

High Performance Windows and Glazing in Cooling-Dominated Climates

A Growing Hot Opportunity

Brad Begin

Alpen High Performance Products



PHOENIX 2026

What We Are Going to Talk About

It is all about windows and glass in hot climate zones.

We will discuss:

- 01** How we got to where we are: technology, policy and “*prejudice*”
- 02** The opportunities emerging in high-performance building, and why they matter
- 03** Fenestration lessons from passive buildings and other high-performance homes built for hot climates

PREJUDICE

That may sound like a strange word to start a presentation about windows



**The building industry
and even industry policy makers
share one such PREJUDICE**

Super-insulating building shells have always been associated with cold climates.

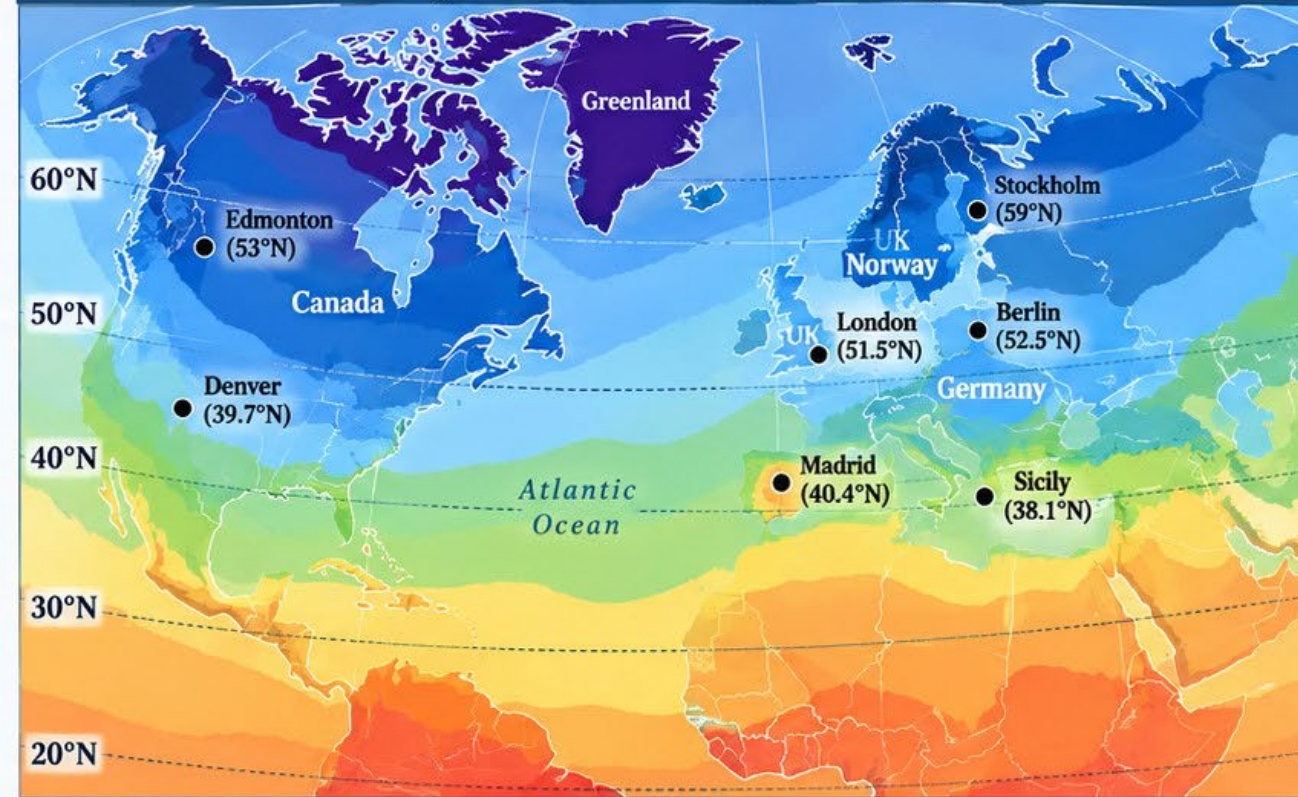


Approximate Temperature Bands Across the North Atlantic

Winter and Summer Average Temperatures (°C)

WINTER (January)

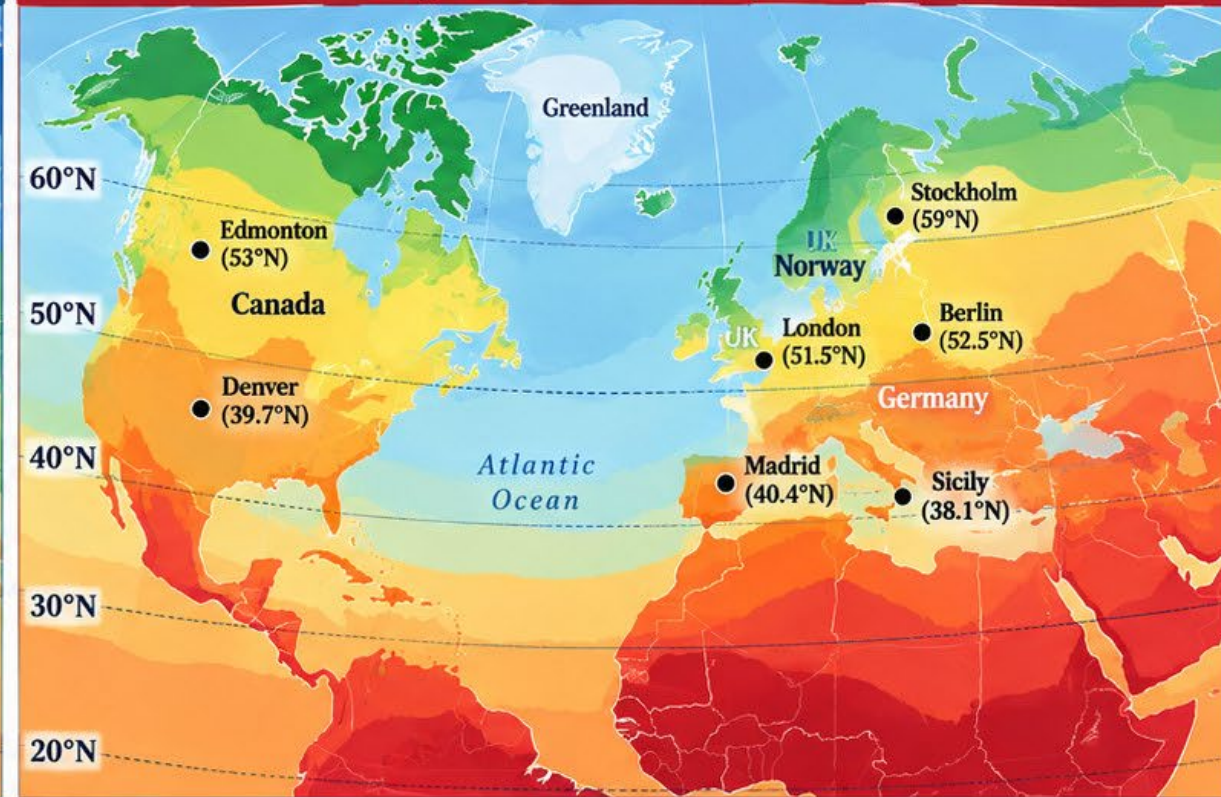
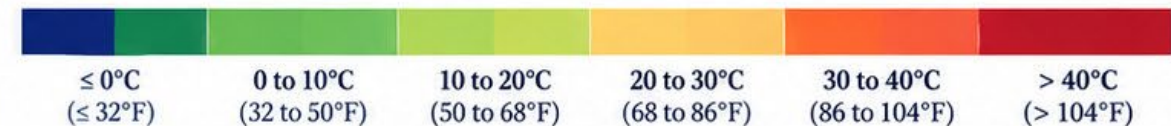
Average Near-Surface Air Temperature (°C)



Colder → Warmer

SUMMER (July)

Average Near-Surface Air Temperature (°C)



Cooler → Hotter

Higher-performance building envelopes are most common in colder winter climates.

