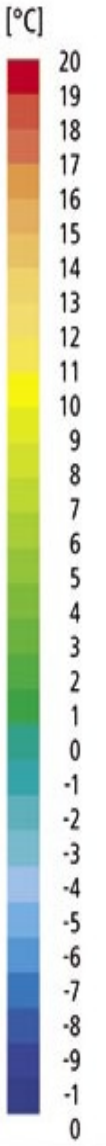
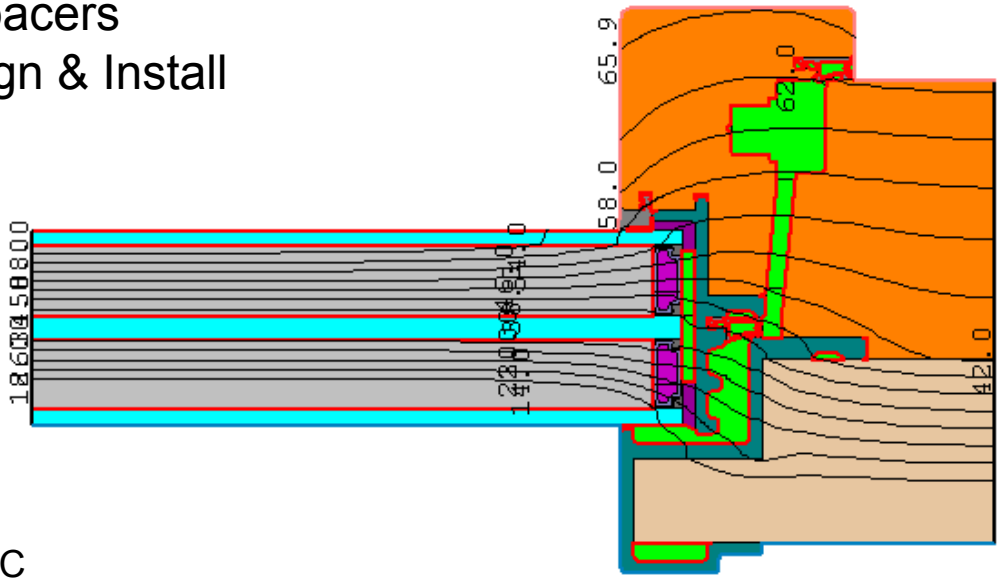


How to Look *at* Windows Designed for Performance

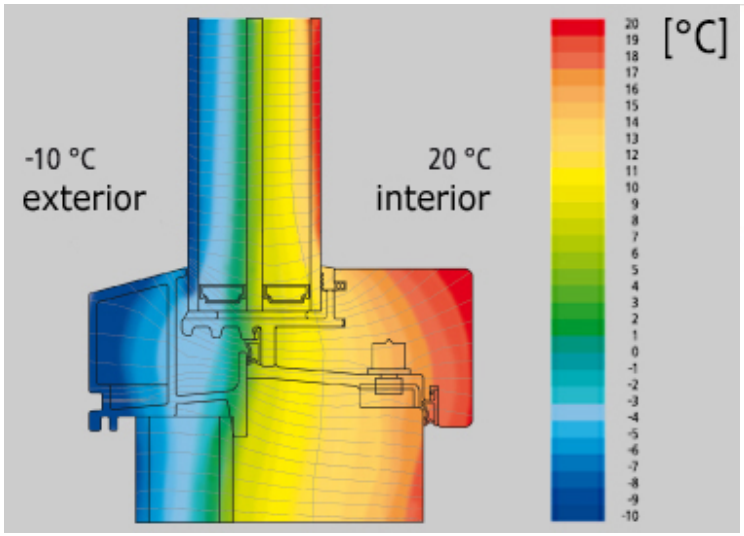
- Hot Frames, Good Bones, Great Anatomy
- Looking at Glass and Spacers
- Your responsibility: Design & Install
- Reading the Ratings
- The Alaska Special
- Fluff, lies and B.S.

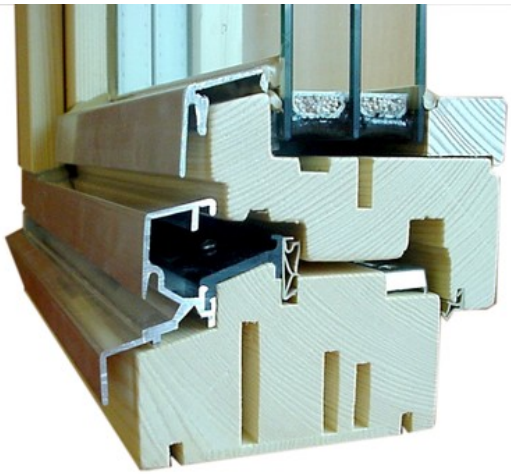


Bronwyn Barry, Assoc. AIA, CPHC
Director, One Sky Homes
PHCA Co-President
2012

Every House needs good windows

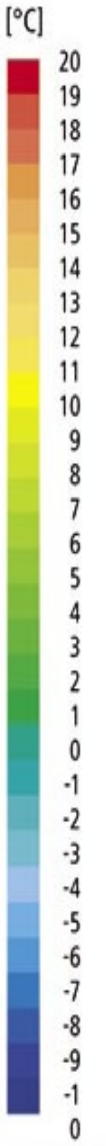
Triple glazing: the new normal?





They can be part of your heating system (or not!)

Image 1: Enersign.de, Image 2: passivehausfenster.at , Image 3: optiwin-usa.com



Using A Performance lens

GAINS

Solar Heat Gains Q_S

- Location
- Shape
- Orientation
- Glazing
- SHGC
- Shading

Internal Heat Gains Q_I

- Occupants
- Lighting
- Electronics
- Appliances
- Mechanicals
- HW storage

LOSSES

Transmission Heat Losses Q_T

- Insulation
- Thermal Bridging
- Windows/Doors
  - Glass U-value
  - Frames
  - Install

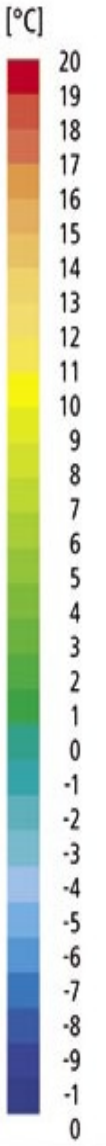
Ventilation Heat Losses Q_V

- Air Sealing
- HRV

$$(Q_S + Q_I) - (Q_T + Q_V) = Q_H$$

* Comfort criterion: no interior surface temp > 5°F ΔT

Formula from Passive House Planning Package by Passive House Institute, Germany, Graphic courtesy: www.OneSkyHomes.com



Windows have pluses and minuses

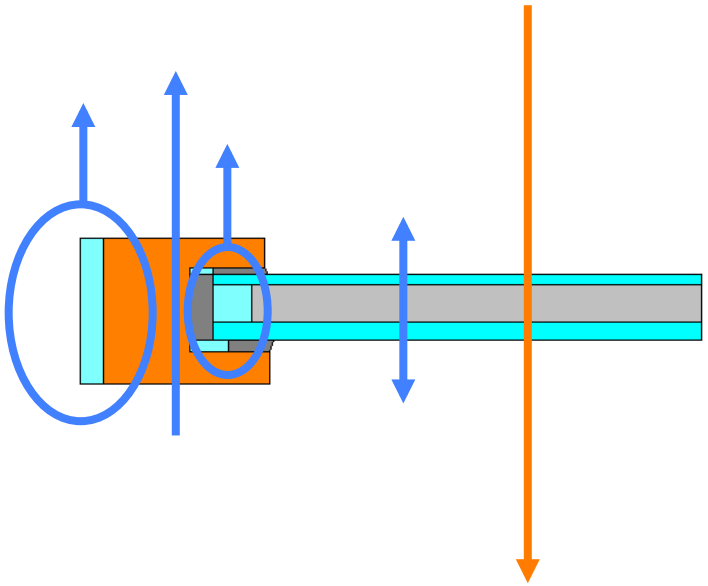
And should be ‘Energy Positive’

LOSS ITEMS:

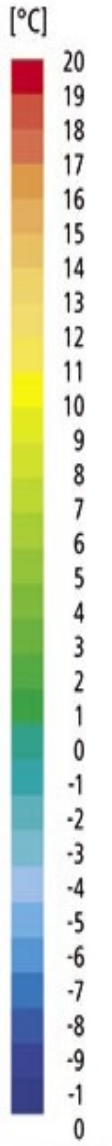
- Frames
- Glass
- Glazing spacers
- Installation edge

