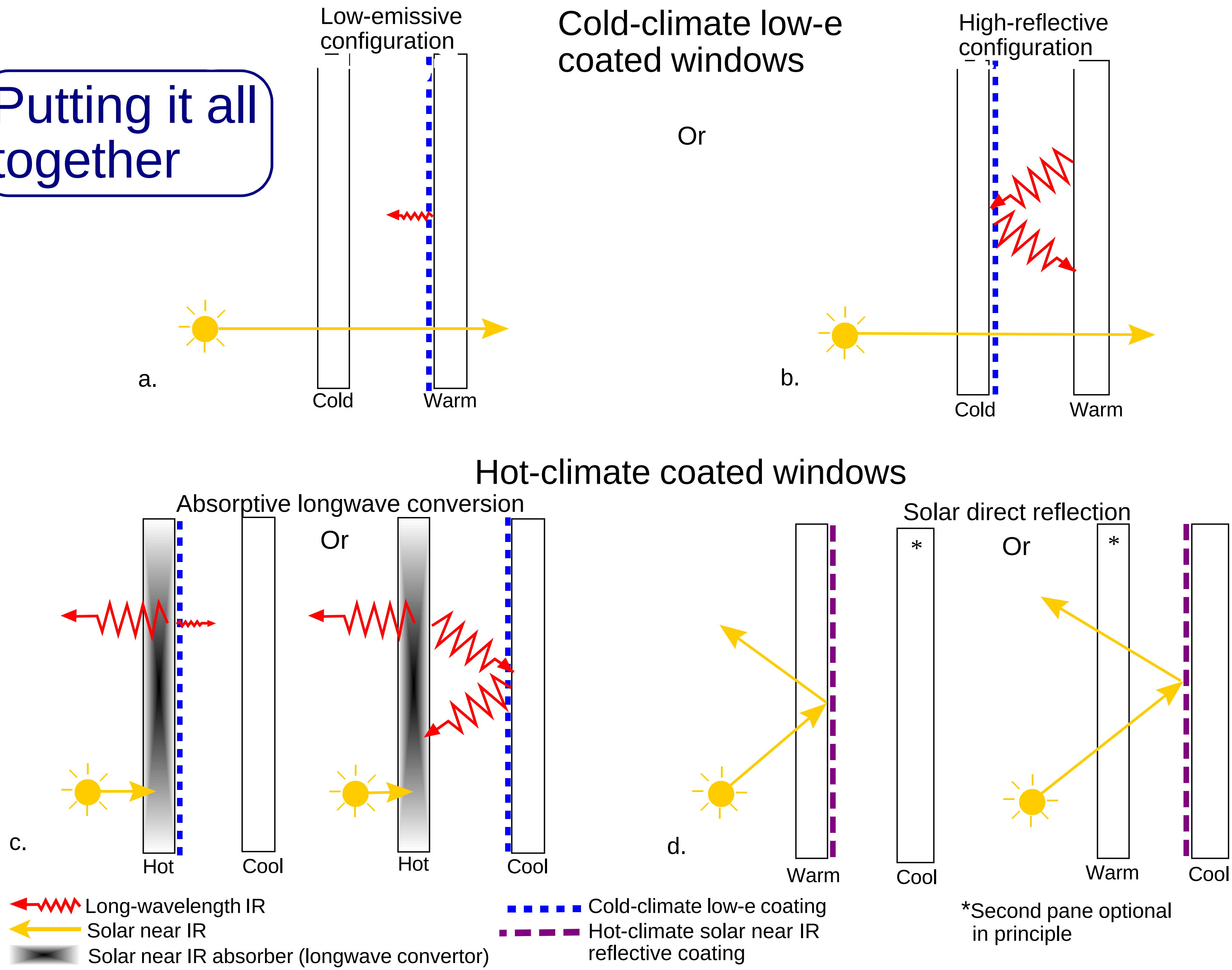
Solar near IR
Visible light

Hot-climate near-IR reflective coating
(Also called “hot-climate low-e coating)
(or a low-solar-gain low-e coating)

