SOLARGLASS WINDOW & DOOR

BGBG Lunch Presentation

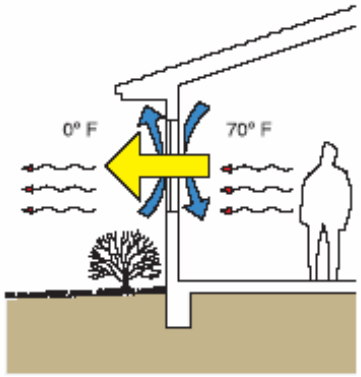
Dynamics of Windows and Energy Windows and HERS Scores

Presentation Overview

- Elements of Window Performance
- Cost / Energy Dynamics
- Energy Star Changes and the Future of Windows
- Windows and HERS Scores
- REM/Rate Examples

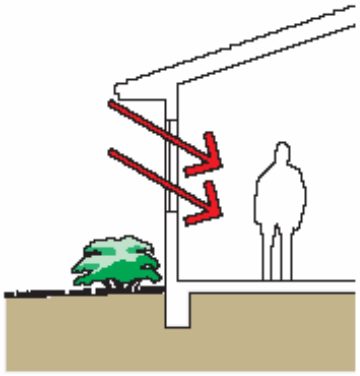
Elements of Window Performance

Basic Window Performance Terminology



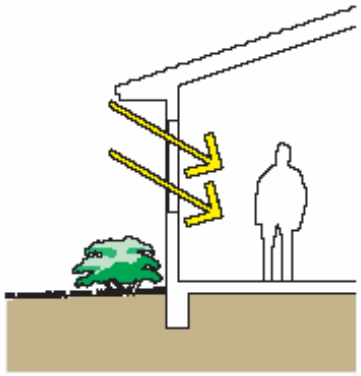
U-Factor

The rate of heat loss is indicated in terms of the U-factor (U-value) of a window assembly. The insulating value is indicated by the R-value which is the inverse of the U-value. The lower the U-factor, the greater a window's resistance to heat flow and the better its insulating value. U=U-factor in Btu/hr-sf-°F.



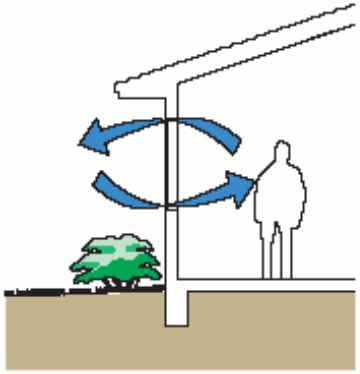
Solar Heat Gain Coefficient (SHGC)

The SHGC is the fraction of incident solar radiation admitted through a window. SHGC is expressed as a number between 0 and 1. The lower a window's solar heat gain coefficient, the less solar heat it transmits. Use a computer program such as RESFEN to understand heating and cooling trade-offs. SHGC=Solar Heat Gain Coefficient in fraction of incident solar angle.



Visible Transmittance (VT)

The visible transmittance (VT) is an optical property that indicates the amount of visible light transmitted. The NFRC's VT is a whole window rating and includes the impact of the frame which does not transmit any visible light. While VT theoretically varies between 0 and 1, most values are between 0.3 and 0.8. The higher the VT, the more light is transmitted. A high VT is desirable to maximize daylight. VT=Visible Transmittance in fraction of incident visible radiation.