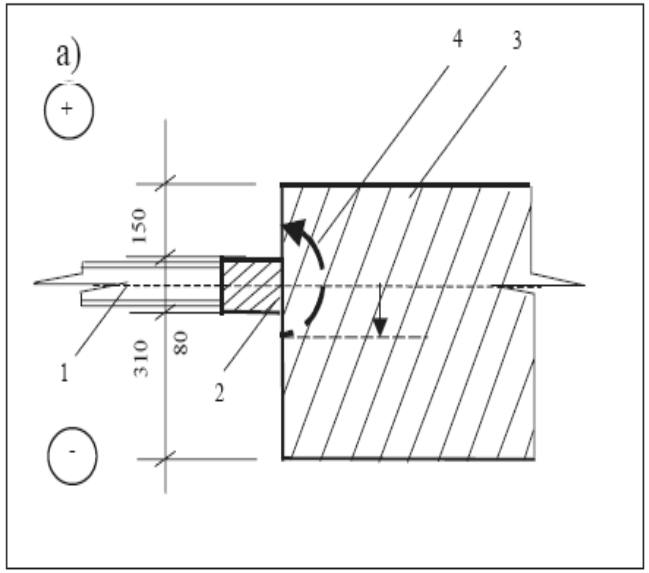
GAIN ITEM:

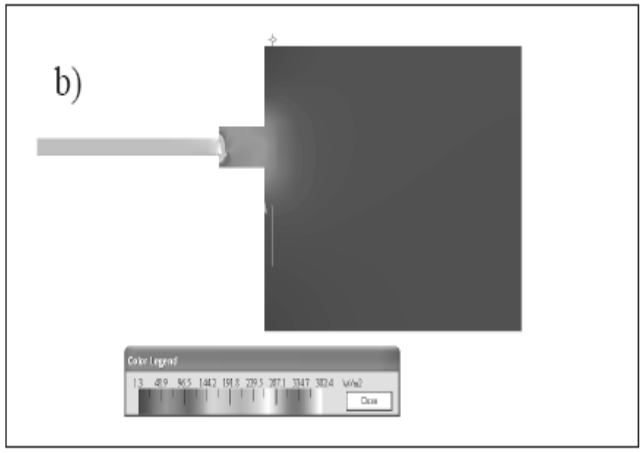
- Glass

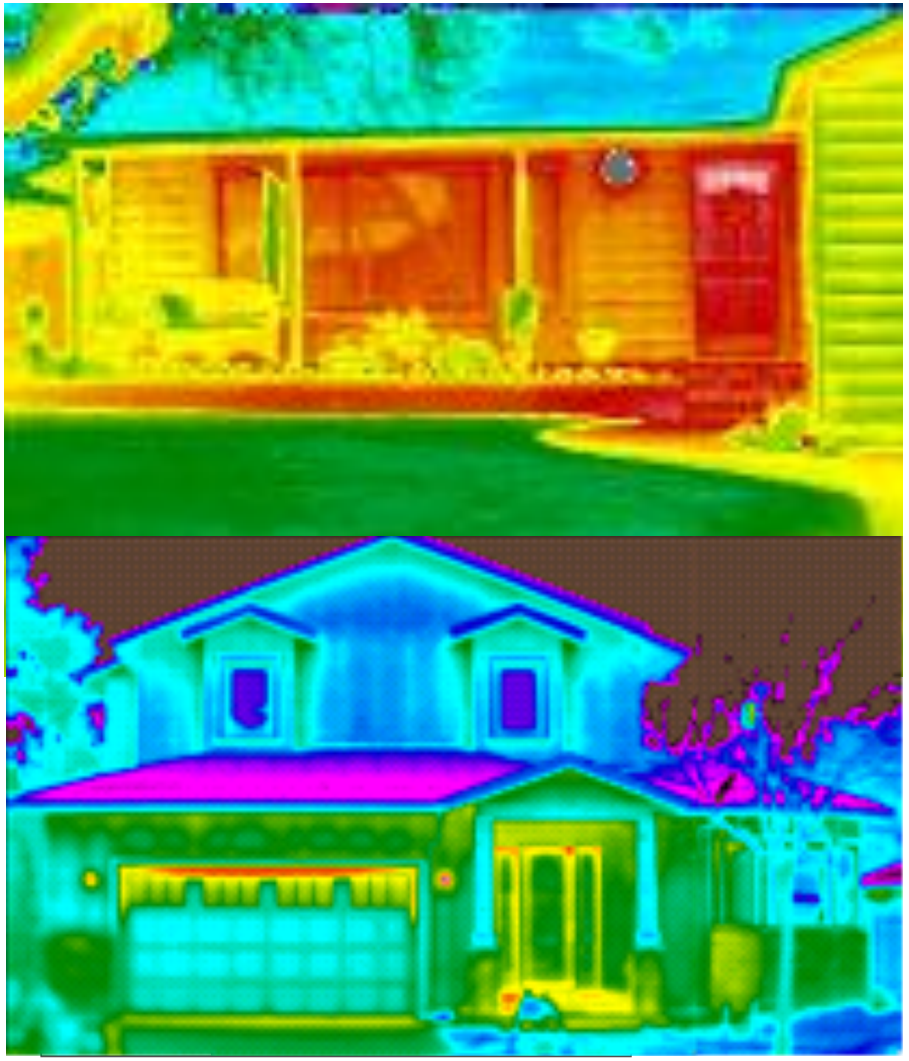


The big losers here



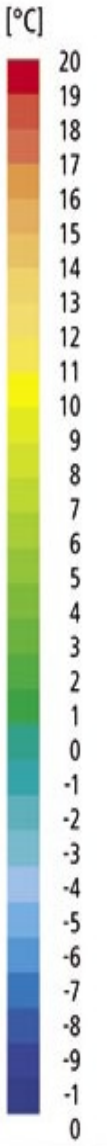




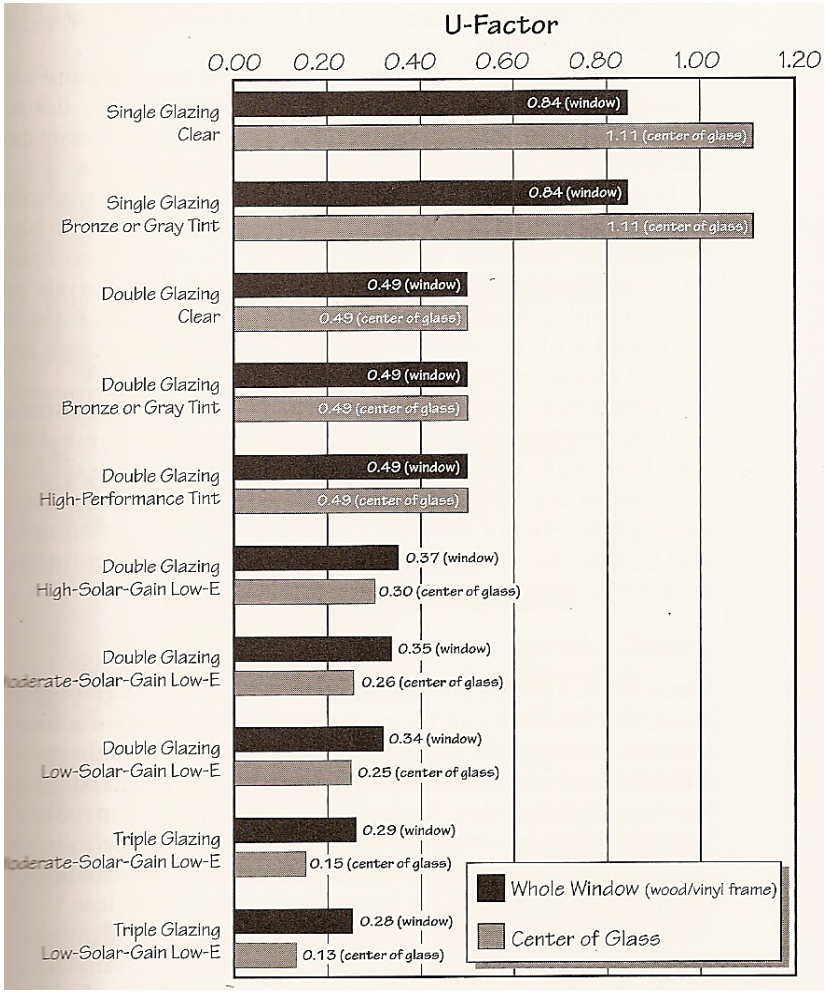


Source: Analysis of Heat Loss Reduction through window edges by E. isevieius, V. Staponkus, & A. Jurelionis; Kaunas University of Technology, Lithuania. 2005