European and Canadian markets with widespread triple-pane adoption are generally in regions with long, cold winters, while many lower-latitude regions experience much warmer conditions, especially in summer.

Where Triple-Glazing Adoption Clusters

Highlighted countries are the cold-climate and northern markets most often associated with stronger triple-pane adoption.



Where High-Performance Building Took Hold

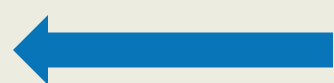
Passive building, Minergie, FEBY, CasaClima, NZEB, ZEB and related high-performance building systems cluster heavily in northern climates.



Rule # 1

Heat does not know where you live

30°F



70°F

WINTER: HEAT FLOWS OUT

110°F



70°F

SUMMER: HEAT FLOWS IN

$$40^{\circ}\text{F } \Delta T = 40^{\circ}\text{F } \Delta T$$

$$Q \propto U \times A \times \Delta T$$

Same window. Same 40°F temperature difference.
The arrow simply reverses.

Temperature Transfer Works Both Ways

High-performance glazing helps keep cooling indoors.



High-Performance Window

Cooling Reflected
Back Indoors

Reduced
Cooling Load

Lower-Insulating Window

More Cooling Lost

Higher
Cooling Load

Comparing Window Heat Transfer

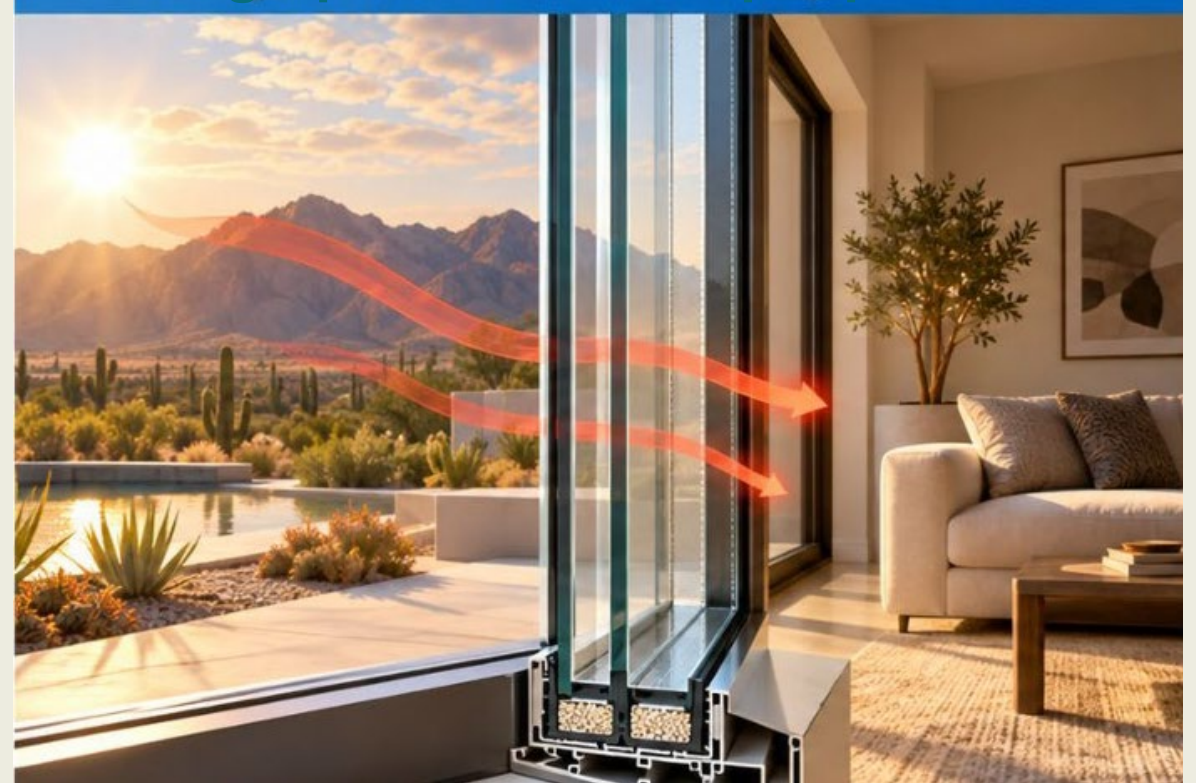
The same temperature difference. Different insulating performance.

Conventional dual-pane



More heat transfer

High-performance triple-pane



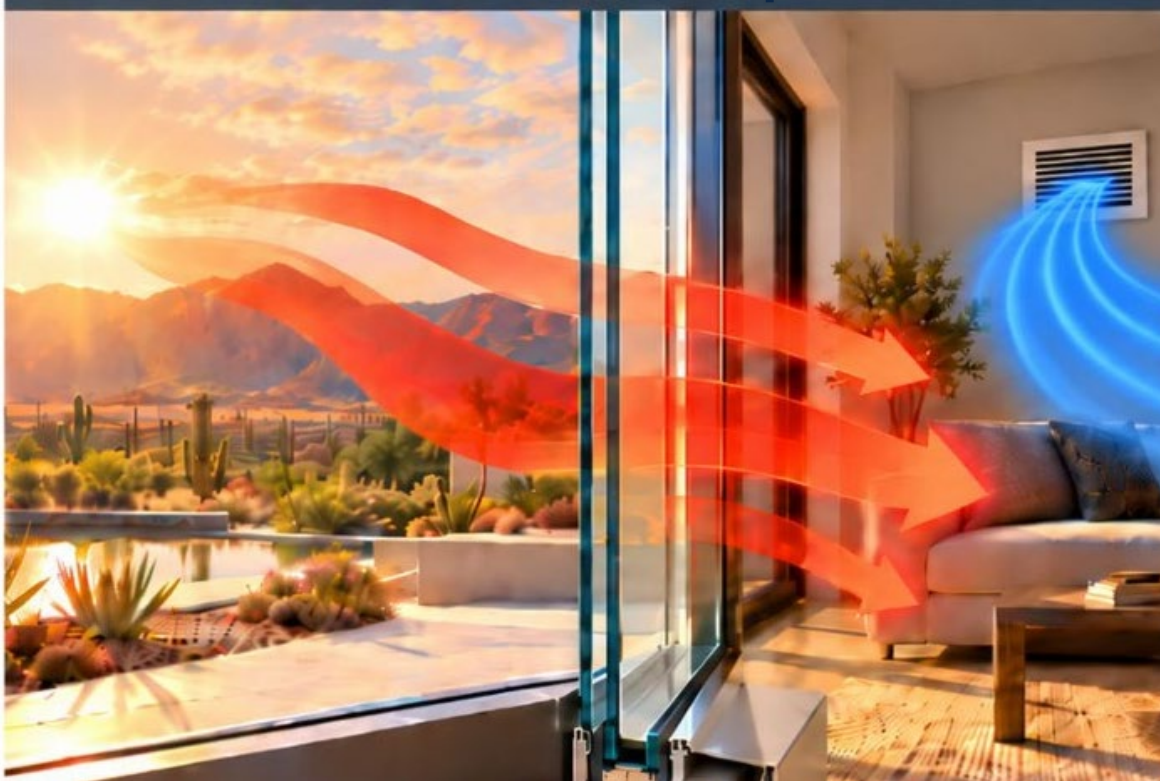
Less heat transfer

Less heat enters through the better-insulated window.