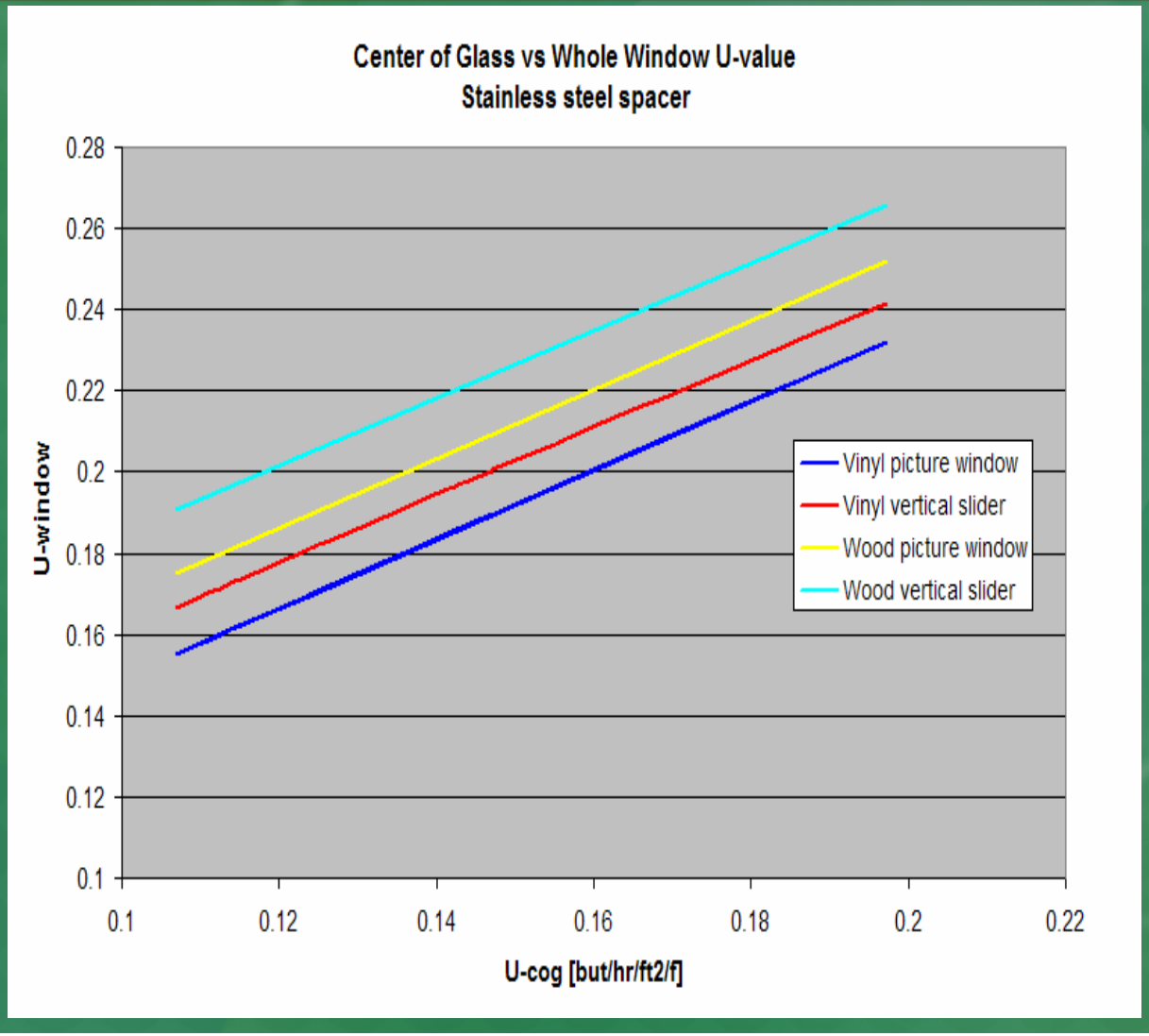


Air Leakage (AL)

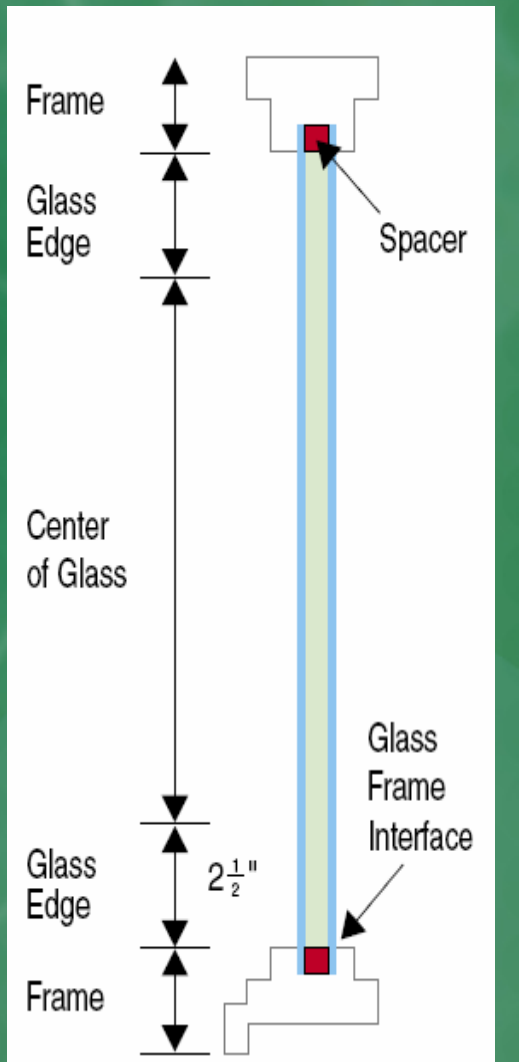
Heat loss and gain occur by infiltration through cracks in the window assembly. Air leakage is expressed in cubic feet of air passing through a square foot of window area. The lower the AL, the less air will pass through cracks in the assembly. While many think that AL is extremely important, it is not as important as U-factor and SHGC. AL=Air Leakage in cfm/sf.