Hot Climate Glazings
Admit visible, reject invisible solar

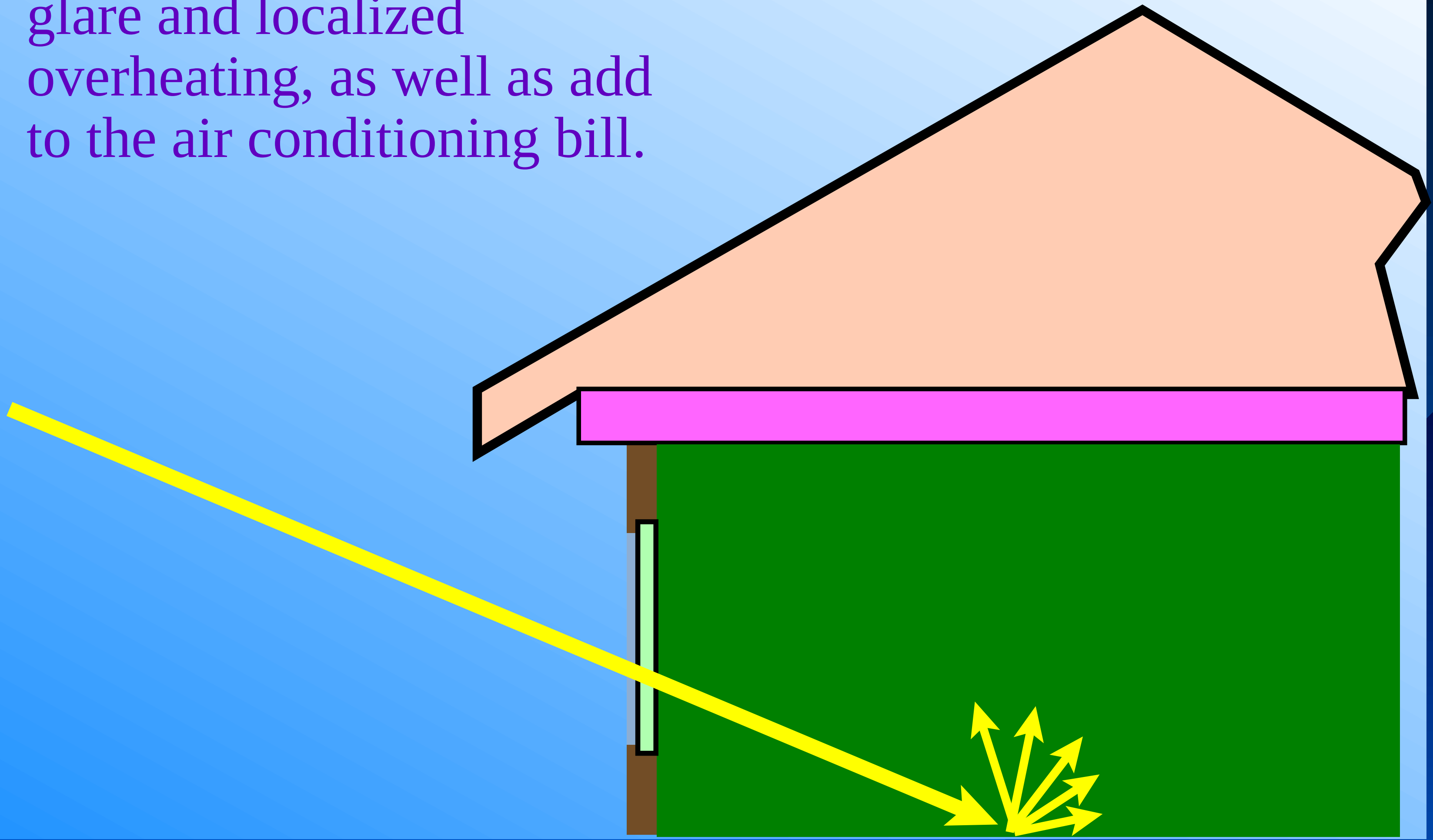


Putting it all together

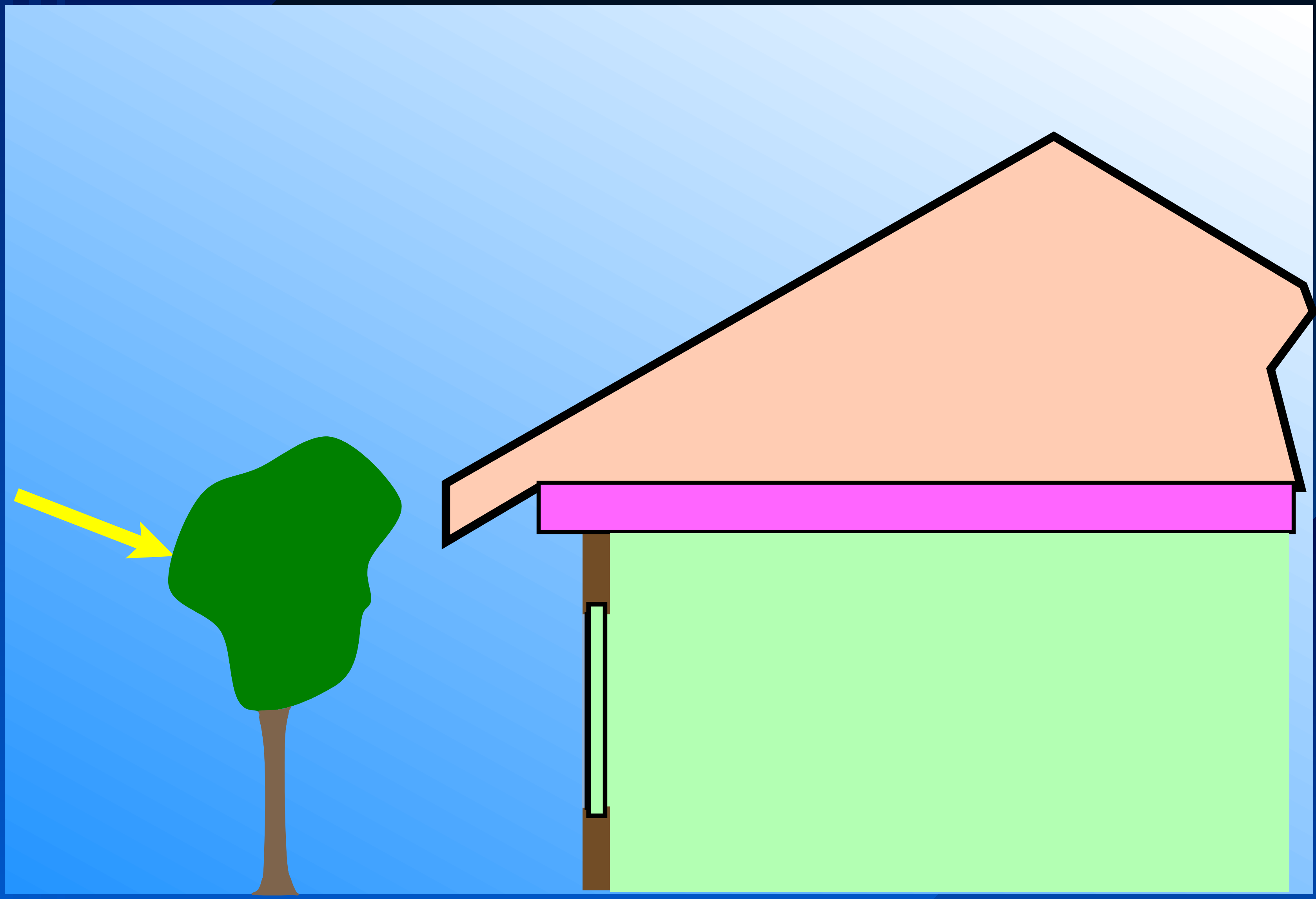