Same Comfort, Less Cooling Work

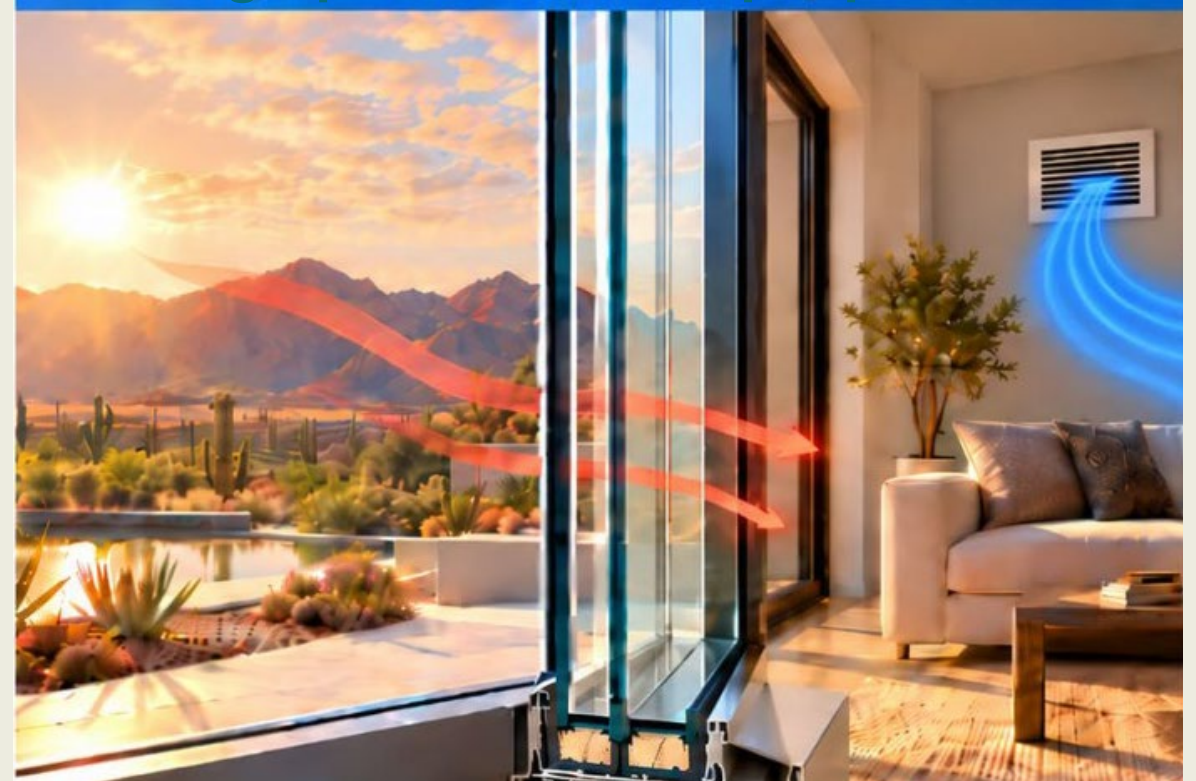
Better insulation reduces the load that cooling equipment must meet.

Conventional dual-pane



More cooling work

High-performance triple-pane



Less cooling work

A smaller load can support a smaller cooling system.

SAME
HIGH-PERFORMANCE
WINDOWS.

DIFFERENT
VIEW.

High-Performance Windows Belong Everywhere.

MORE PLACES. A BRIGHTER TOMORROW.



KEEPS THE COLD OUT.
COMFORT IN.

SAME
HIGH-PERFORMANCE
WINDOWS.

DIFFERENT
VIEW.



KEEPS THE HEAT OUT.
COMFORT IN.

**It is far colder where high-performance windows
and building shells have traditionally found their footing.**



**But hot climates — also known as
cooling-dominated climates — are **the new frontier.****



Before we move forward, let's briefly drive backward.

To understand the window technologies most common in warm and hot climates today, it helps to look at how we got here.

The evolution of the technology is actually quite remarkable.

How Long Ago Were Our “Ancestors” Living Behind Single-Pane Clear Glass Windows?

200 Years Ago?



100 Years Ago?



1976 wasn't that long ago.

1976



Apple was building its first computer



The internet was just beginning



Star Wars was about to hit theaters



Concorde had just entered passenger service



Humanity had already gone to the Moon 6 times

...and the vast majority of windows in the United States were still
SINGLE-PANE.



Today's glass and window technology didn't appear overnight.

The evolution happened fast.



Two events changed the trajectory.

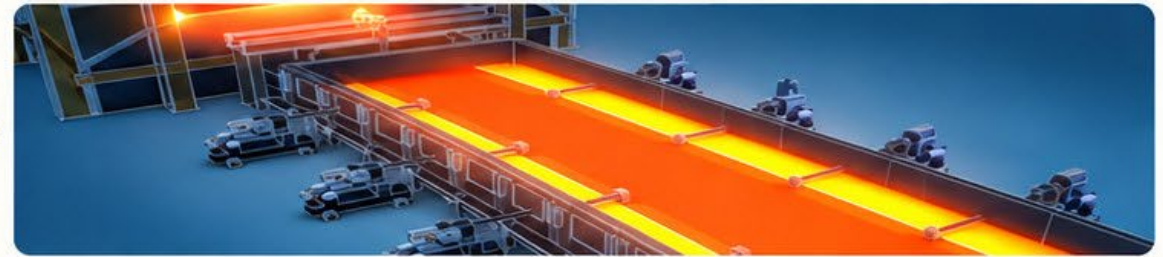
Two events changed the trajectory:

The First Event

The Invention of the Float Glass Process Changed Everything



Glass making went from this to this



Float glass revolutionized the size, availability, quality, and cost of flat glass — setting the stage for an explosion in dual-pane IGUs.

Before Low-e: Solar Control Meant Tint

Early solar management relied on heat-absorbing glass.



1950s - 1970s

The early solution was straightforward: darken the glass and absorb more solar energy.



Effective solar control — but with darker glass and reduced daylight.

Two events changed the trajectory:

The Second Event

What?



The Important Triggering Event — The Arab Oil Embargo of 1973



Gas lines and rationing made the energy shock visible to every American.

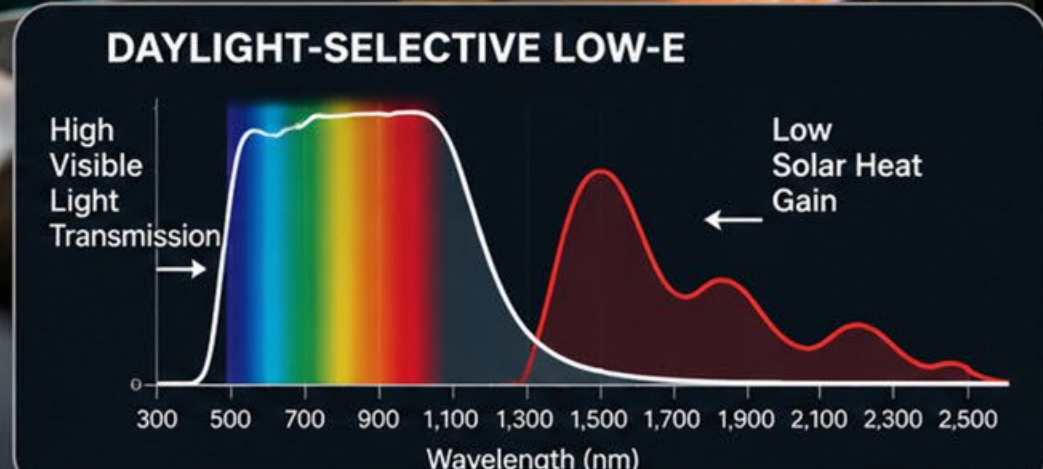
38.8¢ → 53.2¢ / gallon

U.S. average leaded regular gasoline, 1973 → 1974

+37% in one year

The Big Breakthrough in Low-E Coatings Occurred in the Late 70s and Early 80s.