Source: www.efficientwindows.org

Whole Window vs. Center-of-Glass Performance



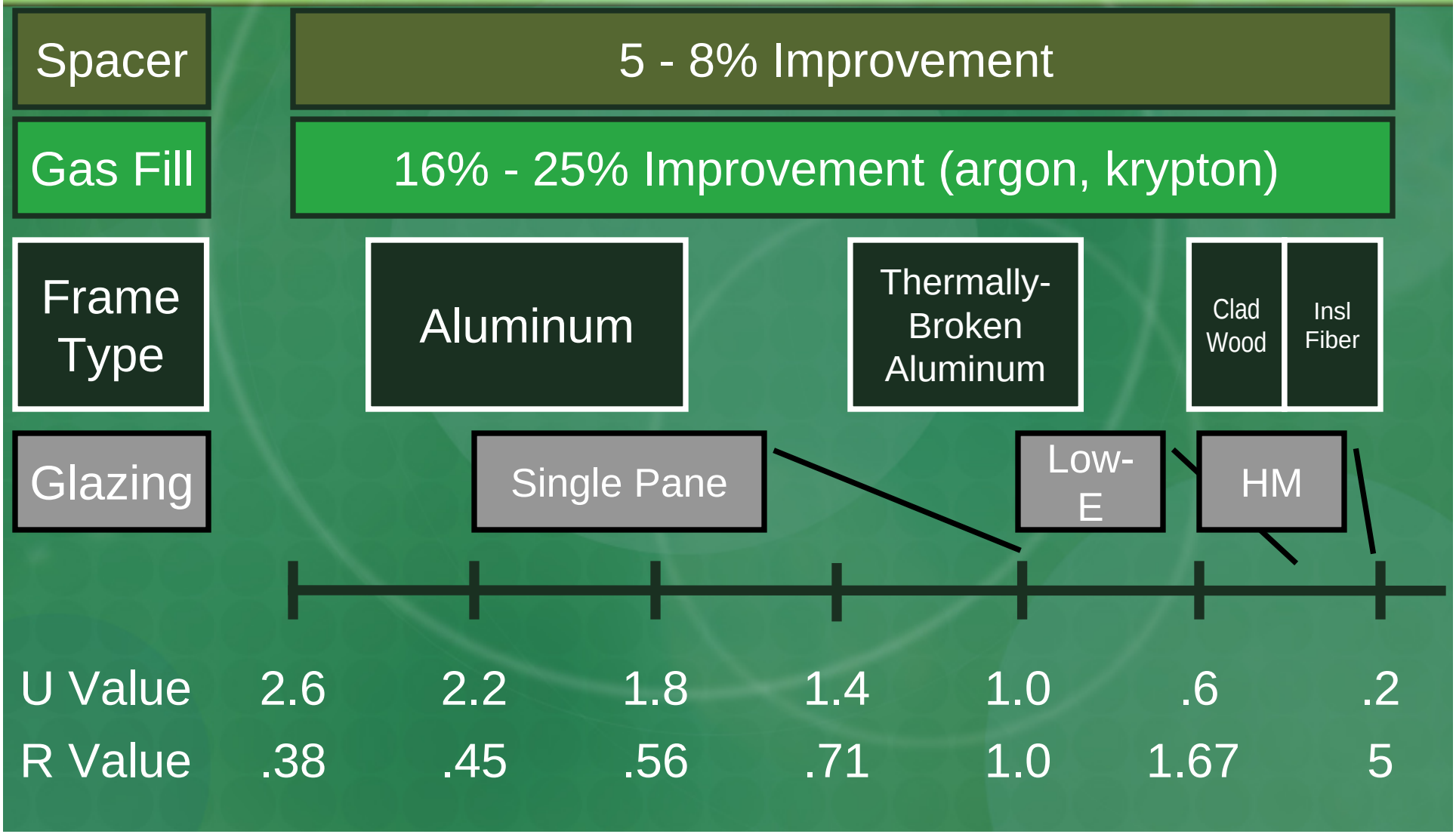
Window Thermal Cross Section



Window Performance Considerations

- Glazing Unit Structure
- Low-E Coatings – Only 66% of windows sold in 2007 have low-e coatings
- Low-Conductance Gas Fills
- Spacer Systems
- Thermally Improved Sash and Frame
- Improved Weatherstripping

Window Component Performance



Design Considerations

Quality Installation, Energy Star, SHGC Tuning as Givens

Cost/Value
Initial Cost
Product Lifecycle
Warranty
Energy Savings

Performance/ Comfort
VT / U / SHGC
UV Protection
Sound
Transmission
HERS Score

Aesthetics

Design Flexibility

Degree of Customization

National Fenestration Rating Council Certification

- Recognized independent third party, www.nfrc.org
- Provides verified U-value, SHGC, & air infiltration performance
- Certifies all sizes in a given product line

Cost /Energy Dynamics

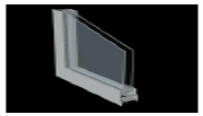
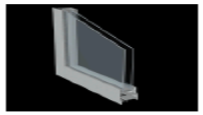
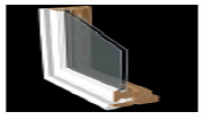
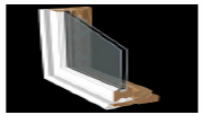
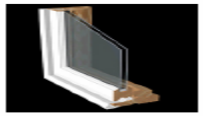
Window Cost/Benefit Analysis

- Discounted Lifetime Energy Savings
- Product Longevity
- Initial Transaction Costs
- Value of Warranty and Brand
- Embodied Energy Costs / Carbon Footprint
- Comfort
- Design Flexibility and Aesthetics
- Fading, Sound Control, Condensation
- Mechanical System Downsizing Opportunities
- Daylighting Tradeoffs

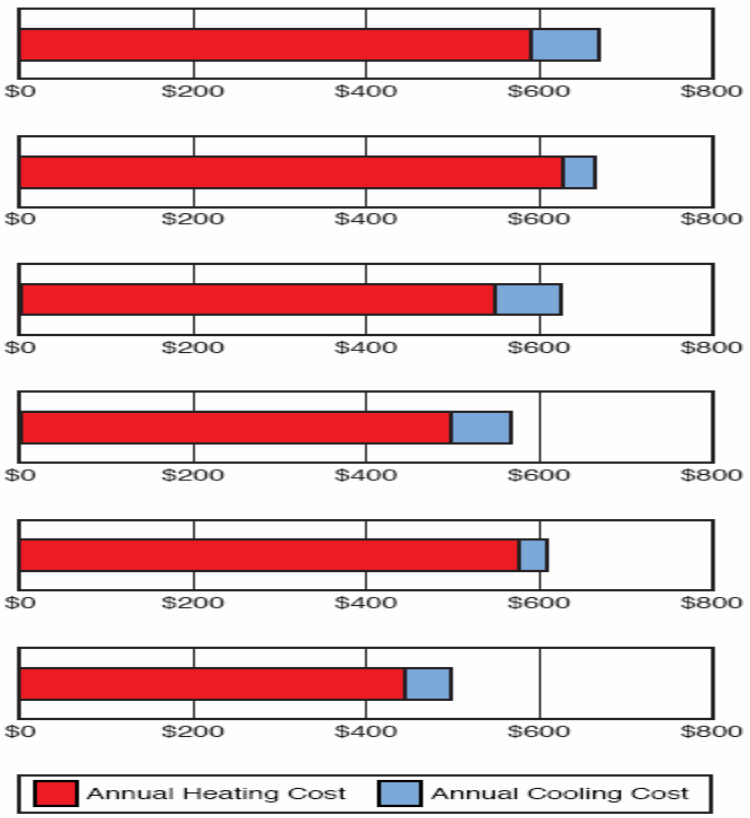
Window Energy Performance

Comparing Window Performance in Denver, Colorado

The annual energy performance figures shown here were generated using RESFEN for a typical, new 2000 sq. ft. house with 300 sq. ft. of window area (15% of floor area). The windows are equally distributed on all four sides of the house and include typical shading (interior shades, overhangs, trees and neighboring buildings). *

Case Studies		Properties
	**CASE 1** double glazing clear glass aluminum frame w/ thermal break	U = 0.63 SHGC = 0.62 VT = 0.62
	**CASE 2** double glazing low-E coating (low solar gain) argon gas fill aluminum frame w/ thermal break	U = 0.47 SHGC = 0.33 VT = 0.53
	**CASE 3** double glazing clear glass vinyl/wood frame	U = 0.49 SHGC = 0.56 VT = 0.58
	**CASE 4** double glazing low-E coating (high solar gain) argon gas fill vinyl/wood frame	U = 0.37 SHGC = 0.53 VT = 0.53
	**CASE 5** double glazing low-E coating (low solar gain) argon gas fill vinyl/wood frame	U = 0.34 SHGC = 0.30 VT = 0.50
	**CASE 6** triple glazing low-E coating (high solar gain) argon gas fill insulated vinyl frame	U = 0.18 SHGC = 0.40 VT = 0.49