Direct Beam Solar Radiation

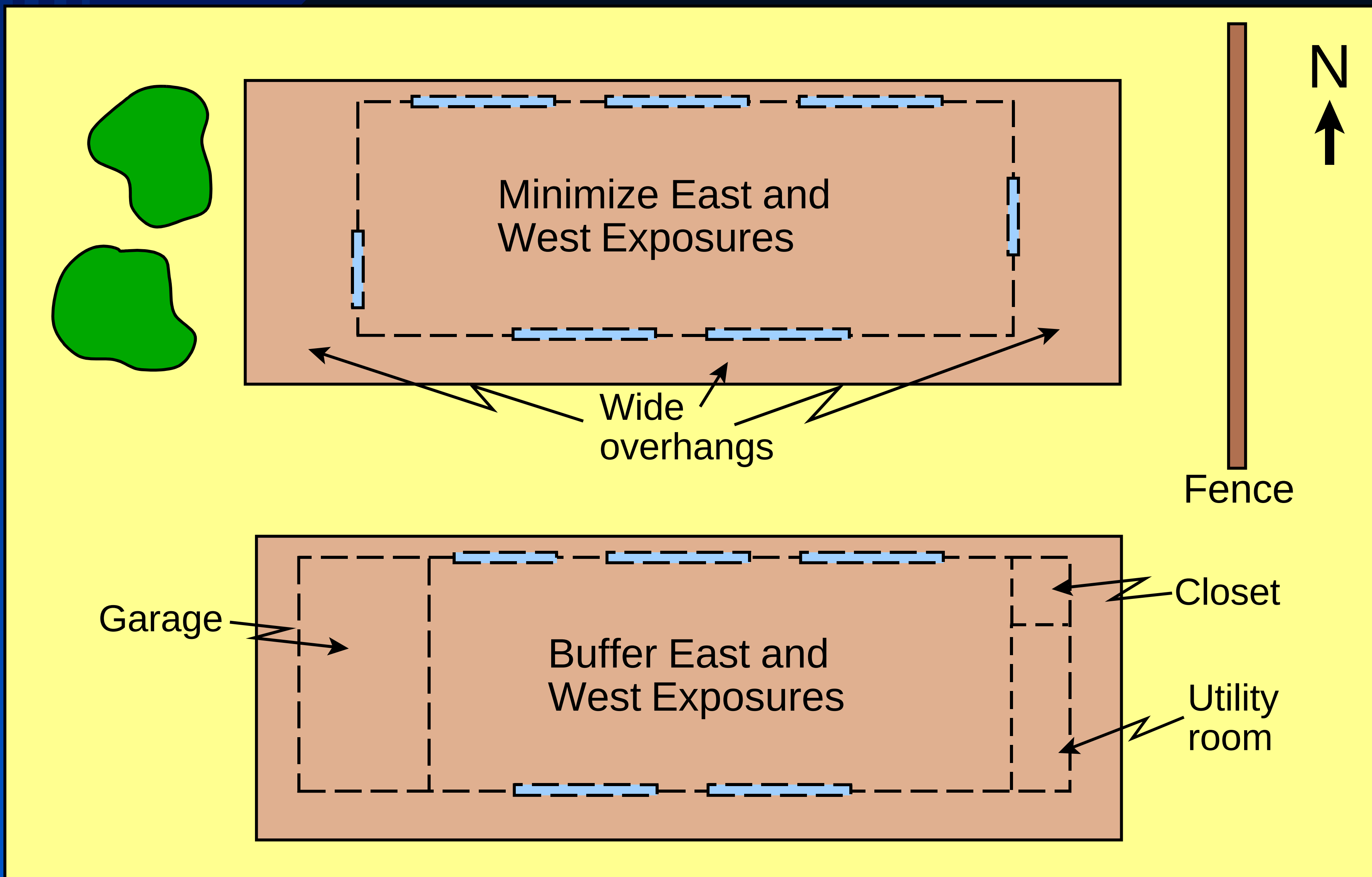
Can produce discomforting glare and localized overheating, as well as add to the air conditioning bill.