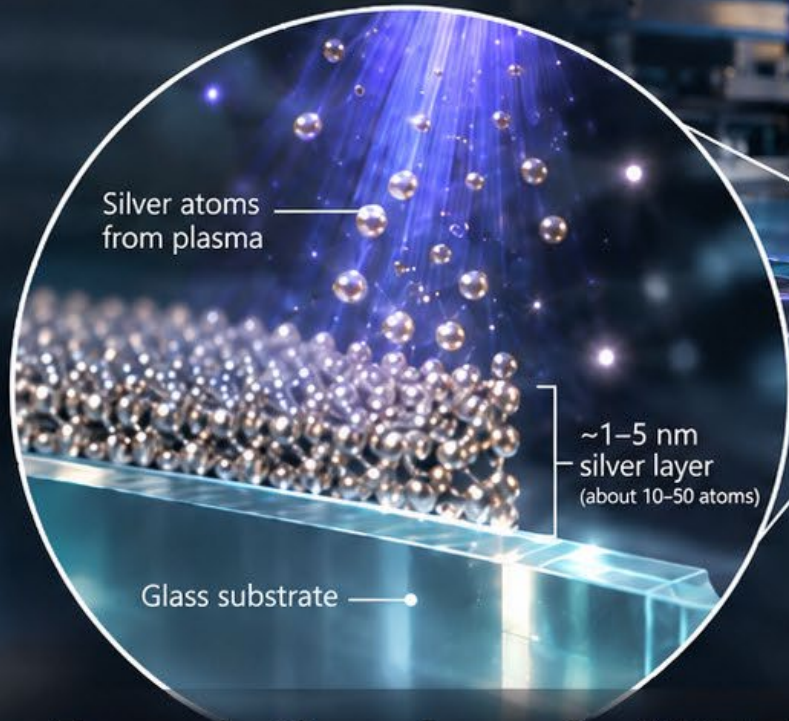
MAGNETRON
SPUTTER COATING



Directly as a Result of Early Support by the New DOE of Research Started at MIT

Tiny Layers. Transformational Technology.

Magnetron sputter coating made
daylight-selective low-e possible.



MAGNETRON
SPUTTER COATING

GLASS
A BRIGHTER
BUILDING TOMORROW

CLEARER
COOLER
MORE DAYLIGHT
A BRIGHTER TOMORROW

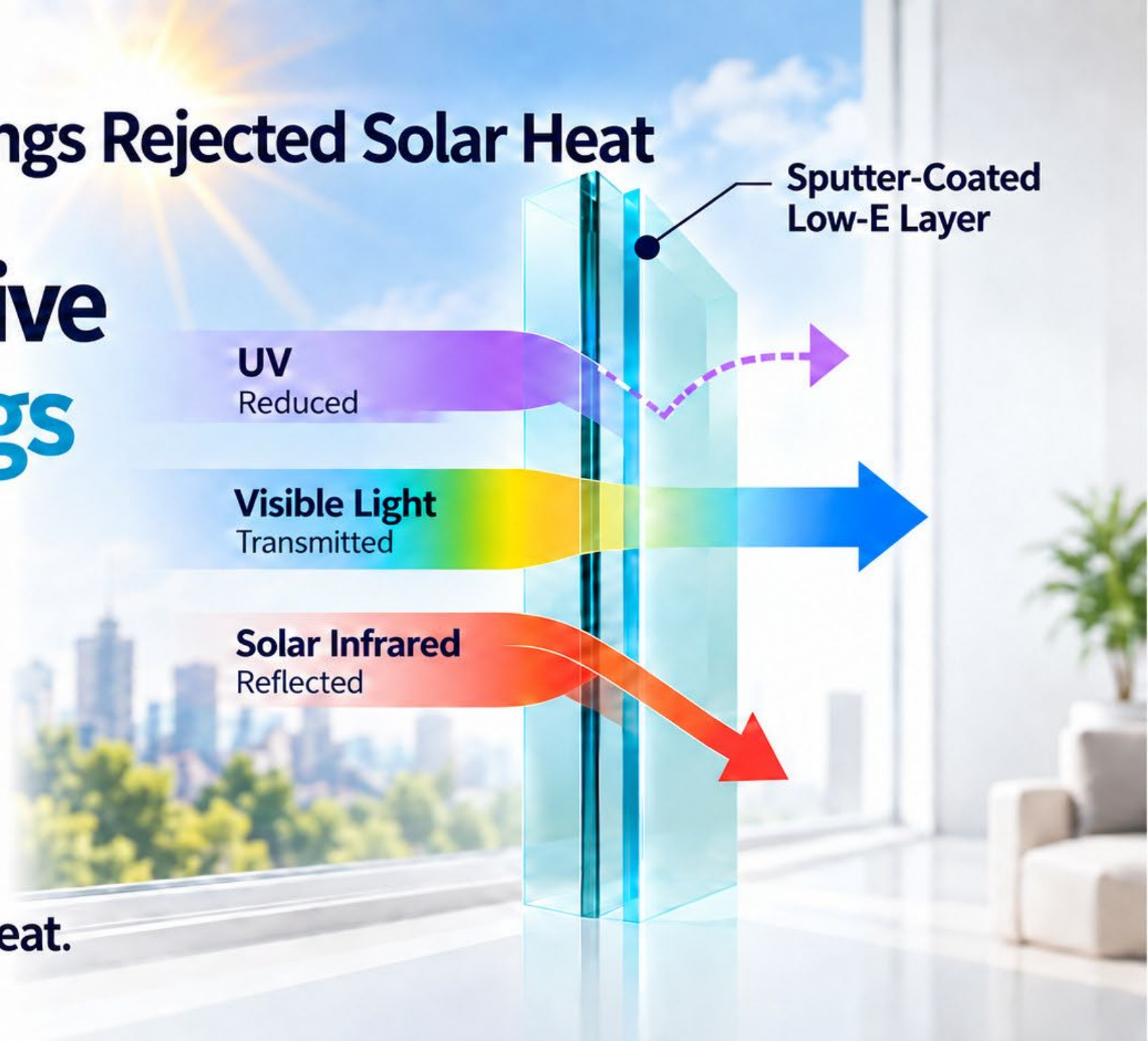
Foundational work: MIT, Southwall, LBNL • Commercial scale-up: Cardinal, PPG