Annual Energy Use



Source: www.efficientwindows.org

Impact of Window Choices on Energy Consumption Using RESFEN Software

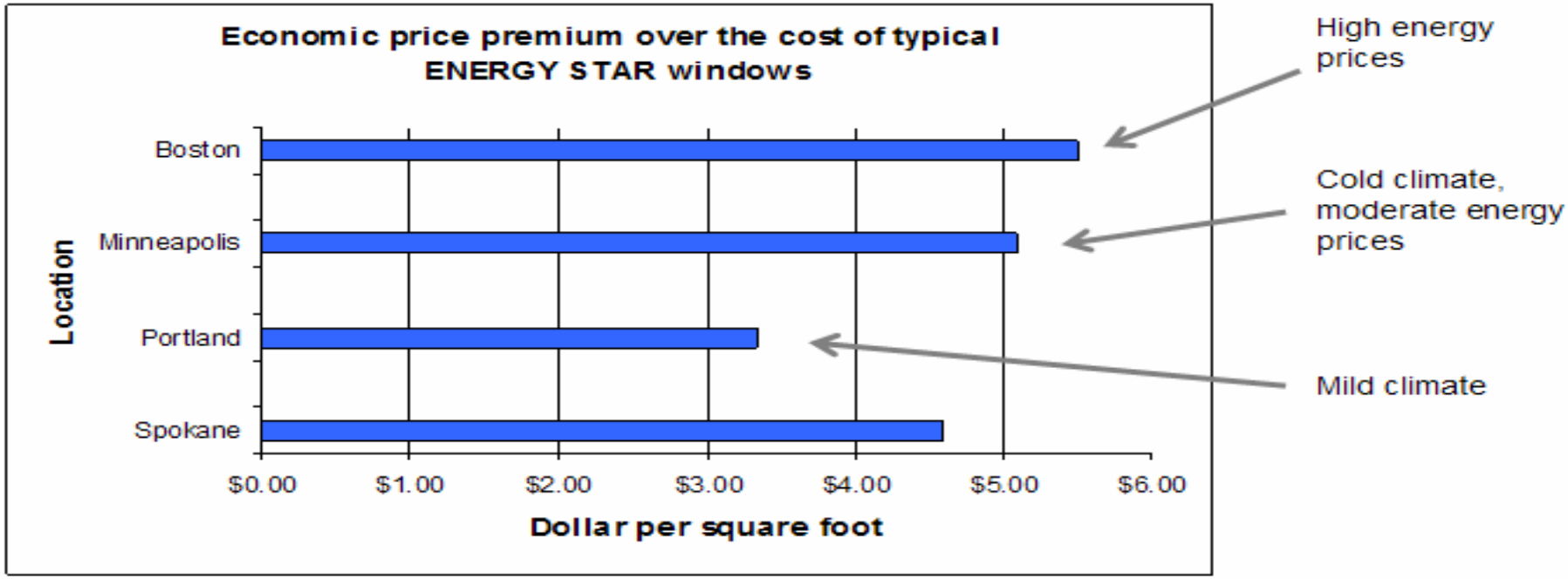
Simple Example of Estimated Annual Energy Costs Based on Typical Denver, Colorado 2000 square foot home with 300 square feet of windows evenly distributed by elevation

Energy Star	U .34, SHGC .30	$611.36
Triple Glazed, Hi SHGC	U .18, SHGC .40	$505.01

Annual Savings of $106.35 for 300 square feet of glazing of $.35/sf/yr

High Performance Price Premium

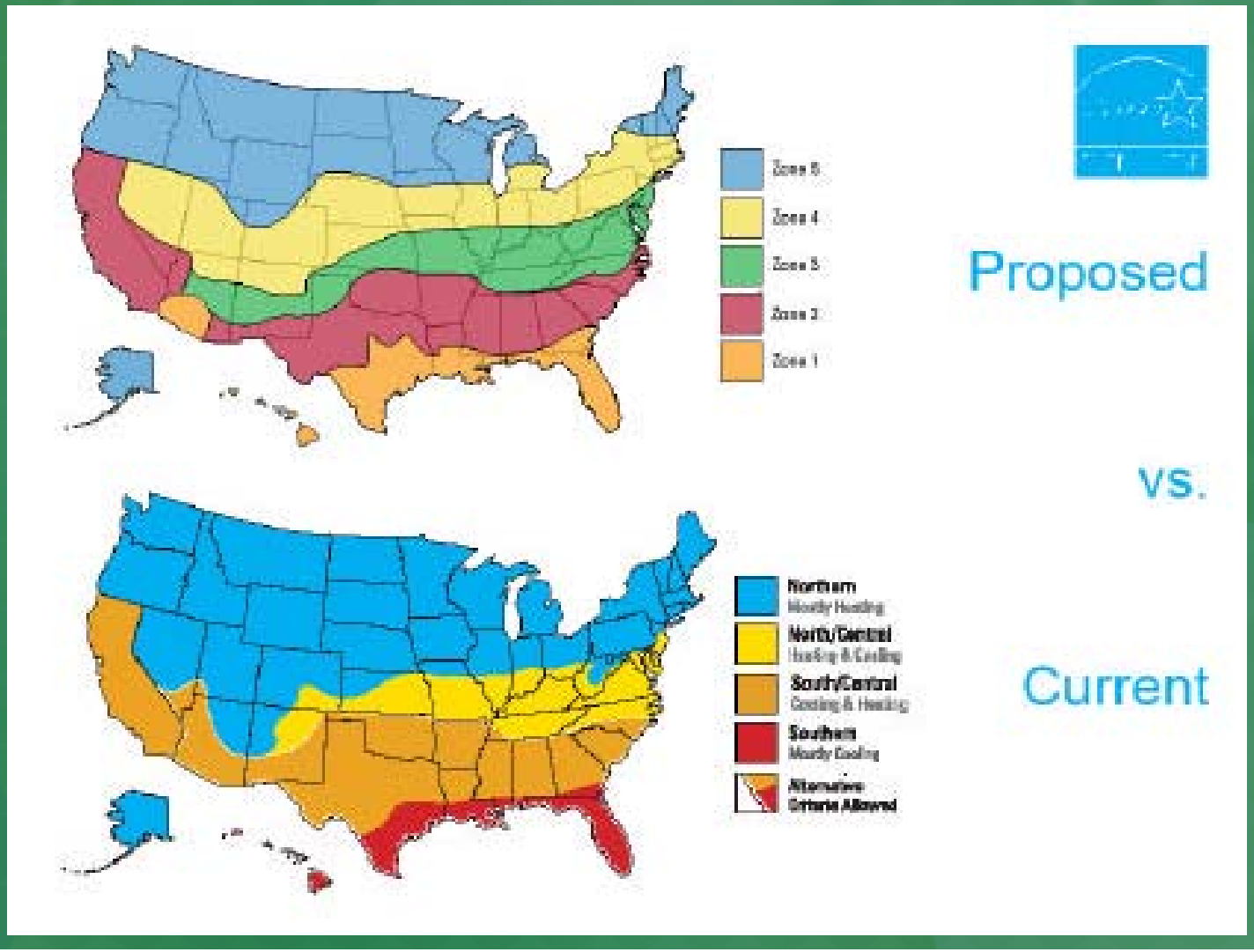
Cost Effective Incremental Price Premium Estimated by LBL for R-5 Windows Over the Cost of ENERGY STAR Windows