Images: Lorna Fear IR images



Specify good glass



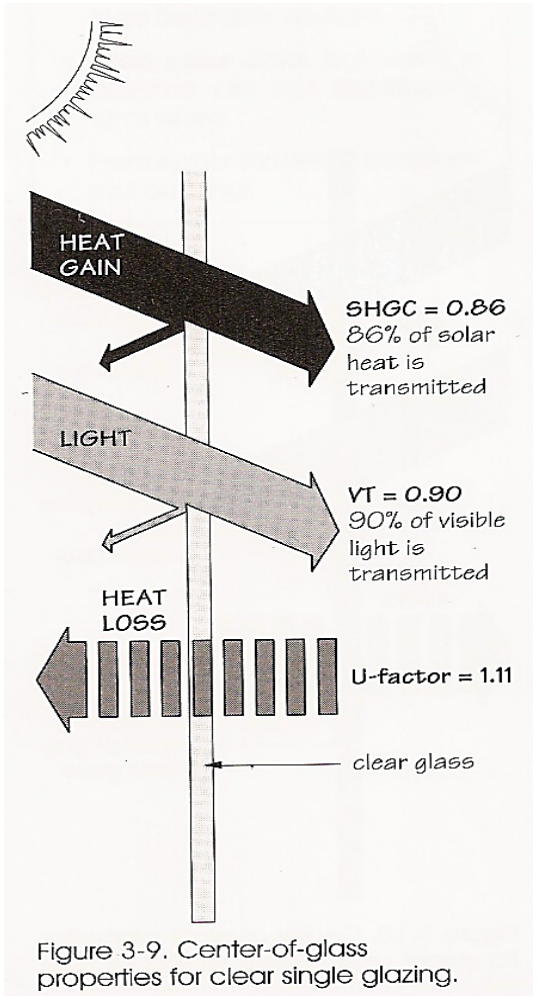
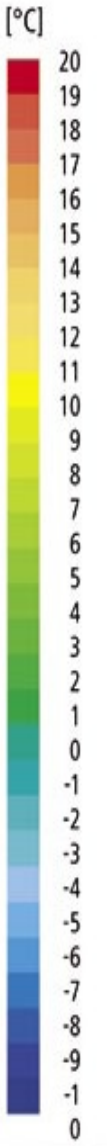
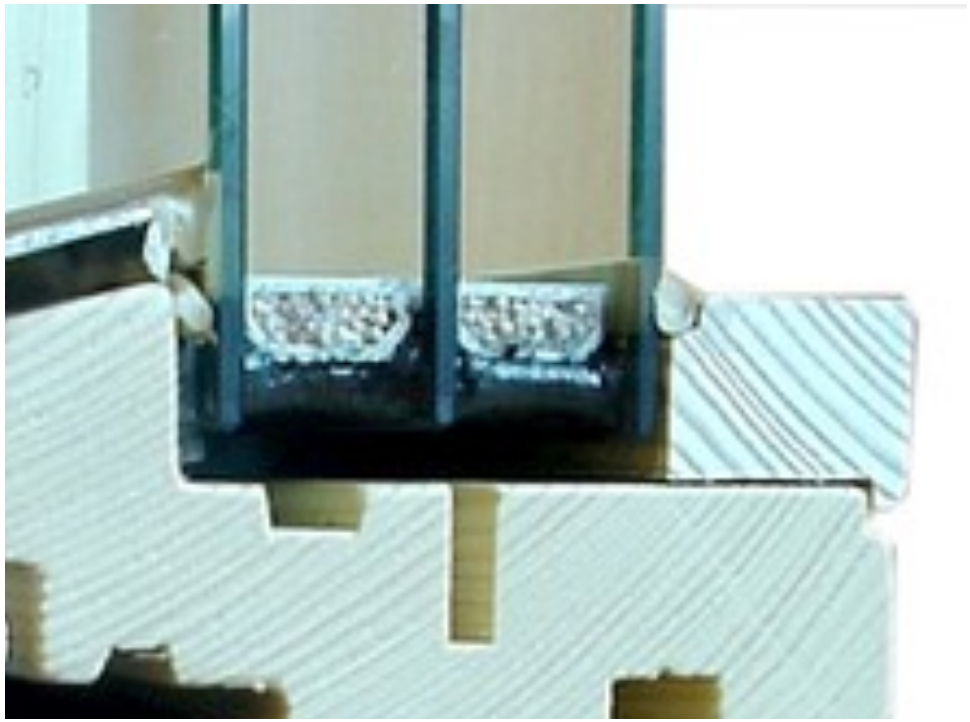


Figure 3-9. Center-of-glass properties for clear single glazing.

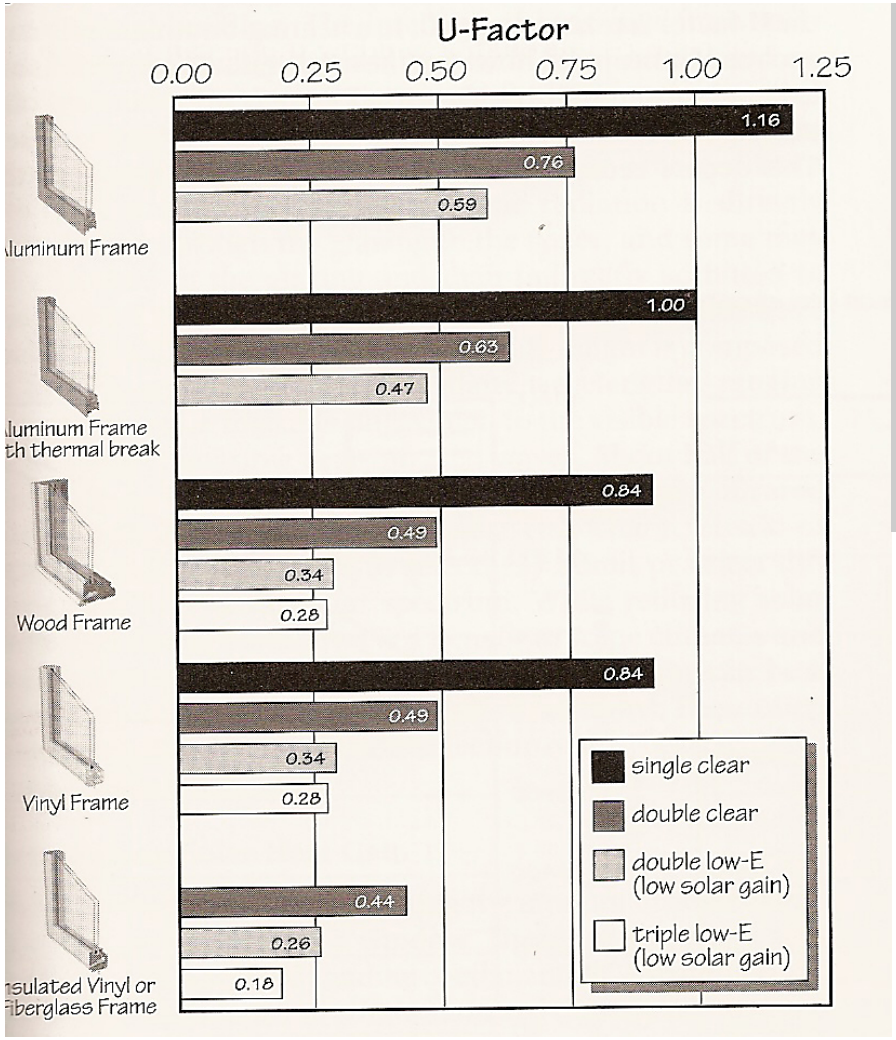
Scanned from: Residential Windows by John Carmody et al