Modern Low-E Coatings Rejected Solar Heat

Daylight-Selective Low-E Coatings

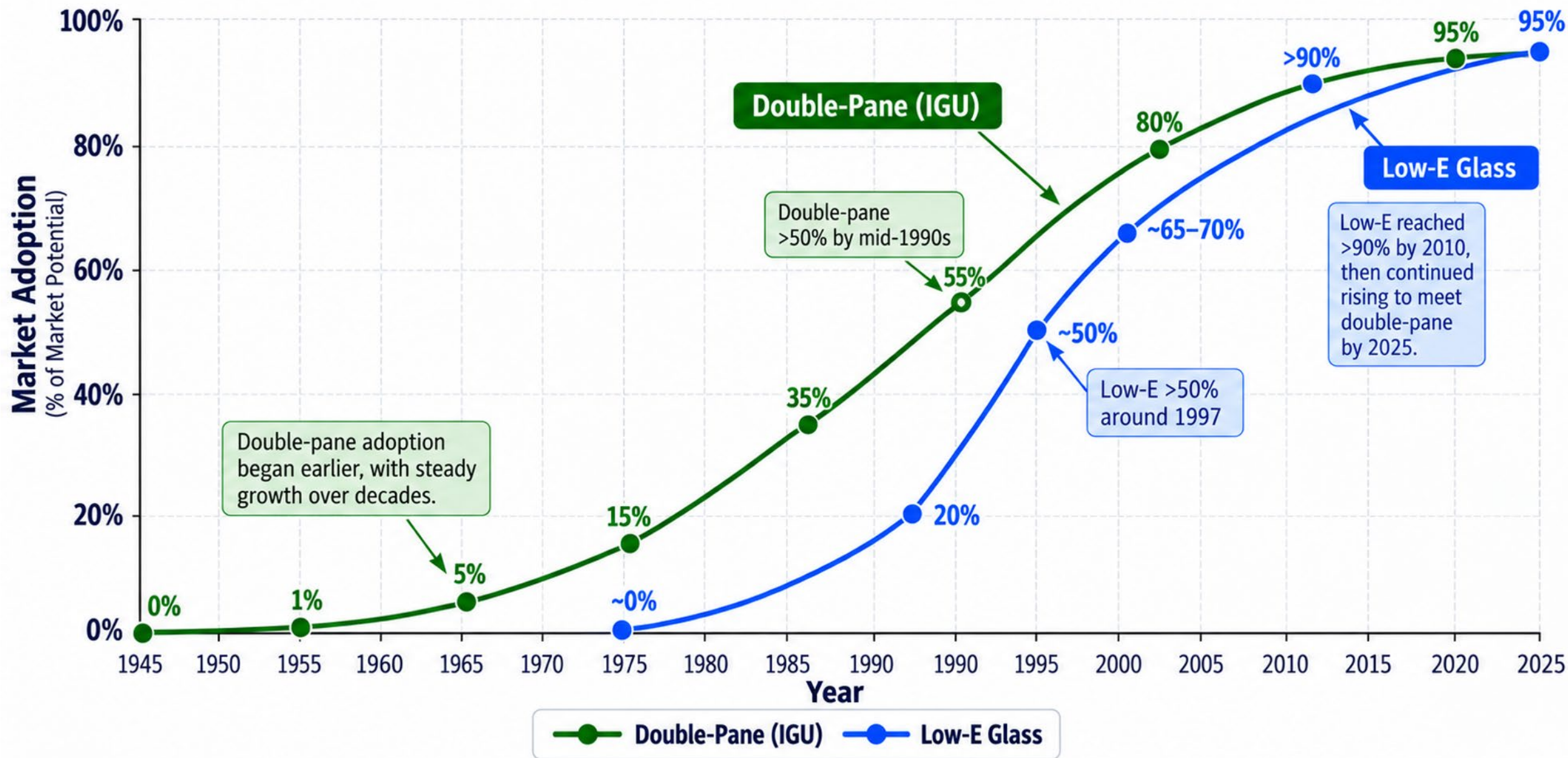
Visible light in.
Solar heat out.

Tinted Glass Absorbed Solar Heat.



Two Staggered S-Curves in U.S. Window Technology Adoption

Double-pane IGUs came first; Low-E followed later and diffused rapidly.



1996 wasn't that long ago.

1996



Windows 95 had just changed personal computing



Amazon was still a tiny online bookstore



Mobile phones were only just becoming pocket-sized



DVDs were just arriving



The first passive house project was only 5 years old

...and low-e glass was still only around

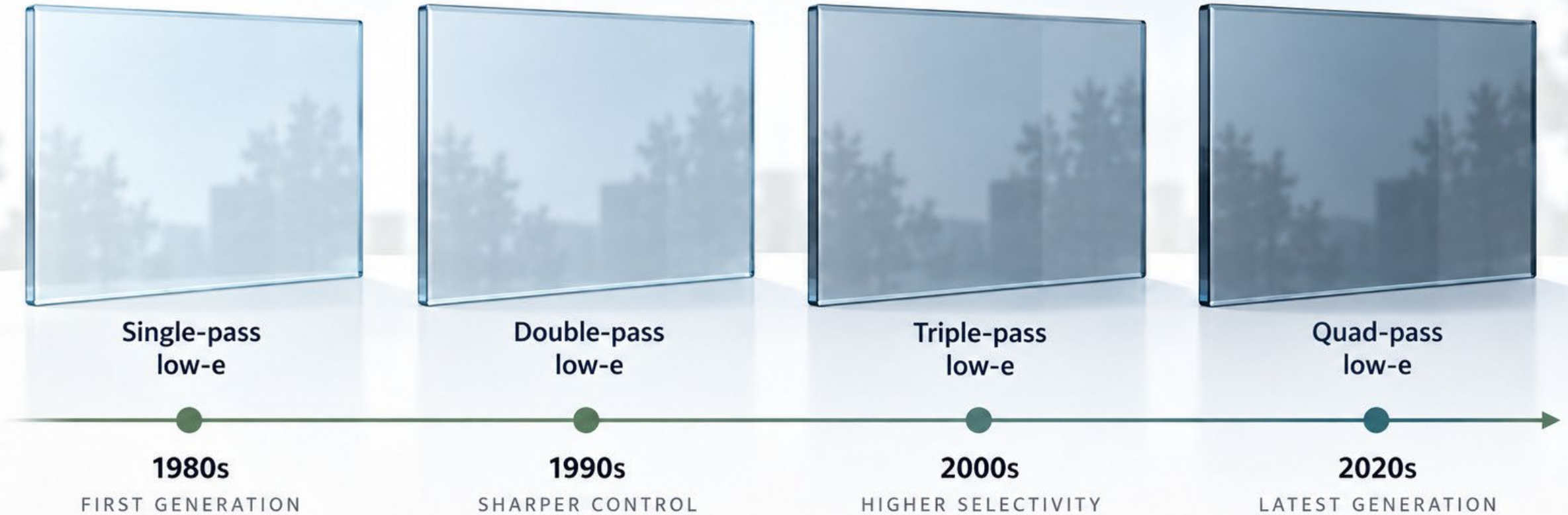
ONE-HALF OF IGUs

Source: Berkeley Lab historical sales figure. Approximate 1995 low-e share.

Modern Solar Control: The Low-e Era

Move the work from glass color into the coating stack.

Successive coating stacks delivered sharper wavelength-selective solar control with clearer views.



Daylight-selective coatings gradually displaced dark tints.

SAME GOAL. A BRIGHTER FUTURE.

From the 1980s forward,
low-e technology advanced rapidly.

In **WARM** and **HOT CLIMATES**,
it was used aggressively to attack the low-hanging
fruit of energy savings and comfort:
SOLAR HEAT GAIN.

SOLAR-CONTROL
HEAT-REJECTING COATINGS
BECAME THE
SLEDGEHAMMER.

PRODUCT DEVELOPMENT
and **PUBLIC POLICY PRIORITIES** moved together.

LOW-E • SOLAR CONTROL • PRODUCT DEVELOPMENT • PUBLIC POLICY



ENERGY STAR: A New Way to Move the Market

A voluntary program that made energy efficiency easier to recognize



1992

EPA LAUNCHES THE PROGRAM

Cut energy use, costs and pollution through a voluntary efficiency label. Computers and monitors came first.