5% annual discount rate, 25 years economic life

Energy Star and Future Technologies

Proposed Energy Star Zone Revisions



Proposed Changes in Energy Performance Standards for ENERGY STAR Windows

	Zone	U-Factor	SHGC
Current	**Zone 4**	**.35 or less**	**No Requirements**
Proposed Criteria (January 18, 2008)			
2009	**Zone 5**	**.30 - .32**	**Minimum .35 - .55**
	Zone 4	**.30 - .33**	**TBD**
2012	**Zone 5**	**.24 - .27**	**Minimum .35 - .55**
	Zone 4	**.24 - .32**	**TBD**
2015	**Zone 5**	**.20 - .24**	**Minimum .35 - .55**
	Zone 4	**.20 - .27**	**TBD**

Why is ENERGY STAR Changing?

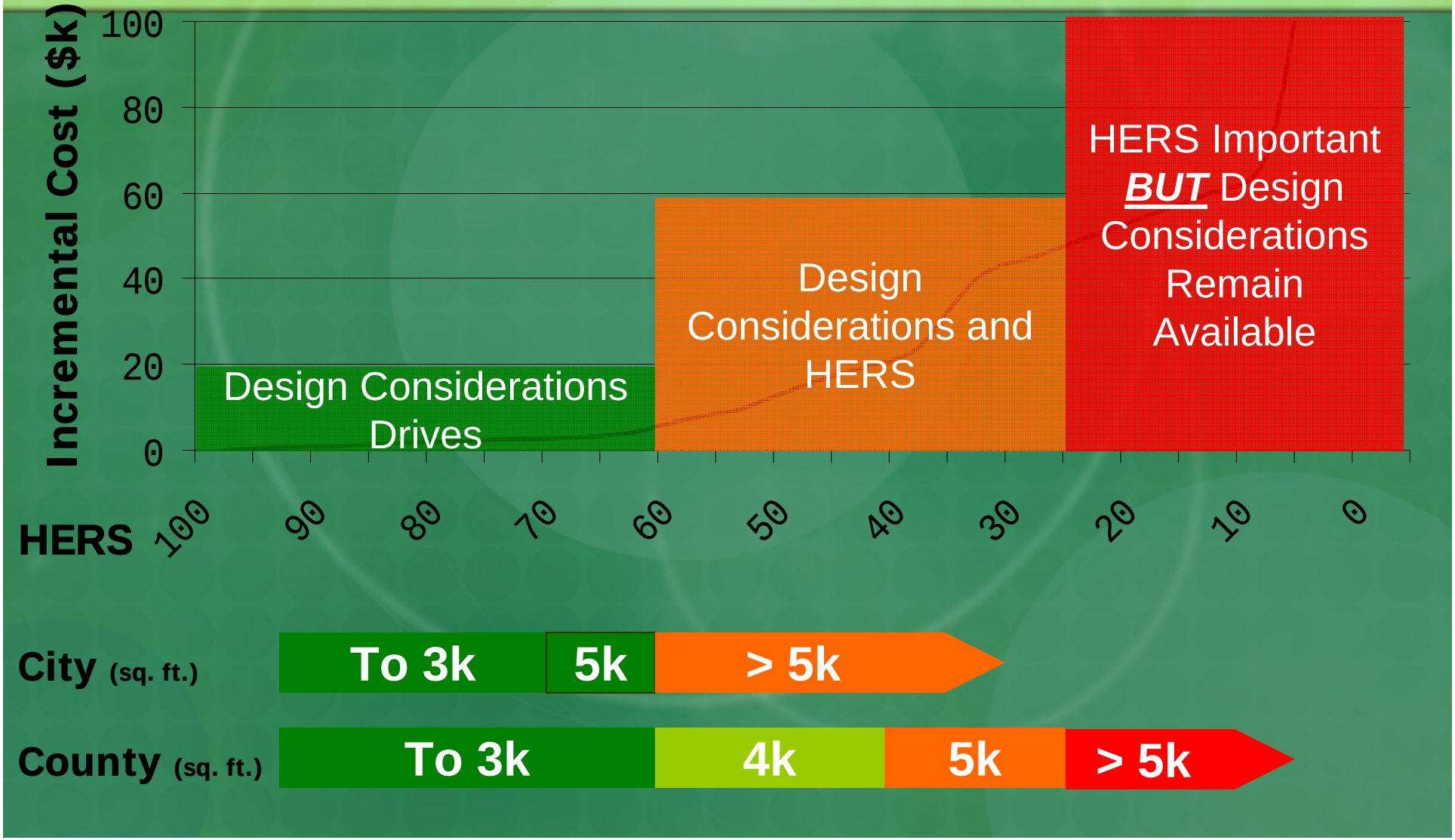
- **Twenty-eight states have adopted IECC 2003 or other more recent editions**
- **Improving energy efficiency is a national priority**
- **ENERGY STAR barely beats code**
- **ENERGY STAR windows make up 53% of the market**