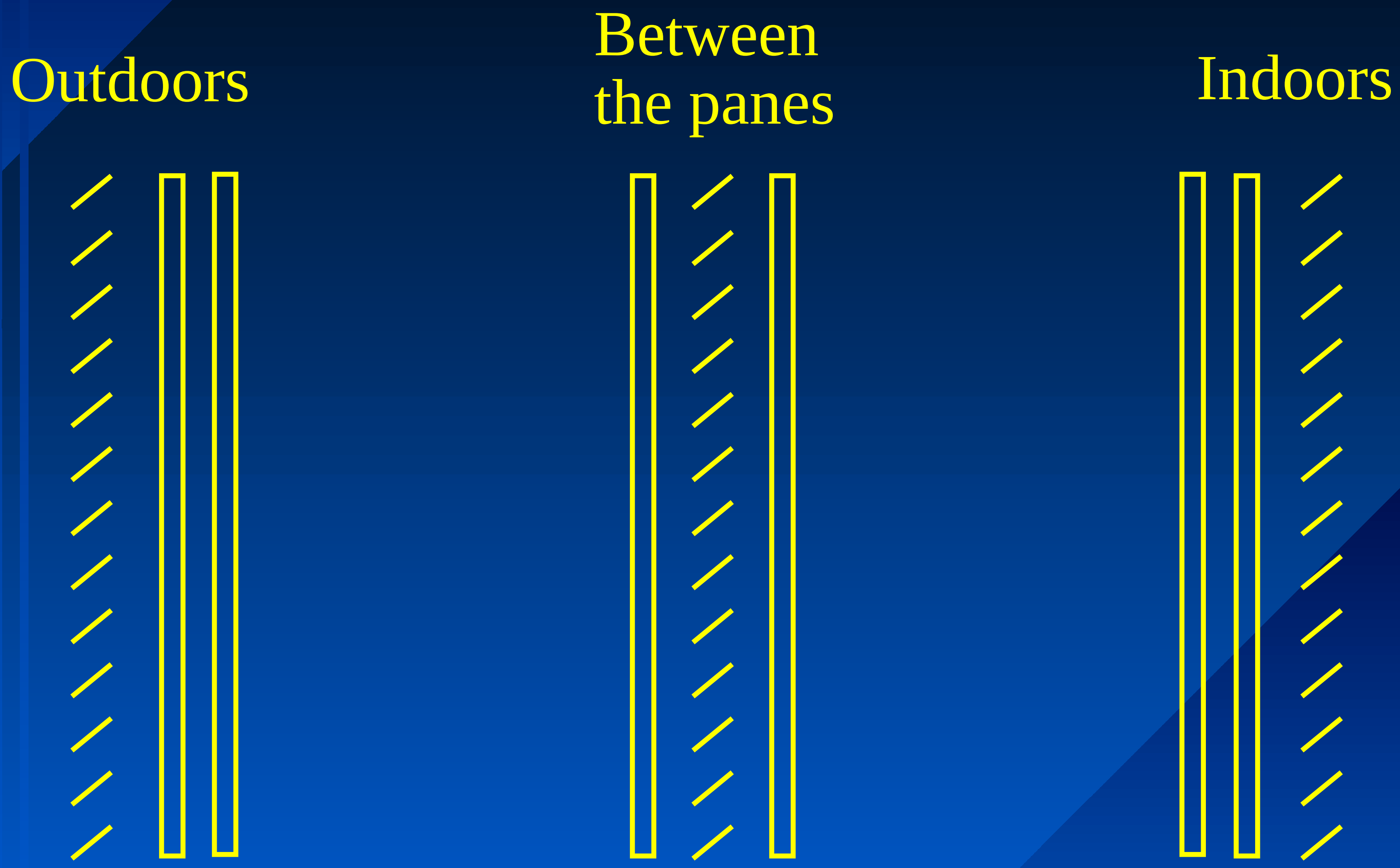
Avoiding Direct Beam



Orientation & Shading Strategies