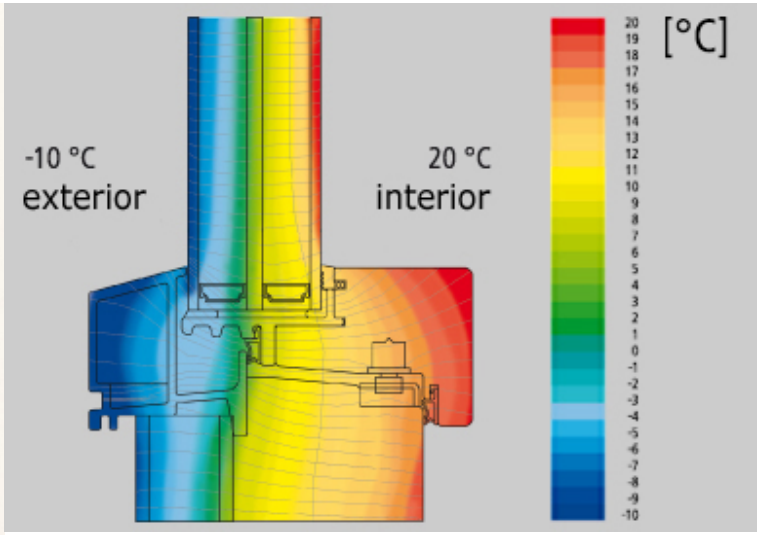
Select good spacers

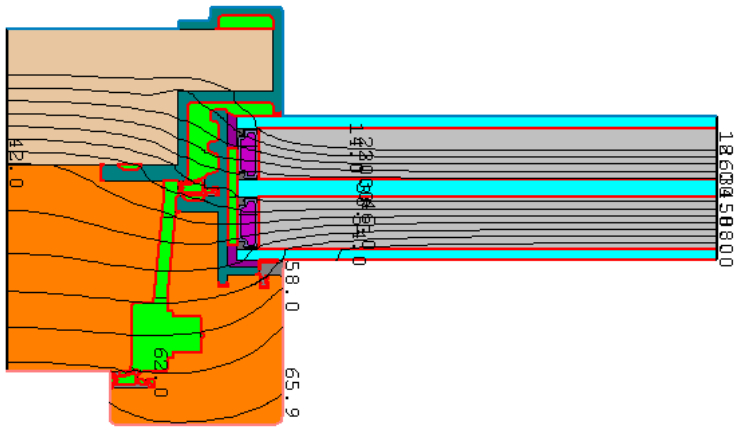




Specify good frames

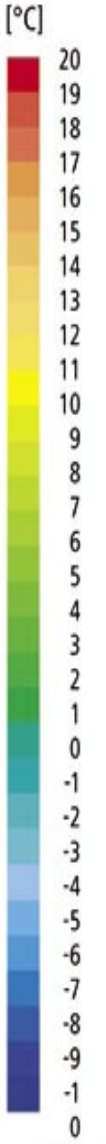






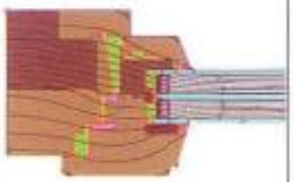
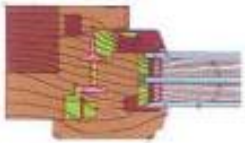
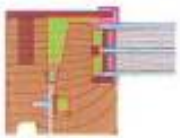
With different Jamb and Sill profiles!

Left: Scanned from: Residential Windows by John Carmody et al, Right: Graphic from EnerSIGN brochure, Pazen Fensterteknik

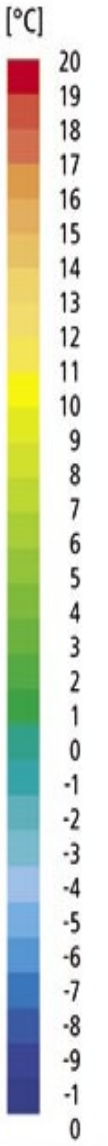


But not too much frame

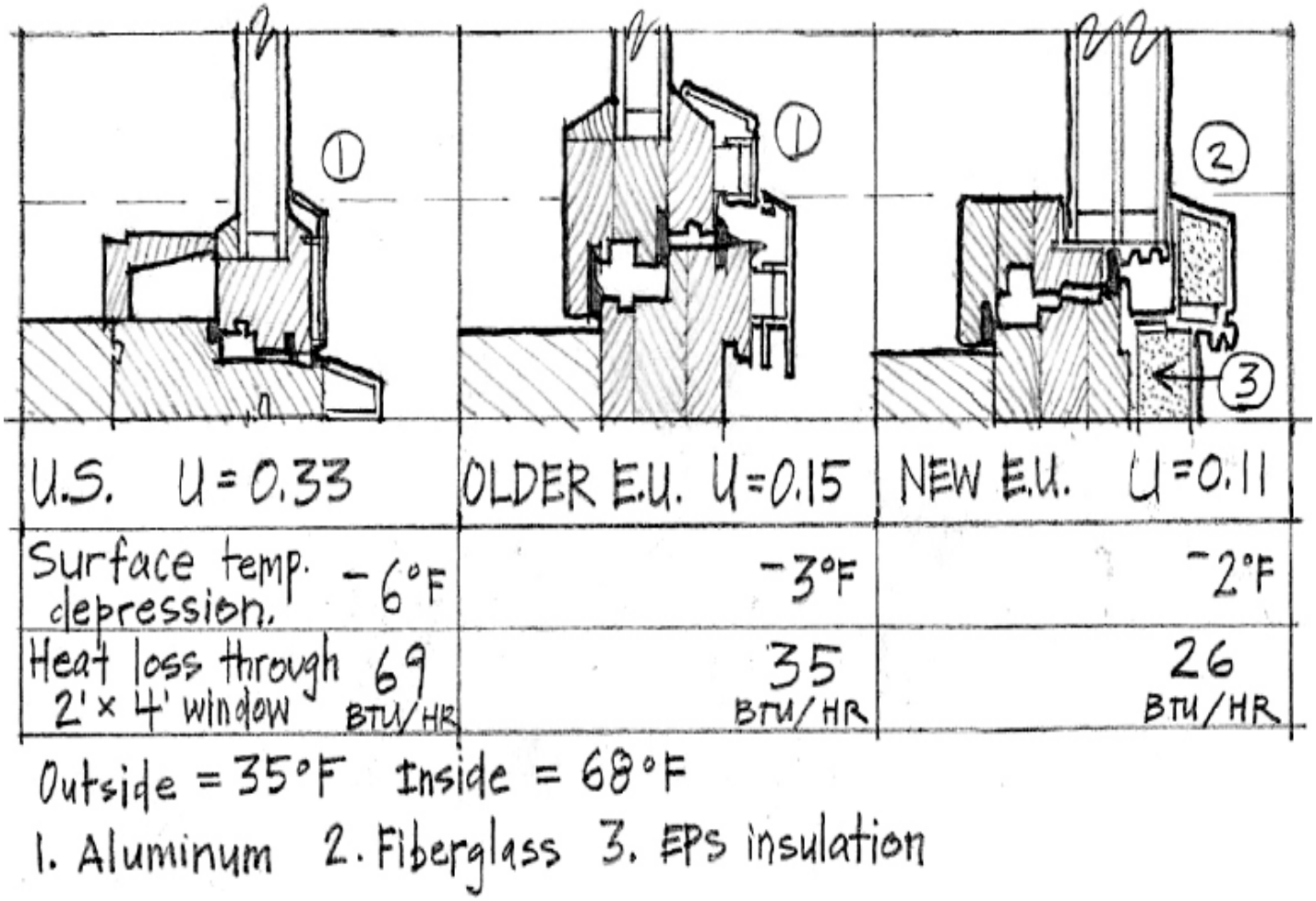
(Less frame, more glazing can lower your Heating Demand)

		HWB	Q_{solar}	$Q_{T\ Fenster}$	HWB	Q_{solar}	$Q_{T\ Fenster}$
	U_f=0,72	15,2	3750	3170	14,6	3692	3289
	U_f=0,97	15	4034	3452	14,8	3885	3547
	U_f=1,05	13,5	4171	3489	14,2	4084	3582

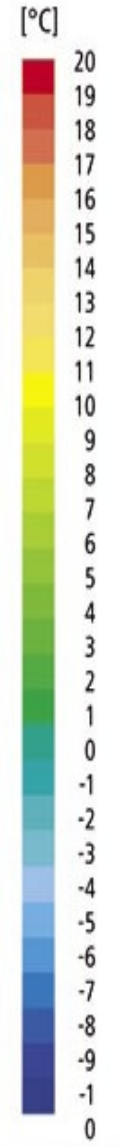
Source: Protokollbund Nr. 37, Passive House Institute, Darmstadt, Nov. 2008



Darwinian window evolution: what has improved?



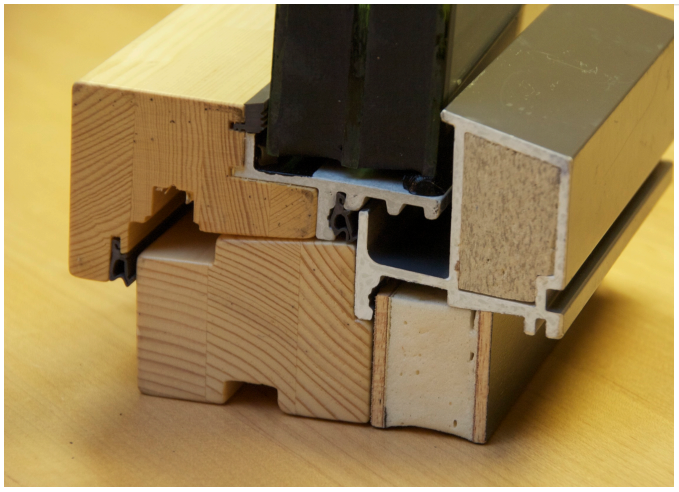
Source: ARCHnews Green Column, June 2009. Dan Johnson, danjoh99@gmail.com



Rratings

The Goldilocks approach:

- Frame: wood, PVC or Fiberglass
- Glass: 3-pane, various SHGC
- Spacers: warm edge only