The Future of Windows

- **Net Positive Energy Window Systems**
- **Dynamic Glazing**
- **Exterior Insulated Shutters and Other Forms of Moveable Insulation**
- **High Performance Frame Insulation and Spacer Systems**
- **BIPV—Integrated into Window Systems and Shading Devices**

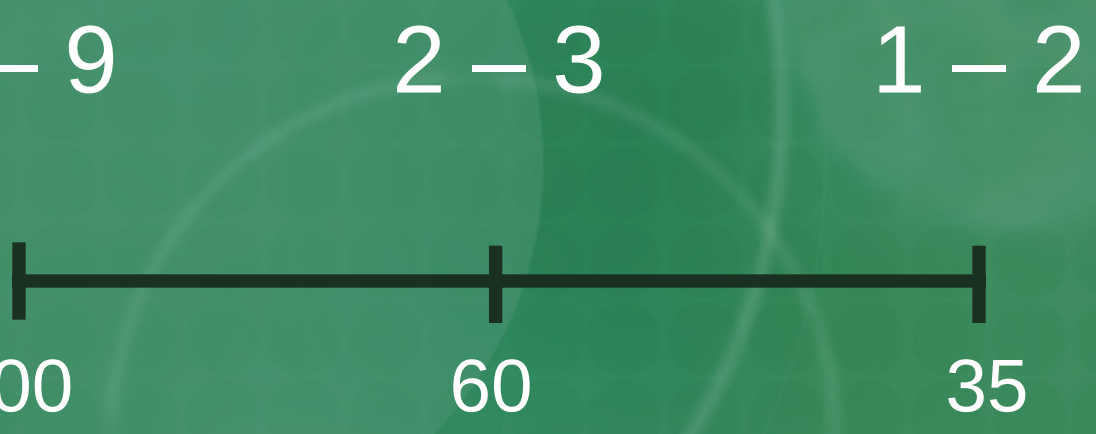
Windows and HERS Scores

Windows and HERS



Law of Diminishing Returns

HERS Points:
R5 vs. Energy Star Windows



The More Energy Efficient the House the Smaller the Impact

Implications

- Overall building envelope much more important than which window / door
  - Air infiltration, HVAC design, walls and ceilings
- Only at very large home sizes does HERS drive design
- There are other ways to “buy” HERS points than which window brand is selected
- Rely on local window vendors for HERS and Design product assistance

REM/Rate Examples

HERS Score Comparisons Boulder City

For Houses 1 & 2 (City):

- **4980 sqft**
- **R-50 attic, R-19 walls**
- **92% AFUE GFA**
- **On demand DHW .80 EF**
- **14 SEER central air**
- **.16 NACH**

Plus windows…

- **House #1 – R5**
  - **U value = 0.2 all windows**
  - **SHGC = 0.62 south orientation only**
  - **SHGC = .25 all other orientations**
- **House # 2 - EStar**
  - **U value = 0.35 all windows**
  - **SHGC = 0.56 south orientation only**
  - **SHGC = 0.25 all other orientations**

HERS Score Comparisons Boulder County

For Houses 3 & 4 (County):

- **4980 sqft**
- **R-50 attic, SIP walls (.018 U value)**
- **92% AFUE Boiler**
- **Demand DHW .80 EF**
- **Solar thermal**
- **Solar PV, sun space**
- **No airco; whole house fan**
- **.16 NACH**

Plus windows…

- **House # 3 – R5**
  - **U value = 0.2 all windows**
  - **SHGC = 0.62 south orientation only**
  - **SHGC = .25 all other orientations**
- **House # 4 - EStar**
  - **U value = 0.35 all windows**
  - **SHGC = 0.56 south orientation only**
  - **SHGC = 0.25 all other orientations**

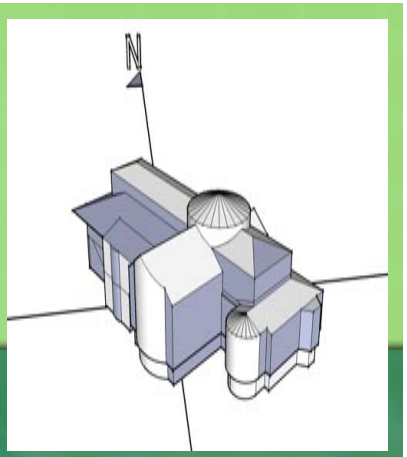
HERS SCORES

- Boulder City
  - Need minimum HERS score of 60 for home 3001- 5000 square feet
- R5 HERS = 52
- EStar HERS = 54

- Boulder County
  - Need minimum HERS score of 25 for homes 4001-5000 square feet
- R5 HERS = 33
- EStar HERS = 35

for the people
for the planet
Populus
Sustainable Design Consulting

5787 SF Boulder Home



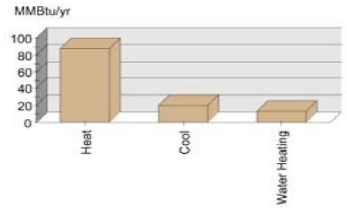
- *14.7% glazing ratio*
- *Crawl space walls – R10 interior rigid insulation*
- *Basement walls – R30 polyurethane foam insulation in interior furred wall cavity*
- *Basement slab – R15 rigid insulation below slab*
- *Frame floors over crawlspace and garage – R30 polyurethane foam cavity insulation*
- *Above grade walls – R34 polyurethane foam cavity insulation, 2x6 framing, 16” O.C.*
- *Attic and vaulted ceiling insulation – R56 polyurethane foam cavity insulation*
- *No skylights*
- *HVAC system – ground source heat pump, EER: 24.5, COP 4.1*
  - *Heat exchanger within forced air system – ave. duct leakage to outside rate = 88 cfm*
  - *2 Heat Recovery Ventilators*
- *Domestic hot water system – preheat via ground source heat pump de-superheater*
  - *On-demand hot water heater – 82% efficient*
- *Whole house air leakage rate – 0.18 natural air changes per hour (NACH)*
- *Lighting – 20% compact fluorescent lighting*