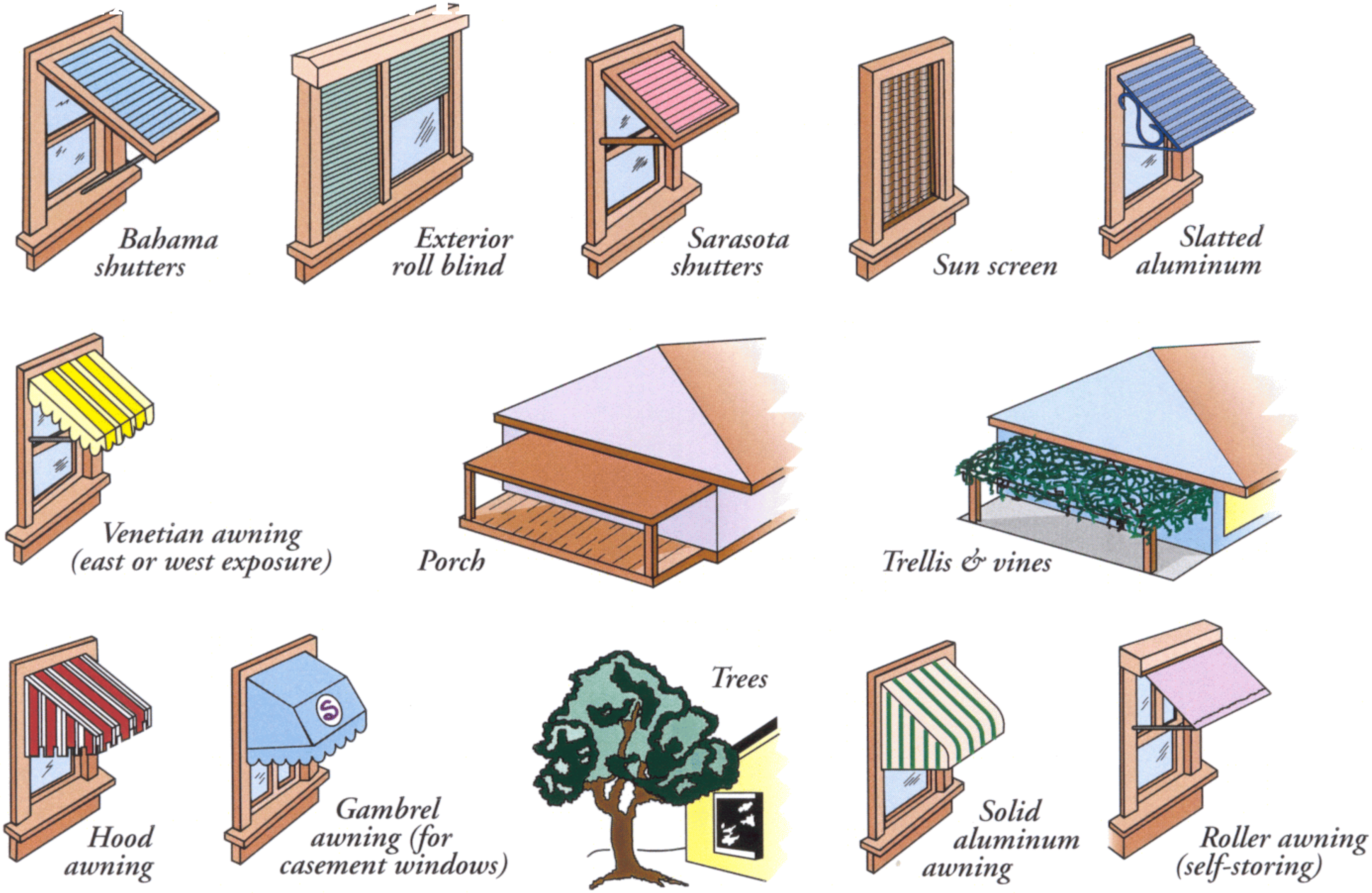


Window Shading



Exterior window shading strategies

Block solar gain before it reaches the window