1998

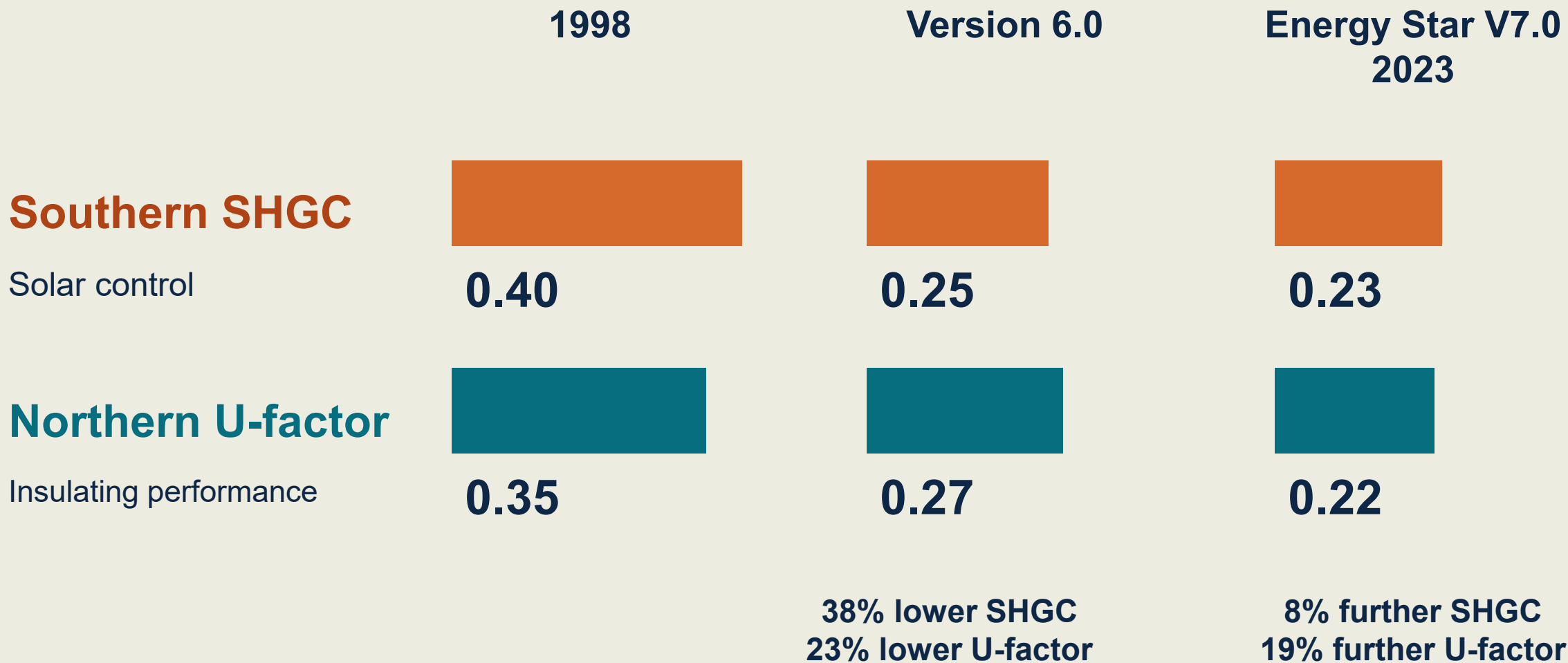
DOE BRINGS WINDOWS IN

Residential windows, doors and skylights join the program, giving buyers a label and industry a performance target.

Voluntary participation. A shared goal for better windows.

Two-Phase Tightening Since 1998

Northern U-factor took another significant step with Energy Star V7.0.



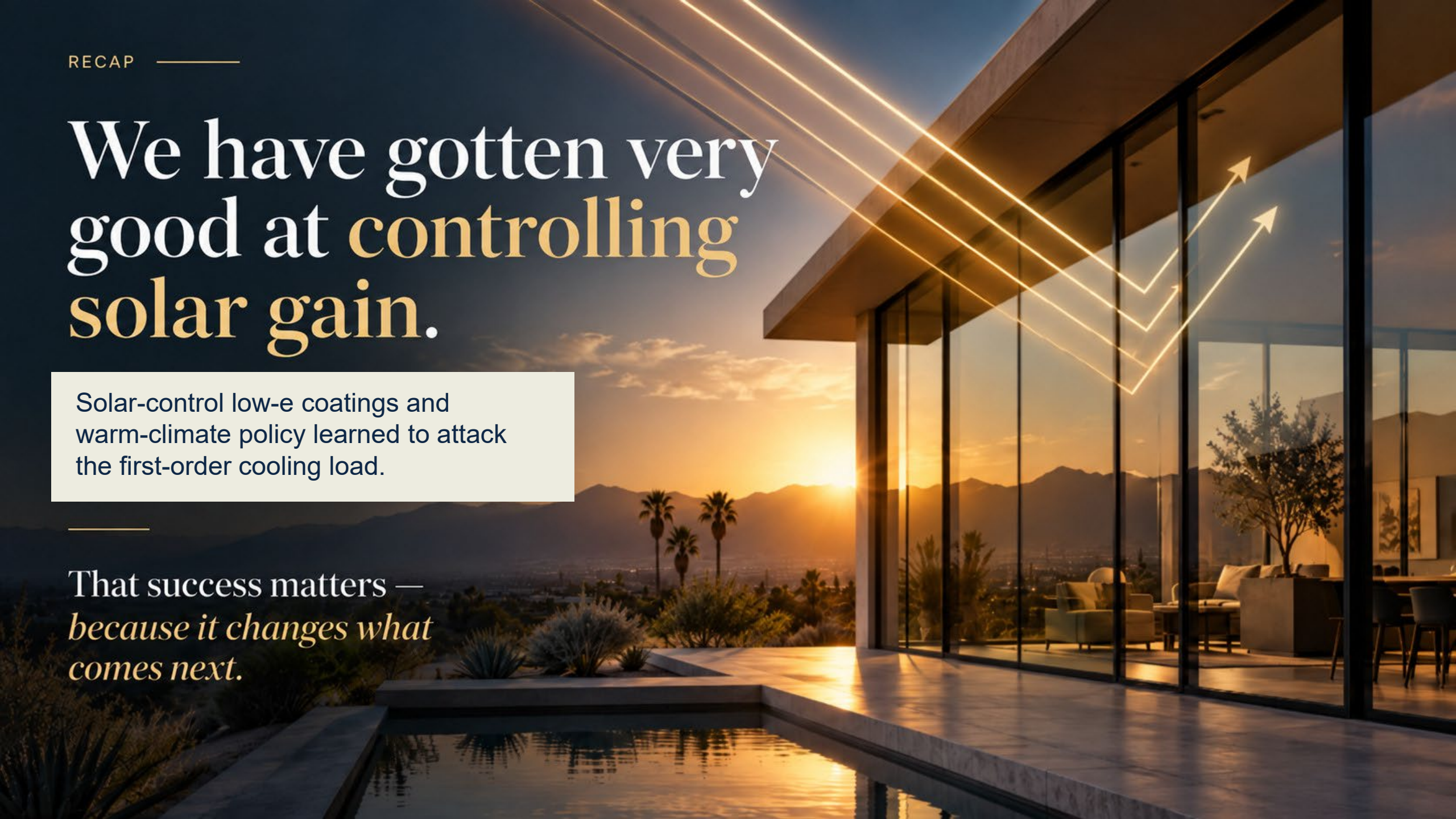
Sources: ENERGY STAR criteria history, Versions 6.0 and 7.0. Bars share a 0–0.40 scale. Northern prescriptive path.

RECAP —

We have gotten very good at **controlling solar gain**.

Solar-control low-e coatings and warm-climate policy learned to attack the first-order cooling load.

That success matters —
because it changes what comes next.



PIVOT

Success changes the problem.

Once solar gain is controlled, the remaining load becomes more visible, especially in airtight, low-load buildings with smaller mechanical systems.

*The better the shell,
the more the residual window load matters.*

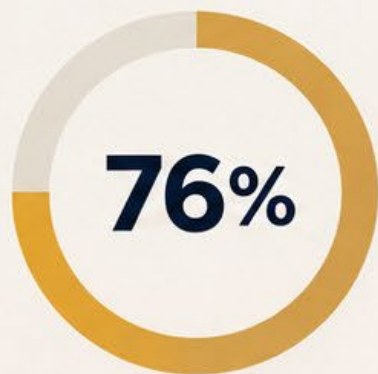


Rule # 2

IN HOT CLIMATES
**MANAGE
THE SUN
FIRST**



In hot climates, focus first on a solar control strategy.