HERS 35
Summary Performance Reports

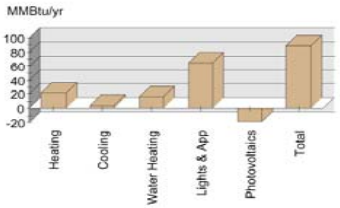
Energy Star

PERFORMANCE SUMMARY

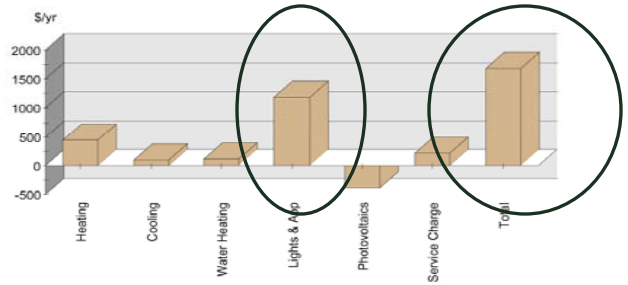
Annual Load



Annual Consumption



Annual Energy Cost



REM/Rate - Residential Energy Analysis and Rating Software v12.51

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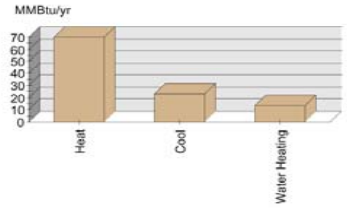
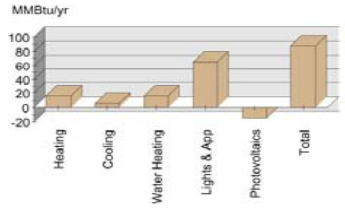
R5

PERFORMANCE SUMMARY

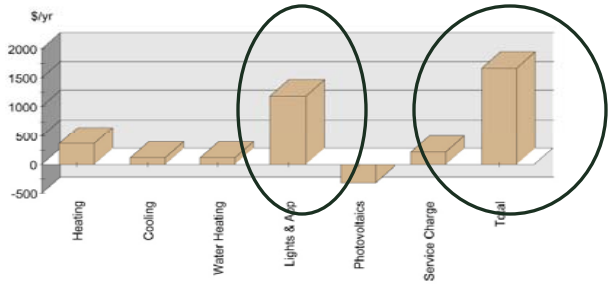
Annual Load



Annual Consumption



Annual Energy Cost



REM/Rate - Residential Energy Analysis and Rating Software v12.51

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City – HERS 35

- Holding all else constant and using PV as the HERS point alternative:
  - Energy Star windows would require .6 kW more PV than Hi Performance windows with an incremental installed cost of ~$2,700

County – HERS 10

- ***Changes from HERS 35***
  - ***Solar thermal for domestic hw & space heating***
  - ***Change system from forced air to hydronic (or reduce duct leakage to outside to 0 cfm)***
  - ***On-demand boiler from 82% to 90% efficiency***
  - ***Increase CFL density to 50% of fixtures***
- **Energy Star windows would require .6 kW more PV with an incremental installed cost of ~$2,100**

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Appendix

Frame U-Value Performance

Frame Type	U-Value Range
Aluminum (no thermal break)	**1.7 – 2.4**
Aluminum (with thermal break)	**0.8 – 1.3**
Aluminum Clad Wood	**0.4 - 0.6**
Wood and Vinyl	**0.3 – 0.5**
Insulated Vinyl and Fiberglass	**0.2 – 0.4**

Source: *Residential Windows, 3rd Edition,* Carmody, Selkowitz, Arasteh & Heschong

Window Component Performance

Glass Combinations, Coatings and Low-Conductance Gas Fills (COG U-Value)

Glazing Configuration	Air	Argon	Krypton
Single Uncoated (1/8” glass)	**1.00**	**--**	**--**
Double Pane Uncoated (1/8” glass, 1/2” airspace)	**0.48**	**0.45**	**0.44**
Double Pane with Low-E (1/8” clear glass, 1/2” airspace, 1/8” Cardinal 272)	**0.30**	**0.24**	**0.22**
Triple with Double Low-E (1/8” clear glass center, 1/4” airspaces)	**0.26**	**0.19**	**0.13**
Quad Pane (1/8” clear glass, 1/4” airspaces, double TC88 SCF)	**0.20**	**0.15**	**0.10**