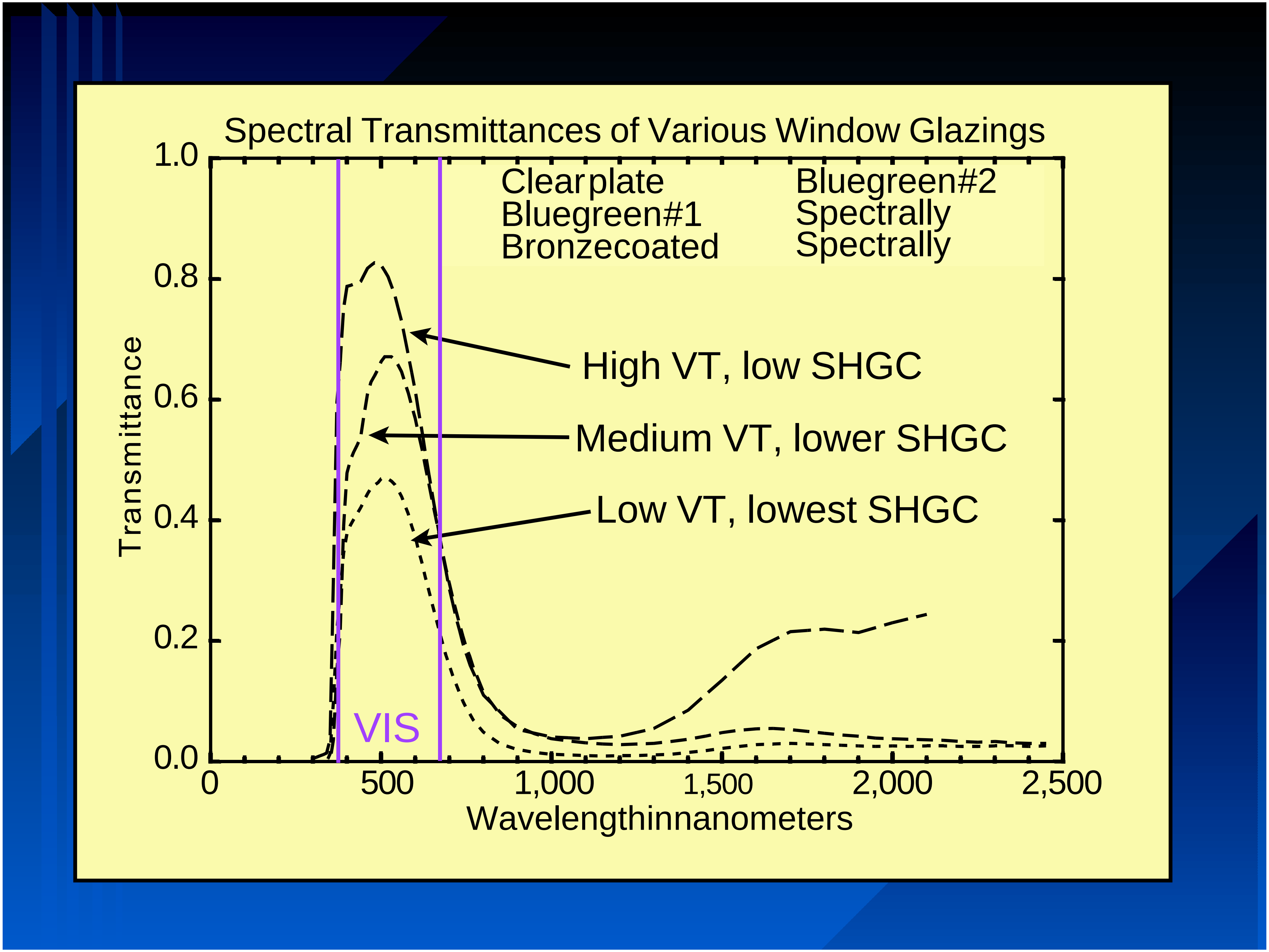
When exterior shading is not permitted, desired, or possible