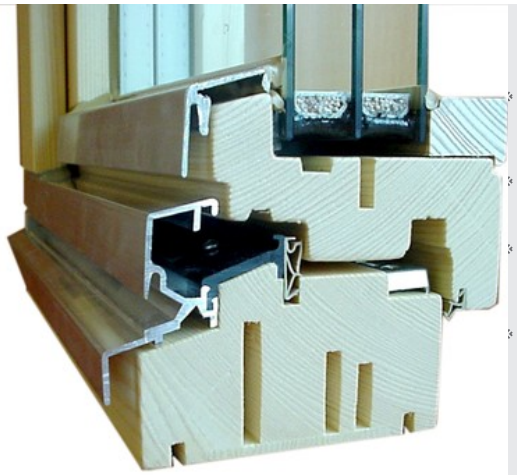
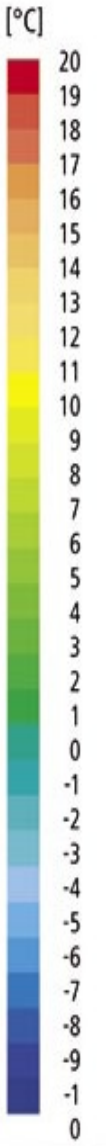


Image 1: Enersign.de, Image 2: passivehausfenster.at , Image 3: walchfenster.at



The Rating Systems

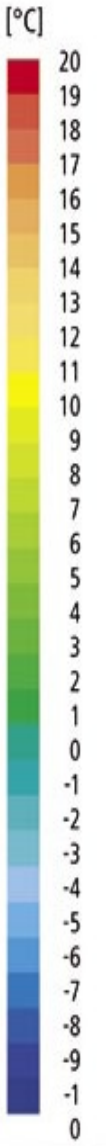
National Fenestration Rating Council (NFRC)

- U.S. based
- No minimum standards
- Simulation and product test

Passive House Institute:

- German based
- Set performance standards
- Simulation only

From presentation: 'A Tale of Two Rating Systems' by B. Barry, October 2011



PHI's Certification Criteria

Passivhaus Institut
Dr. Wolfgang Feist
Rheinstraße 44/46
D-64283 Darmstadt

Zertifikat

gültig bis 31.12.2007

Passivhaus geeignete Komponente: **Fensterrahmen**
Hersteller: **PAZEN Fenster + Technik, D-54492 Zeltingen-Rachtig**
Produktname: **ENERsign**

Folgende Kriterien wurden für die Zuerkennung des Zertifikates geprüft:

Passivhaus-Behaglichkeitskriterium:
Unter Standardbedingungen (Verglasung mit U_g = 0,7 W/(m²K), Fensterbreite 1,23 m, Fensterhöhe 1,48 m) erfüllt der Fenster-U-Wert die Bedingung:

$U_w = 0,77 \leq 0,80$ W/(m²K)

Rahmenkennwerte:

Rahmen	unten	seitl./oben
U_f [W/(m²K)]	0,78	0,64
Breite [mm]	100	

Abstandhalter Thermix	unten	seitl. / oben
Ψ_g [W/(mK)]	0,031	0,033

Passivhaus spezifische Auflagen:
Die Passivhauseignung wurde nur mit dem o.g. Abstandhalter geprüft; andere Abstandhalter, vor allem solche aus Aluminium, führen zu wesentlich höheren Wärmeverlusten.

Passivhaus-Einbausituationen:
Einschließlich Einbauwärmebrücken erfüllt das Fenster

$U_{w,eingebaut} \leq 0,85$ W/(m²K),

wenn die in der Anlage dokumentierten Einbaudetails des Fensters in Passivhaus geeignete Wandaufbauten (Wärmedämmverbundsystem, Holzbaufassade und Betonschalungsstein) eingehalten werden.

Das Zertifikat ist wie folgt zu verwenden:

Fensterrahmen:
$U_f = 0,78 / 0,64$ W/(m²K)
$= 0,031 / 0,033$ W/(mK)

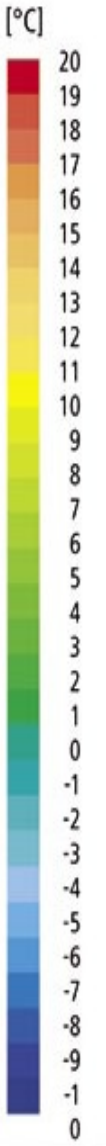
1. U_w </= 0.8 W/m²K
(0.14 BTU/hrft²F or 6.7 hrft²F/BTU)

2. $U_{w\ installed}$ </= 0.85 W/m²K

3. f_{Rsi} (temperature factor at edge of glass)

(Varies for other transparent components, including curtain walls roof domes and skylights. See document: Certification criteria and calculation regulations Passive House Suitable Transparent Components Version 1.0 E, 16. May 2011)

Image from ENERsign brochure: http://www.qplus-llc.com/index.php?id=1191&L=



NFRC's Certification Criteria

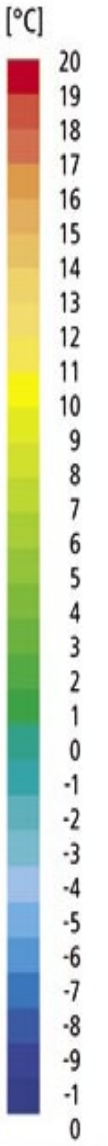
Simulation:

1. U_{window} (required)
2. SHGC (required)
3. Air Leakage (optional)
4. Visible Light Transmittance (optional)

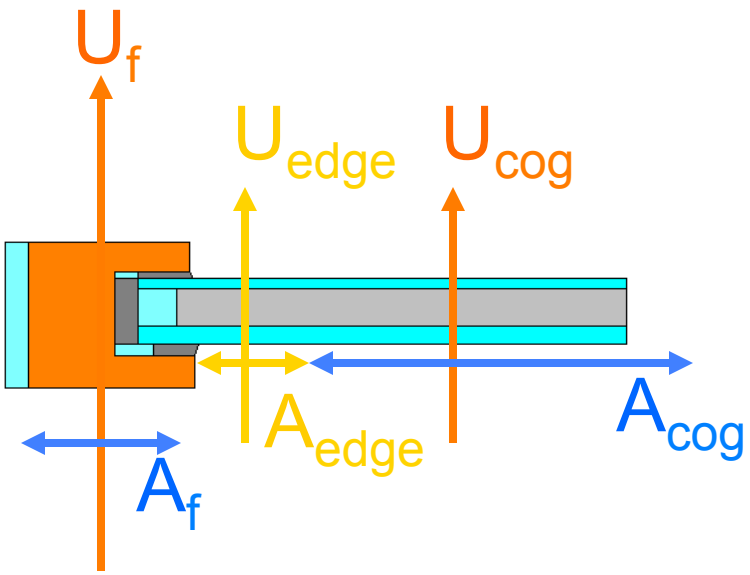
Verification:

1. Destructive test of window sample
2. Factory inspection

Image from NFRC website: http://nfrc.org/fenestrationfacts.aspx



How the NFRC rates windows



U_{cog} = U-value glass

A_{cog} = Area glass

U_f = U-value frame

A_f = Area frame

U_{edge} = U-value edge of glass

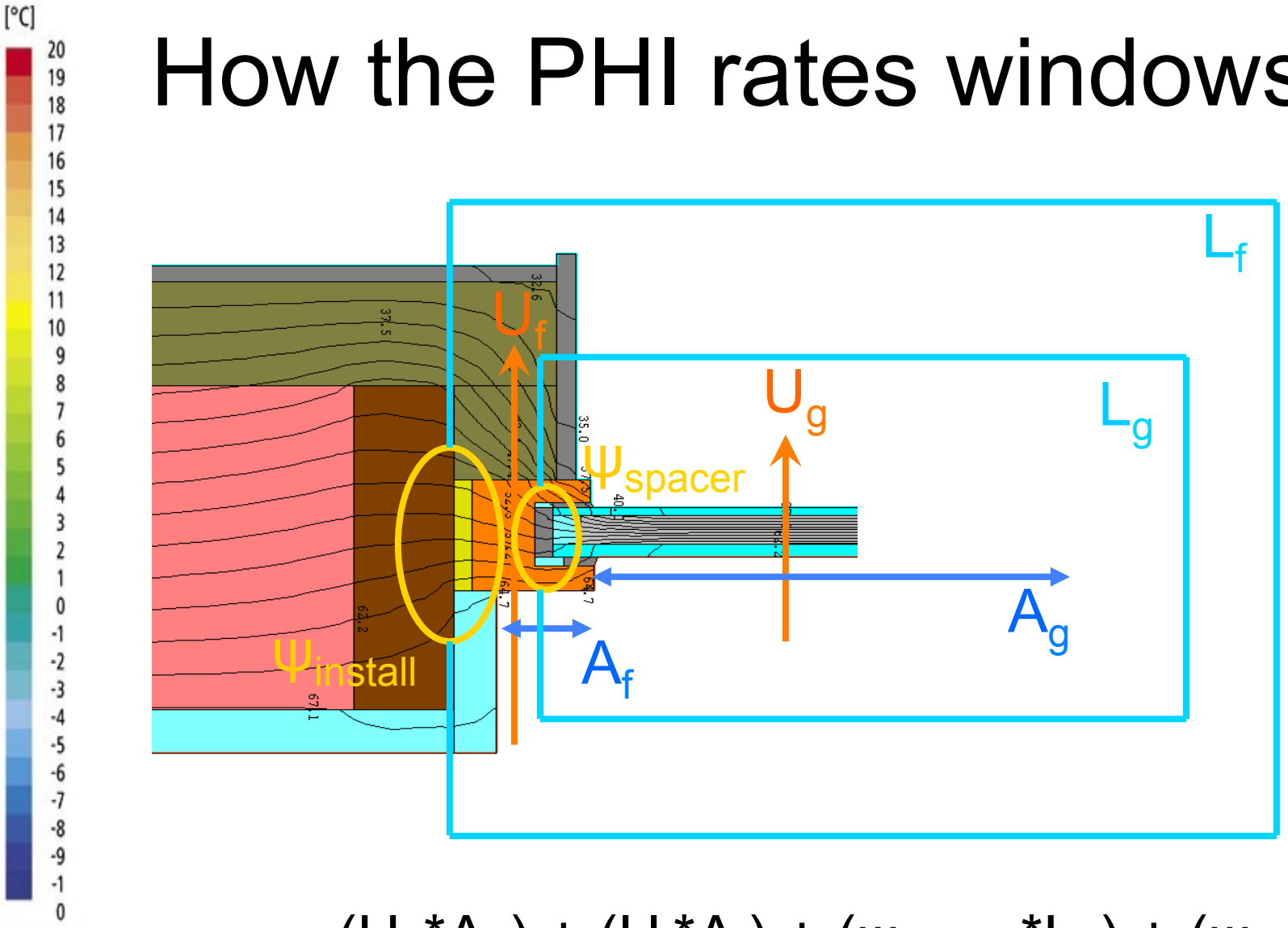
A_{edge} = Area edge of glass

A_w = Area Window

$$U_w = \frac{(U_{cog}*A_{cog}) + (U_f*A_f) + (U_{edge}*A_{edge})}{A_w}$$

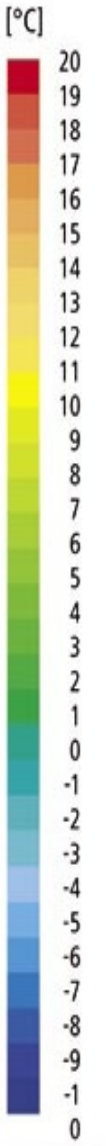
From presentation: 'A Tale of Two Rating Systems' by B. Barry, October 2011

How the PHI rates windows



$$U_{w\text{-installed}} = \frac{(U_g * A_g) + (U_f * A_f) + (\Psi_{spacer} * L_g) + (\Psi_{install} * L_f)}{A_w}$$

From presentation: 'A Tale of Two Rating Systems' by B. Barry, October 2011



The same window

Pazen ENERsign Tilt and Turn Jamb profile

ETC Laboratories

Corporate Offices / Laboratories
460 Buffalo Rd
Buffalo Rd Business Center - Westside
Rochester, NY 14611
(585) 328-7668
Fax: (585) 328-7777

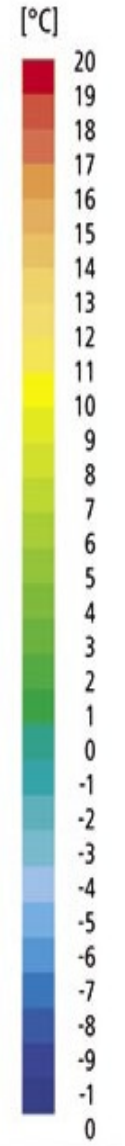
Simulation Report
Rendered To:

Quantum Builders, Inc.
1454 B 4th Street.
Berkeley, CA 94710

Productline Series/Model
Enersign Tilt & Turn Window

Report Number
ETC-09-1166-22817.0

Images from ENERsign brochure: http://www.qplus-llc.com/index.php?id=1191&L=



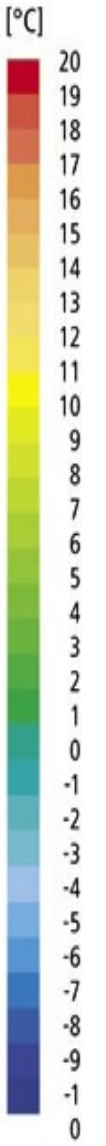
EyeCandy

Generates different results

Component	NFRC	PHI
Window size	1.8 m2	1.82 m2
Width of frame *	0.15 m	0.1 m
Delta T in Therm Boundary condition	39 deg C	30 deg C
U-glass	0.73 W/m2K	0.7 W/m2K
Spacer vs edge of glass	0.22 W/K	0.15 W/K
Final U-window value (metric)	0.79 W/m2K	0.77 W/m2K
Final U-window value (IP)	0.139 BTU/hr.ft2.°F	0.135 BTU/hr.ft2.°F
Final R-value	7.18 hr.ft2.°F/BTU	7.37 hr.ft2.°F/BTU

* Frame size variation is due to different profile options submitted by manufacturer's representative to the two testing agencies and is not a protocol difference.

From Oct. 2011 study by B.Barry: 'A Tale of Two Rating Systems' based on the simulation results for the ENERsign profile, calculated by others, using the two testing protocols being compared here.

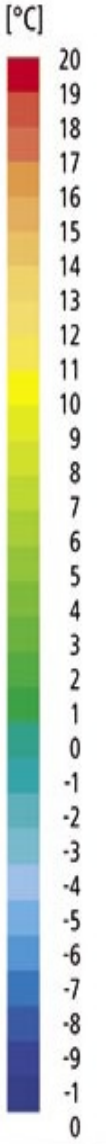


Some Cold Climate eye candy

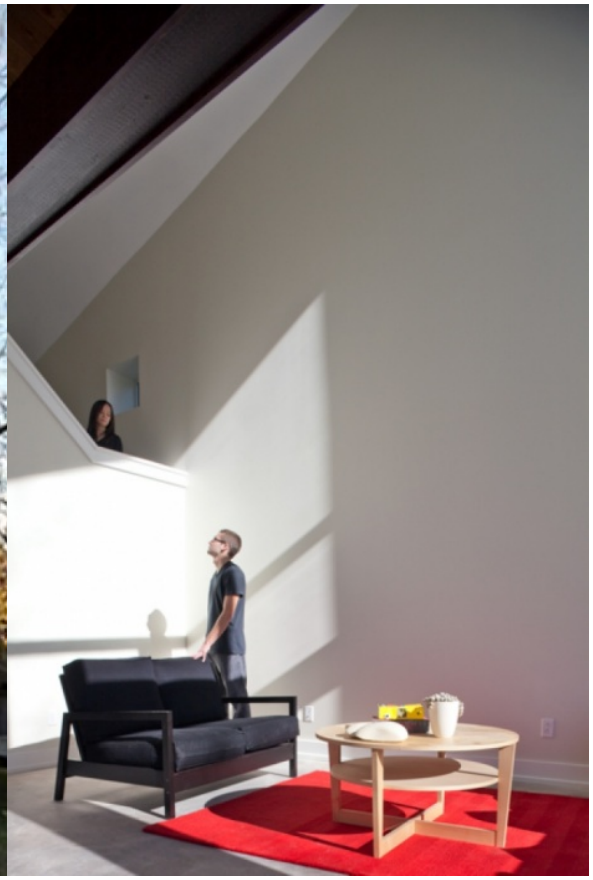
The ‘Go Home’ receives USGBC 2011 Project of the Year Award

G.O Logic Homes, Belfast, Maine

www.gologichomes.com



Some Cold Climate eye candy

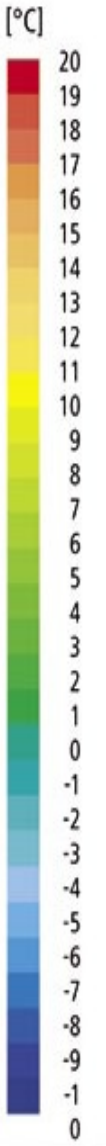


R-House, Syracuse, NY wins AIA Housing Award 2011

Della Valle Bernheimer and Architecture Research Office

www.d-bd.com and www.aro.net

Image credits: della valle bernheimer



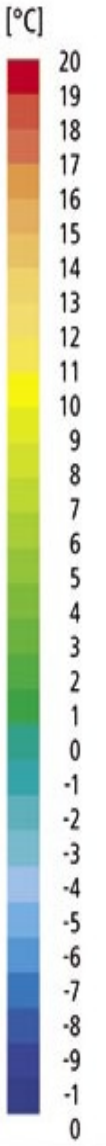
Some Cold Climate eye candy

Carbon Neutral & Net Energy +
Passive House
in…. WISCONSIN!