In cooling seasons, about 76% of sunlight that falls on standard double-pane windows enters to become heat.

Source: U.S. Department of Energy



Solar control is the low-hanging fruit.

But insulation still matters.



Hot-Climate Lessons: Reorient the Glass

Shift the priority from collecting heat to controlling solar gain



FAVOR NORTH-FACING VIEWS

Where feasible, place more view glazing to the north.
Keep daylight and limit direct sun.

LIMIT EAST AND WEST GLASS

Minimize exposed glazing.
Low-angle morning and afternoon sun is difficult to shade.

DESIGN DEEP EXTERIOR SHADE

Use deep overhangs and recesses.
Add vertical or adjustable shade where low-angle sun demands it.

Set glass area, coatings and shade together. Test the whole design.

Rule # 3

AFTER FOCUSING ON THE SUN,

THEN MANAGE
HEAT TRANSFER

THROUGH

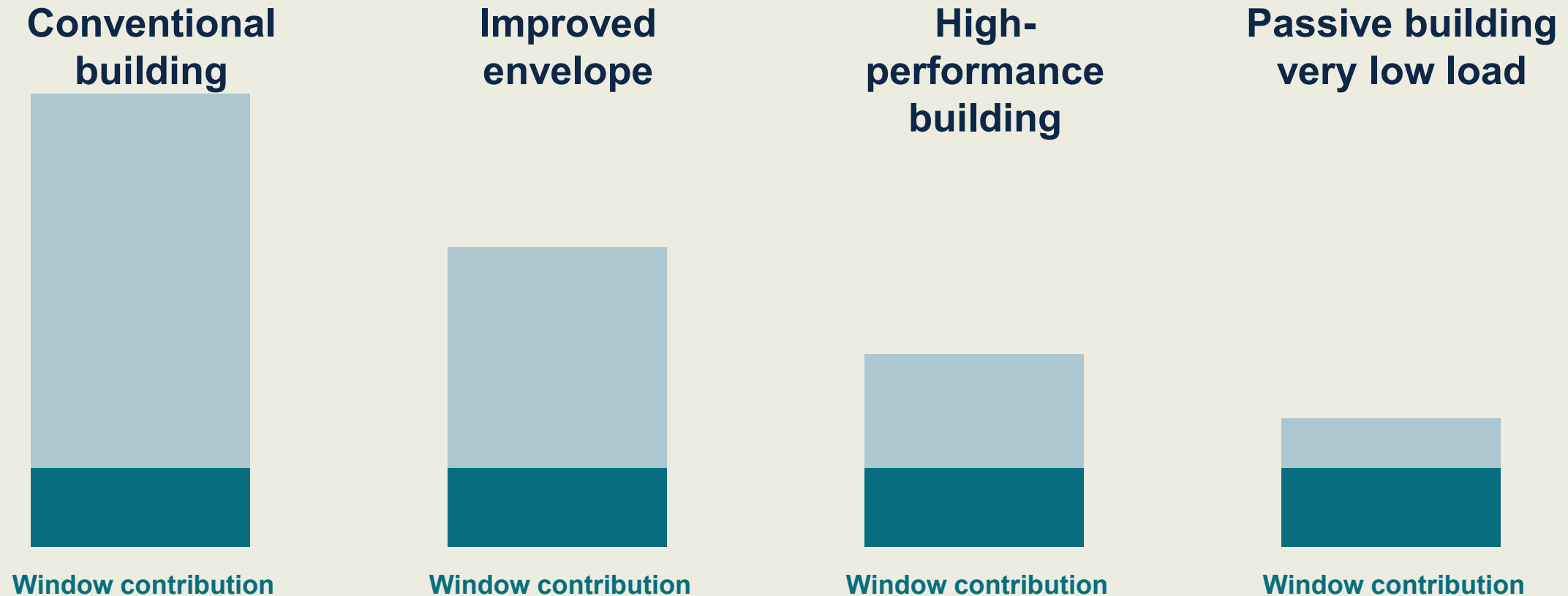
THE GLASS



As the Building Load Shrinks, the Window Matters More

The physics stays the same. The other loads get smaller.

CONCEPTUAL ILLUSTRATION Light blue: other loads. Teal: window contribution.



The window did not get worse. Everything else got much better.

A Little Glass Can Dominate the Conductive Façade Load

1,000 ft² façade Wall U = 0.03 Window U = 0.30 $\Delta T = 35^{\circ}\text{F}$



15% window area

64%

of wall + window
conductive load comes
through the windows

Windows 1,575 Btu/h Wall 893 Btu/h



40% window area

87%

of wall + window
conductive load comes
through the windows

Windows 4,200 Btu/h Wall 630 Btu/h

As glass area grows, the conductive penalty compounds.

Illustrative arithmetic. U-factor units: Btu/(h·ft²·°F). Conductive façade load only; excludes solar and other loads.

WE ARE ASKING GLASS TO DO MORE OF THE BUILDING'S WORK



THE WARMER THE MARKET, THE MORE WE WANT THE WALL TO DISAPPEAR



CALIFORNIA

75+ years of indoor/outdoor modernism



ARIZONA

Views + desert living + expansive glass



TEXAS

Hill Country views + increasingly open façades

LONG OUTDOOR-LIVING SEASON + VIEWS + LUXURY MARKET → LARGER GLAZED OPENINGS

Rule # 4

**PROTECT
COMFORT
NEAR THE
GLASS**



HUMAN COMFORT

**THE THERMOSTAT
SAYS 74°F.
YOUR BODY MAY
DISAGREE.**



COMFORT IS MORE THAN AIR TEMPERATURE

**Hot glass can make a
cool room feel uncomfortable.**

Your body exchanges heat
with nearby surfaces.

More glass. Closer seating.
Greater radiant influence.

Direct sun adds another source of discomfort.

Design for comfort where people sit.



Hot Climates Still Need Year-Round Comfort



Insulating glass slows heat gain in summer and heat loss in winter. It keeps the interior glass closer to room temperature.

TUCSON · 2025

113°F / 24°F

ANNUAL HIGH / LOW

Comfort is a year-round requirement.

Source: ASU Arizona Climate Office, 2025 Annual Report.
Snow image illustrative.

Rule # 5

An aerial photograph of a city skyline at sunset. The sun is low on the horizon, casting a warm, golden glow over the city. In the foreground, several large, industrial HVAC units are visible on a rooftop, with their fans and coils clearly defined. The city below is densely packed with buildings, and a major highway with multiple lanes of traffic is visible, stretching towards the horizon. The overall scene suggests a focus on urban infrastructure and energy efficiency.

REDUCE PEAK COOLING DEMAND

Lower U Can Matter More at the Cooling Peak

Annual energy can understate peak significance. Illustrative comparison.