Use High-Performance Glazing Systems

- 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



Spectral Transmittances of Various Window Glazings
Clearplate
Bluegreen#1
Bronzecoated
Bluegreen#2
Spectrally
Spectrally
High VT, low SHGC
Medium VT, lower SHGC
Low VT, lowest SHGC
VIS
Transmittance
1.0
0.8
0.6
0.4
0.2
0.0
0
500
1,000
1,500
2,000
2,500
Wavelengthinnanometers

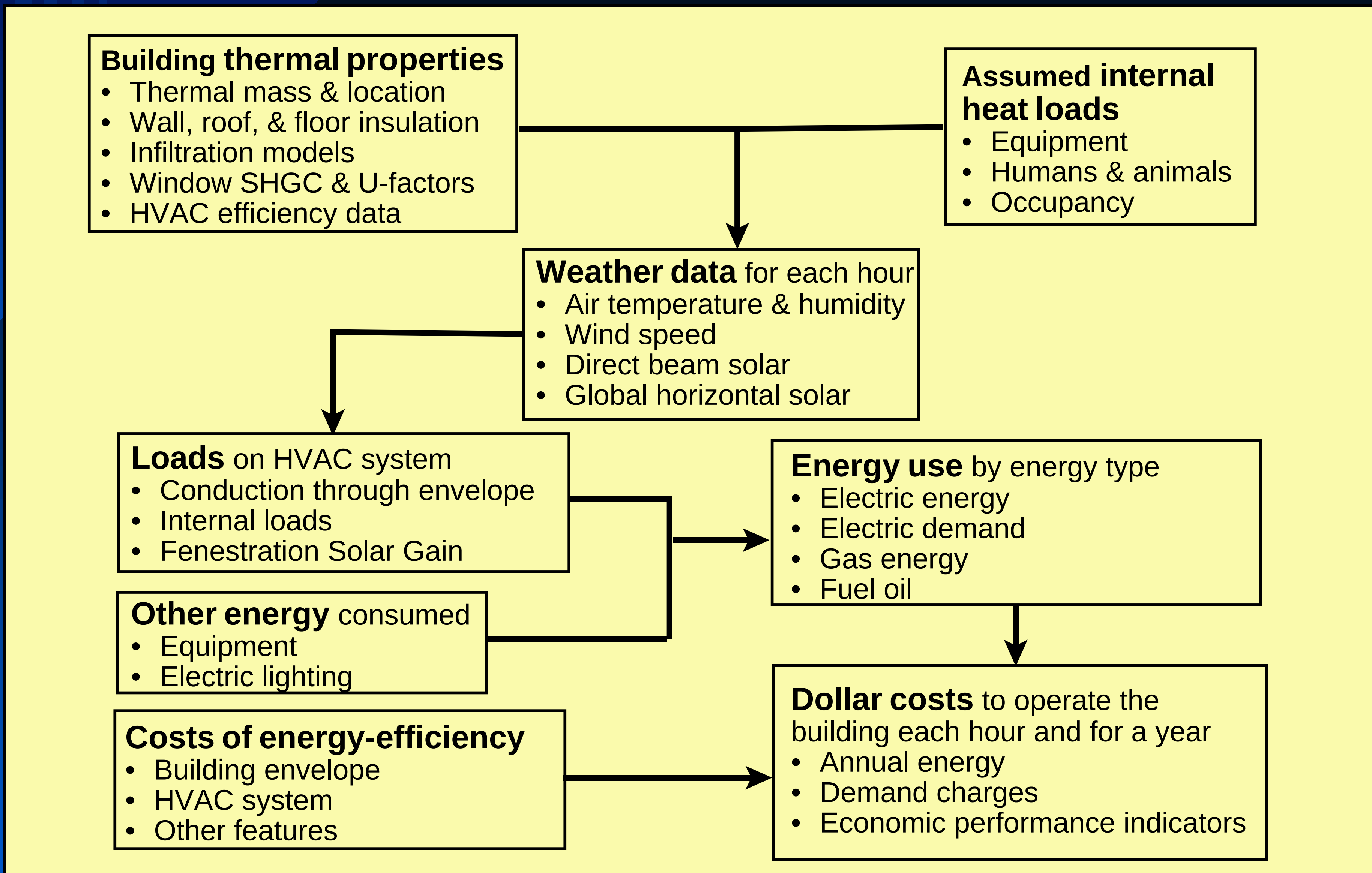
Window Energy Performance

- **Instantaneous** versus **long term hourly** performance
- For instantaneous perf., get the NFRC label information:

U-factor SHGC VT

- But how do you know what are good values of these for your application?
- You need something to tell you about the long-term energy (and peak load) consequences of a given choice
- And you need a way to convert energy efficiency into economic information.
- Next comes some background information on energy computer programs and economic indicators

Hourly Building Energy Simulations



Window Energy Software

- DOE-2 — Large & complex. Needs engineer to run it. Energy Plus is the next generation.
- RESFEN — Easier to run, and based on DOE-2, but you must be somewhat computer savy 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 at www.efficientwindows.org but this treats shading only minimally

What Can You Do to Get Energy Performance Information?

- Use Building Code energy provisions — Minimal
- Insist on NFRC ratings — Instantaneous values only, but still important to know that the numbers are correct
- Obtain Green Home Certification — Great environmentally, but modest incentive for window energy
- Use only Energy Star windows — Good but not best
- Guidance for the average homeowner: www.efficientwindows.org/selection3.html
- Information customized for your home, use RESFEN: http://windows.lbl.gov/software/resfen/resfen.html

Where to find these resources

National Fenestration Rating Council

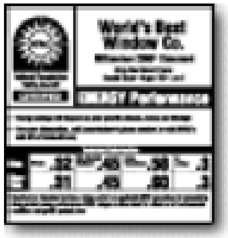
NFRC.org

EfficientWindows.org

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.

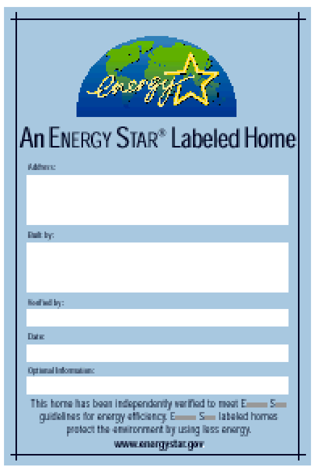