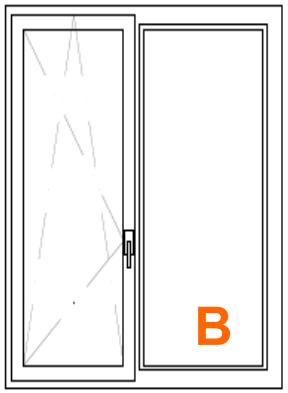
TE Studio
www.testudio.com
Image credits: tim eian

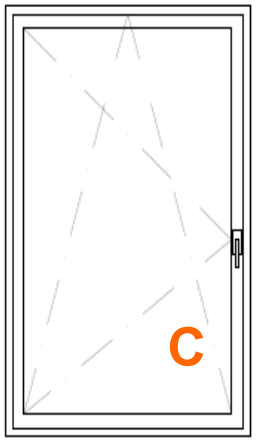
Fossil-fuel free home +
Passive House
in…. ALASKA!

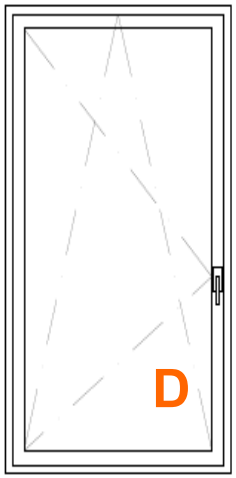
Thorsten Chlupp
www.cchrc.org
Image credits: sam harel/newsminer



So what can I do?



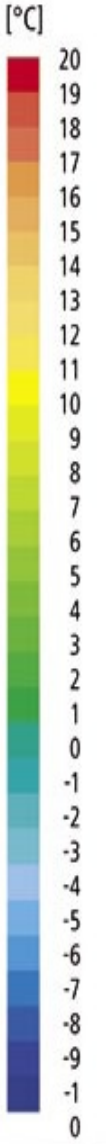




Window	Width	Ht	Total	U-installed	Cost/sf
	(")	(")	SF	BTU/hr.ft^2.F	$
A-1	26 3/8	46 5/8	24.1	0.14	$143.12
A-2	29 5/8	46 5/8		0.14	
A-3	56	15 3/8		0.15	
B-1	26 3/8	62	24.1	0.14	$121.23
B-2	29 5/8	62		0.14	
C	49 3/5	70	24.1	0.13	$83.56
D	45 5/7	76	24.1	0.13	$83.31

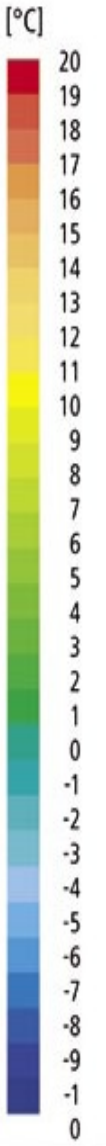
Better Design Choices:

- Large openings
- Taller or vertical
- Fixed preferable
- Casement only for operable
- No muntins and minimal mulls



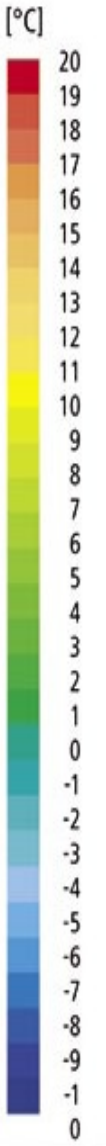
Why put glass in it?

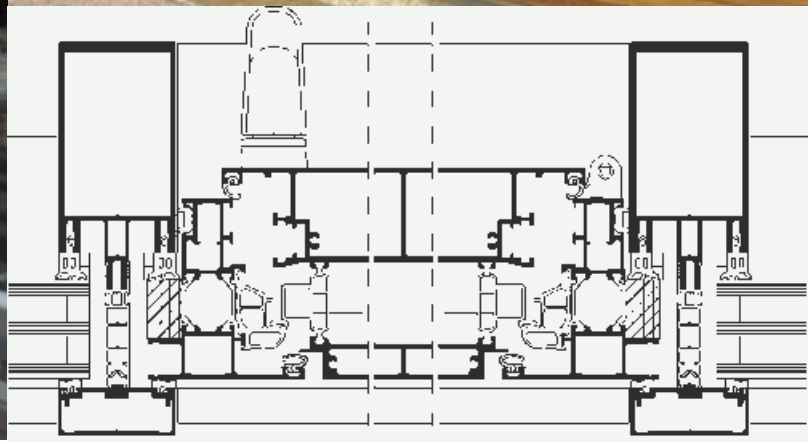
Design and Image Source: zanderroth architekten, with thanks to bruteforcecollaborative.com for all vent panel image sourcing



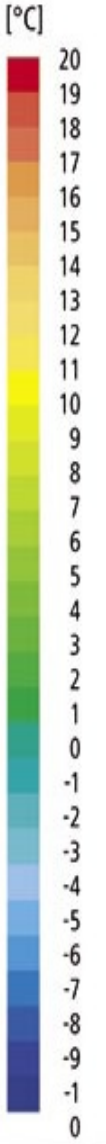
Vent panels are an option

Design: Sauerbruch & Hutton's UBA-Dessau, Project: Passivhaus school in Riedberg





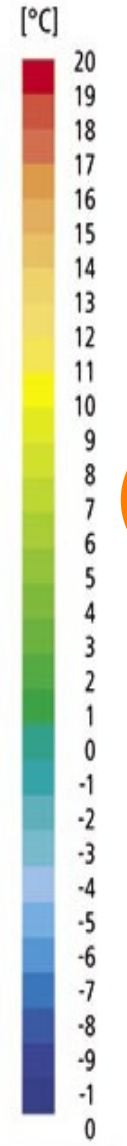
Images: Left and bottom right: Wicona thermally broken ventilation flap for Wicline, Top right unknown. Source BFC

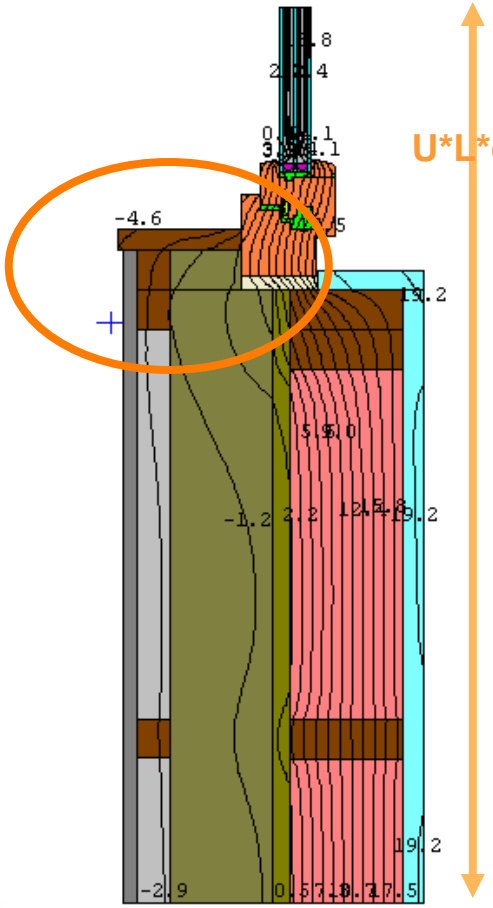


Why make them straight?