ANNUAL COOLING ENERGY

7%

lower annual cooling energy



HOTTEST DESIGN HOUR

24%

lower peak cooling load



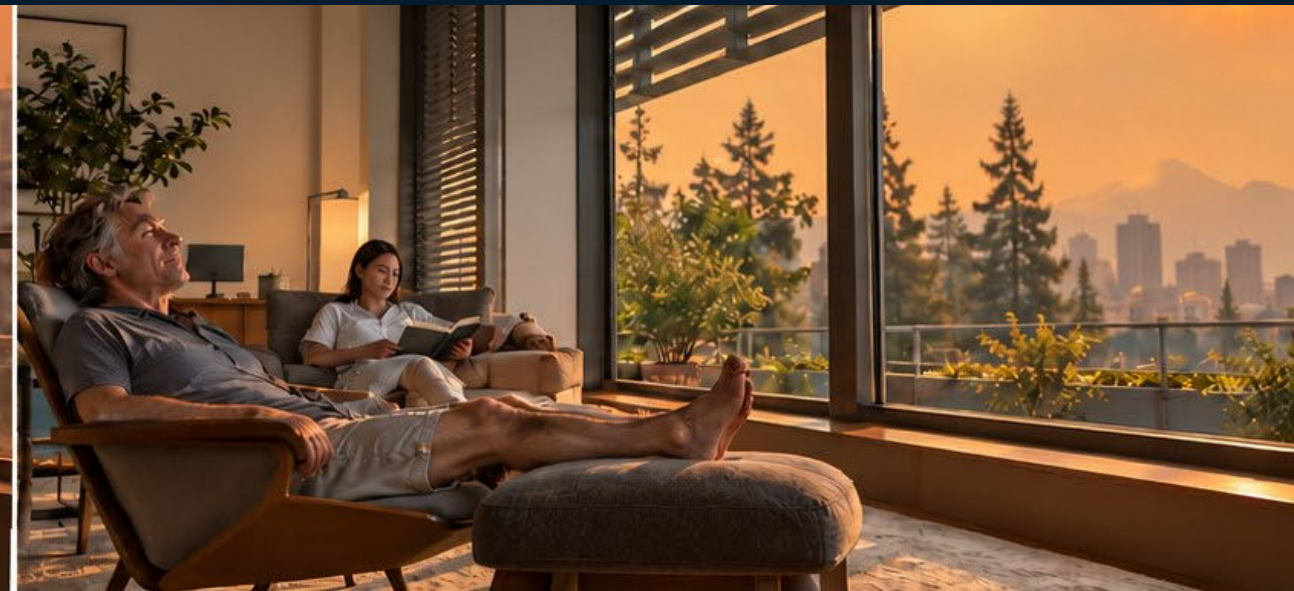
Small annual savings can still have value at the design peak.

ILLUSTRATIVE ONLY. Independent baseline = 100 for each metric. No verified model or documented assumptions.



A Quick Side Discussion on a Related Issue

Resilience and Passive Survivability



Resilience and Survivability:

The Old Rules No Longer Apply

- **Weather extremes reach unexpected regions.**
- **Buildings in hot climates can be especially vulnerable.**

When the grid fails, the building becomes a lifeline.

Texas power use to break records in heat wave this week

Reuters · June 13, 2023



Extreme heat represents a new threat to trees and plants in the Pacific Northwest

Associated Press · Dec. 21, 2023



DESERT FLOODS

Illustrative scene · editorial caption



‘Ice everywhere’ as Texans brave cold, 2.7 million homes lack power

Reuters · Feb. 18, 2021





Enhancing Resilience in Buildings Through Energy Efficiency

July 2023

Pacific Northwest National Laboratory

Ellen Franconi, Luke Troup, Mark Weimar, Yunyang Ye, Chitra Nambiar, and Jeremy Lerond

National Renewable Energy Laboratory

Eliza Hotchkiss, Jordan Cox, Sean Ericson, Eric Wilson, Philip White, Conor Dennehy, Jordan Burns, Jeff Maguire, and Robin Burton

Lawrence Berkeley National Laboratory

Tianzhen Hong, Linqian Sheng, and Kaiyu Sun

Department of Energy

Michael Reiner, Christopher Perry, and Jeremy Williams

Passive Survivability

“A building’s ability to maintain livable indoor conditions during an extended power outage, without mechanical heating or cooling.”

Enhancing Resilience in Buildings Through Energy Efficiency

Franconi et al. (2023)

PNNL-32737, Rev. 1. July 2023.

Modeled Passive Survivability: Houston Heat Wave

Seven-day grid loss. Existing stock vs Plius-based whole-building package.

EXISTING STOCK



4.0 livable days

Plius-based package



7.0 livable days

96% fewer modeled excess deaths

Modeled Passive Survivability: Atlanta Heat Wave

Seven-day grid loss. Existing stock vs Plius-based whole-building package.

EXISTING STOCK



2.9 livable days

Plius-based package



7.0 livable days

93% fewer modeled excess deaths

FENESTRATION LESSONS LEARNED

FROM FIVE
HOT-CLIMATE
HIGH PERFORMANCE
PROJECTS



Five Hot-Climate Fenestration Lessons

Strategies for passive buildings and other high-performance buildings in cooling-dominated climates.

01

ORIENTATION COMES FIRST

Decide where the glass belongs before deciding what glass to use.

02

PUT GLASS WHERE IT WORKS BEST

Use larger glazing where solar exposure is easiest to manage.

03

SHADE BEFORE THE GLASS

Stop solar heat outside before asking the glazing to manage it.

04

SHGC + U-FACTOR SOLVE DIFFERENT PROBLEMS

Control solar gain and conductive heat flow as separate loads.

05

GLAZING IS PART OF A SYSTEM

Coordinate windows with shading, envelope, daylighting and mechanical design.

REAL LIFE EXAMPLE

Sonoran Desert Passive House · 2021

Tucson, Arizona

Phius Certified · PIONEERING CLIMATE ZONE 2B — HOT-DRY



Photo: Nick Merrick / Brubaker Architects

REAL-LIFE EXAMPLE OF:



NORTH-FACING GLASS
views + daylight



ORIENTATION FIRST
lower solar load



DEEP SHADE
protective roof

REAL LIFE EXAMPLE

Cave Creek Residence • 2026

Cave Creek, Arizona

High-performance residence • Not Phius Certified



REAL-LIFE EXAMPLE OF:



HIGH WWR
large glass areas



DEEP EXTERIOR SHADE
stop sun outside



HIGH-PERFORMANCE GLAZING
manage residual load

REAL LIFE EXAMPLE

Theresa Passive House · 2020

Austin, Texas

Phius 2018+ Source Zero pilot · EARLY HOT-HUMID PASSIVE HOUSE



Photo: Theresa Passive House

REAL-LIFE EXAMPLE OF:



SHGC MATTERS
control solar gain



U-FACTOR MATTERS
control conductive heat



DAYLIGHT + VIEWS
design intent preserved

REAL LIFE EXAMPLE

Harvest Mesa • 2024

Hopi Tribe, Arizona

DOE SOLAR DECATHLON DESIGN CHALLENGE GRAND WINNER



REAL-LIFE EXAMPLE OF:



**ULTRA-LOW-U
WINDOWS**

reduce conductive load



**SOLAR-AWARE
PLACEMENT**

manage exposure



WHOLE-HOUSE SYSTEM

envelope + passive design

REAL LIFE EXAMPLE

LeBois House / 204House · 2010

Lafayette, Louisiana

FIRST HOT-HUMID ZONE PROJECT



REAL-LIFE EXAMPLE OF:



CLERESTORY GLASS
controlled daylight



SHADE FIRST
deep overhangs



WHOLE-HOUSE SYSTEM
glazing + enclosure

Brief Review of the Five Rules of High Performance Fenestration in Hot Climates

- Rule #1** Heat Does Not Know Where You Live
Temperature Transfer Works Both Ways
- Rule #2** Manage the Sun First
- Rule #3** After Managing the Sun, Manage
Heat Transfer Through the Glass
- Rule #4** Protect Comfort Near the Glass
- Rule #5** Reduce Peak Cooling Demand



A Brief Review of Fenestration Lessons Learned from Five Hot-Climate High Performance Projects

- 01** **Orientation Comes First**
- 02** **Put Glass Where It Works Best**
- 03** **Shade Before the Glass**
- 04** **SHGC + U-Factor Solve Different Problems**
- 05** **Glazing Is Part of a System**



BUILD BETTER TOGETHER

Questions?

Brad Begin

Alpen High Performance Products, Inc.

bbegin@thinkalpen.com

303-883-9001