3 **Compare Annual Energy Costs for a Typical House**

Compare the annual energy use for different window options for a typical 2000-square-foot house in your state or region.

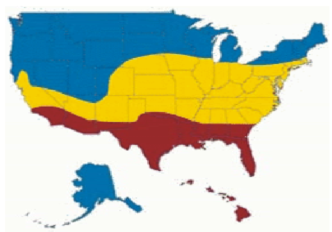
Energy Star

http://www.energystar.gov/products/windows/

Energy Star Homes must meet a performance standard: Have a HERS energy rating of 86 or above



Climatic Zones



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

	Windows & Doors	Skylights
U-Factor	0.75 or below	0.75 or below
Maximum Solar Heat Gain Coefficient	0.40 or below	0.40 or below

None of the previous web sites offers much guidance on selecting window shading. The next one at least gives credit for tree shading.

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 are required if the minimum cannot be met in a category
- Window points are given for daylighting, east and west tree shading, and exceeding the Florida Energy Code HERS rating of 80

Window Selection Advice

To Double-pane or not?

- For energy savings only, double pane is generally not needed in hot climates
- In this case 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)
- Double pane is important for cold climates
- Double pane will protect you from future demand charges

Guidance for the Average Building Owner

- 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

Window Recommendations in Summary

- **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 lowered equipment 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:
  For hot climates:
  - 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

  For cold climates:
  - Well-insulated multiple pane windows with insulated frames
- Laminated glass for impact resistance if exterior shade is not enough for this

Additional Information & Resources

- For more information continue exploring our windows web site: http://www.fsec.ucf.edu/en/consumer/buildings/window_basics/index.htm

- It has much information about windows and guidance in selecting windows.

- It has links to many other web sites with additional information.