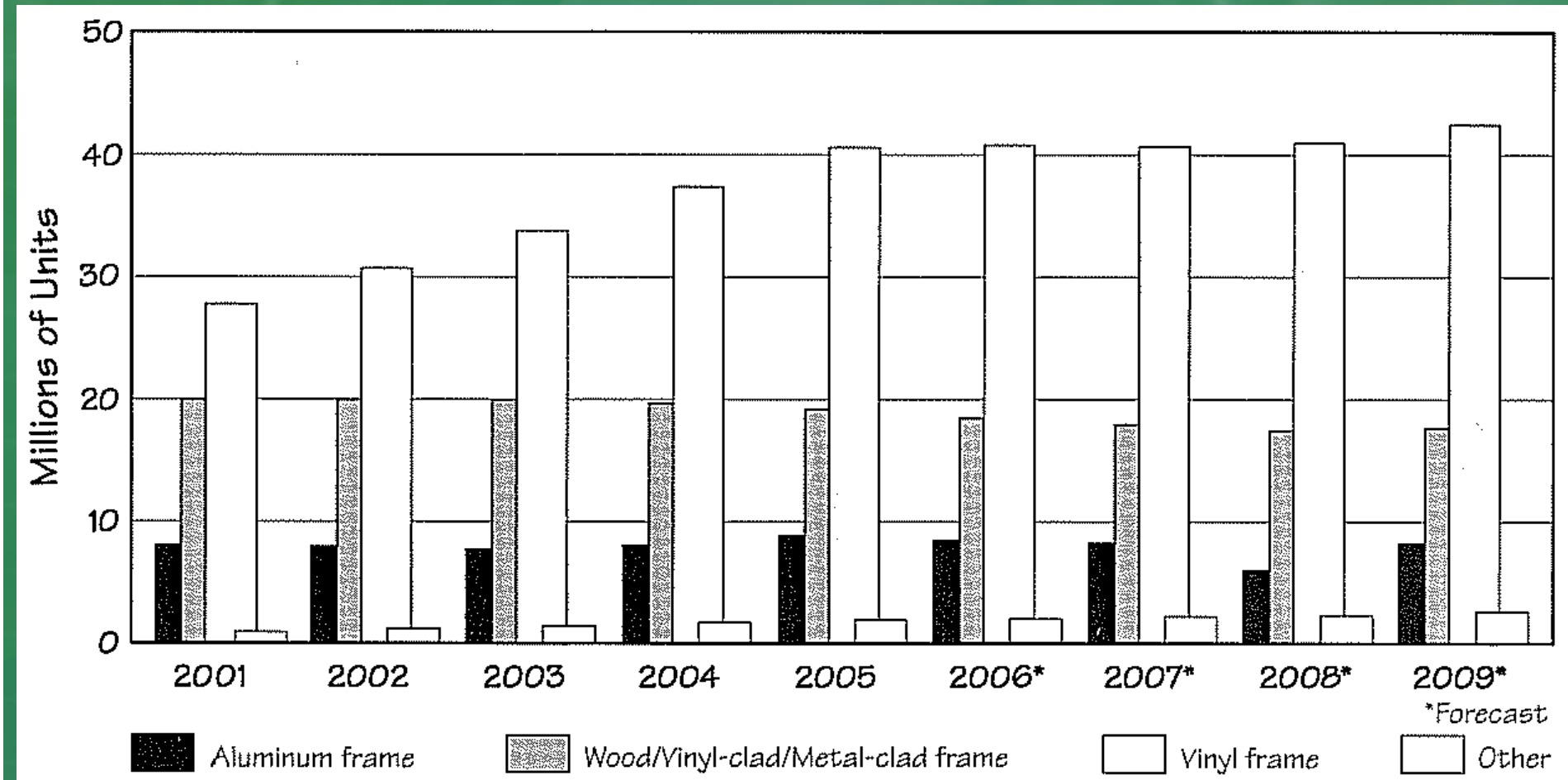
Source: LBNL, Windows 5.2 Software

Window Component Performance

Spacer Material Conductivity

Material	Conductivity **(w/cm*k)**	% of Aluminum
Aluminum	**2.700**	**100%**
Mild Steel	**0.230**	**8.5%**
Stainless Steel – 321	**0.146**	**5.4%**
Polyester	**0.009**	**0.3%**

Frame Type Market Share



Source: "Study of the U.S. Market for Windows, Doors and Skylights" by Ducker Research Co., Inc. for the American Architectural Manufacturers Association (AAMA) and the Window and Door Manufacturers Association (WDMA), 2006.

Windows and Passive Solar Gain

Energy Cost for Average House in North/Central Zone Using Different Solar Gain Glazing Options

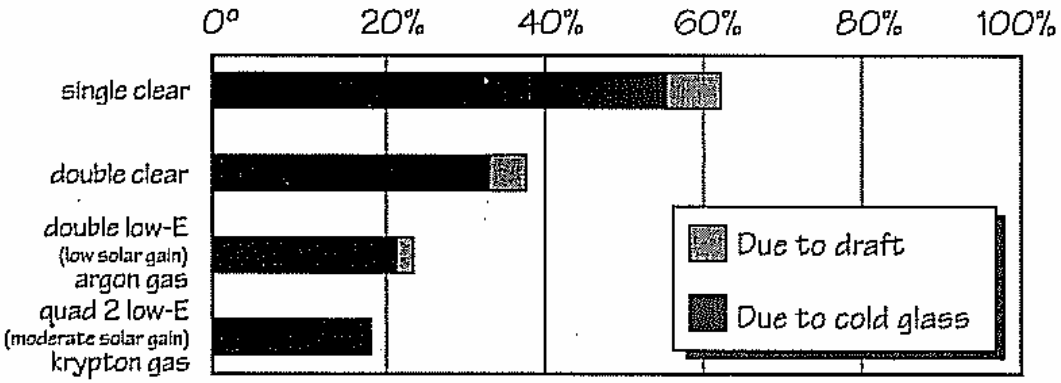
Table 24: Annual results for an average house in the North/Central zone.

Product Type	Heating (MBtu)	Cooling (kWh)	Energy Cost (USD$)	GHG Emissions (ton)
Low Solar Gain	40.2	1,197	729.62	4.26
Low Solar Gain w/ Glare Control	41.4	1,104	741.35	4.25
Medium Solar Gain	38.4	1,372	715.34	4.59
High Solar Gain	34.3	1,865	689.97	4.37
Generic Clear	35.9	2,031	728.99	4.26

Source: Enermodal Engineering Limited – *Determining the Effects of Passive Solar Heating on Whole-House Energy Consumption*

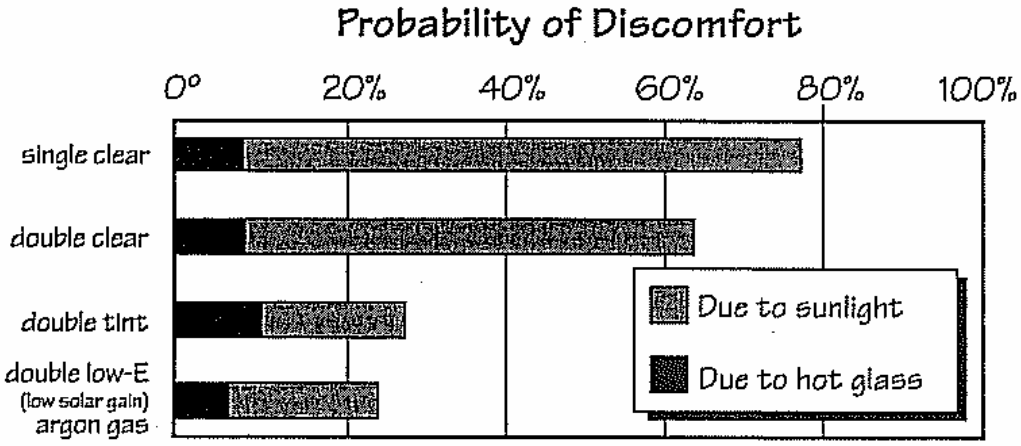
Measuring Comfort

Winter



Source: Lawrence Berkeley National Laboratory.

Summer



Source: Lawrence Berkeley National Laboratory.