Design by: localarchitecture, Luasanne, Switzerland. Foto: Milo Keller

Consider your installation





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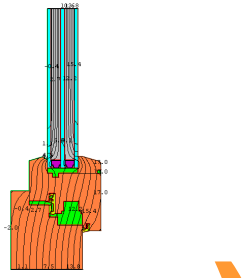
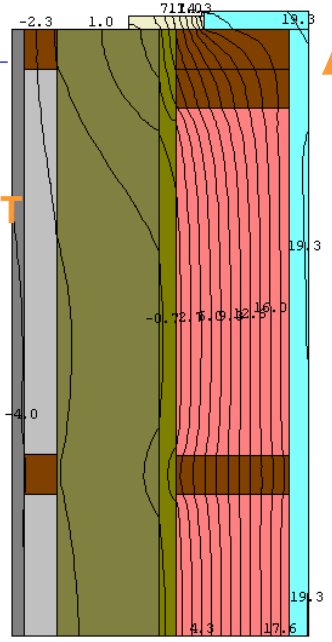




=

U*L*dT / dT

= Psi

The Psi of install:

EXTERIOR

POOR: U_w(installed) = 0.85 W/m²K
Psi-install = 0.033 W/m²K

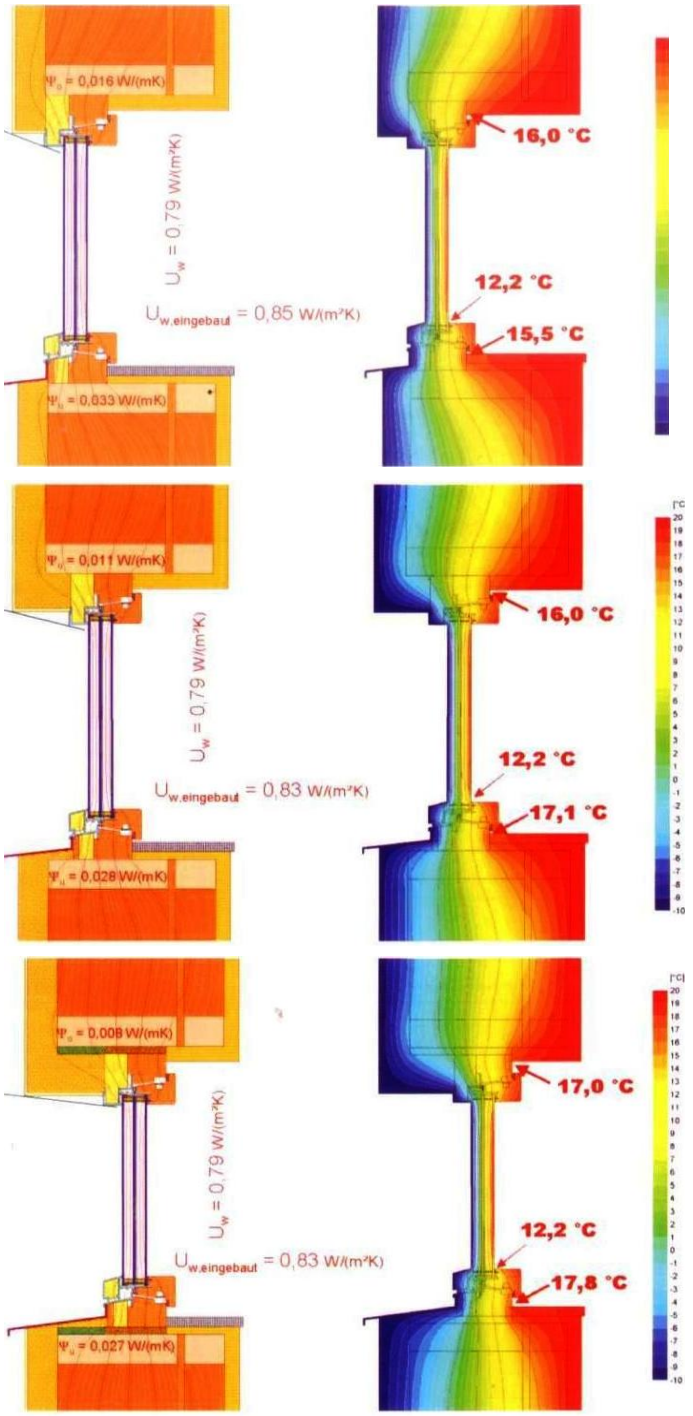
INSET

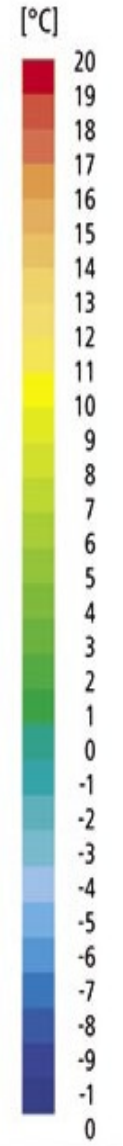
BETTER: U_w(installed) = 0.83 W/m²K
Psi-install = 0.028 W/m²K

CENTERED

BEST: U_w(installed) = 0.83 W/m²K
Psi-install = 0.027 W/m²K

Source: Protokollbund Nr. 37, Passive House Institute, Darmstadt, Nov. 2008

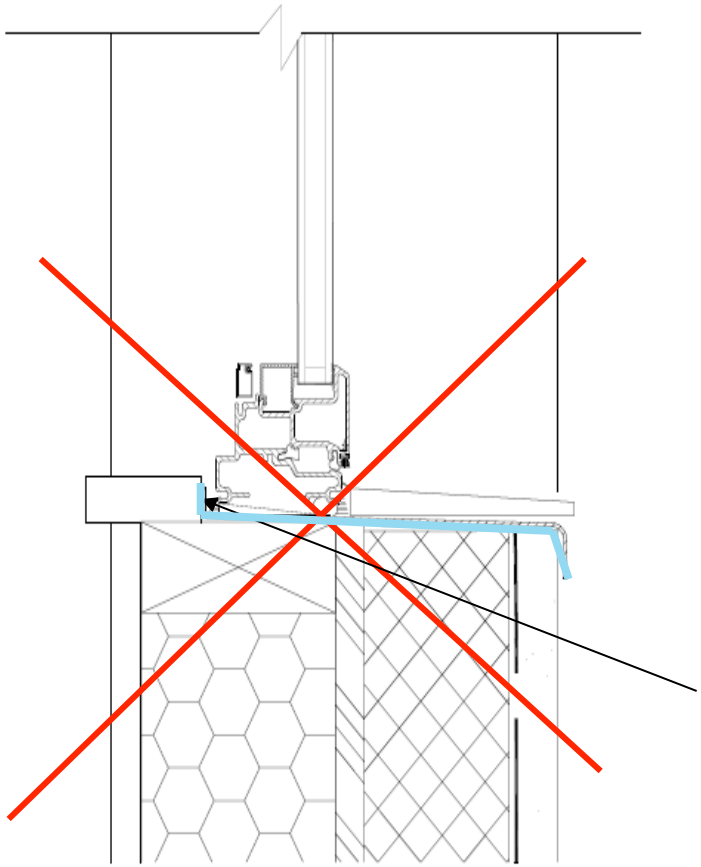




Fluff

But don’t forget the other install…

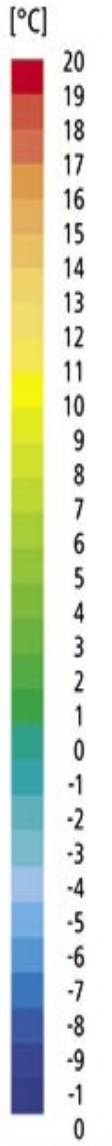
Please - NO thermal bridge pan flashing!



Sill pan under window to interior

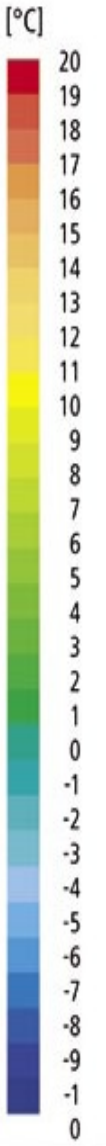
Flash often, but flash carefully!

Good solar orientation basics



- Large south-facing windows
- Fewer operable units with less mullions

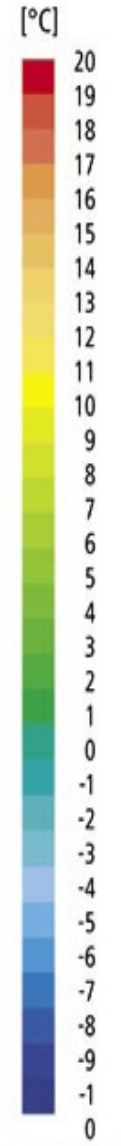
Image source: Left: author's own photo of project in Germany using EnerSIGN by Pazen Fenster + Technick. Right: Enersign brochure



Don’t mind the threshold

- Learn to LOVE the step-over threshold!

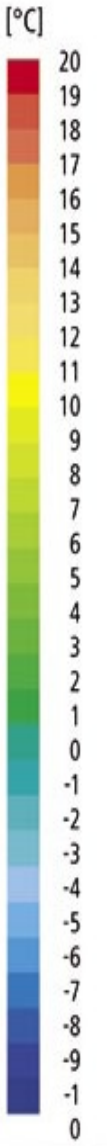
Image source: author’s own photos of projects in Germany using EnerSIGN by Pazen Fenster + Technic



Don’t forget to SHADES

Image source: author’s own photos of projects in Germany (left) and Berkeley, CA (right)

BS



Some of that BS!

Larkspur Remodel Window Cost Benefit Analysis

Brand	Existing	US- Av.	Euro Av.	PH Certified	US -good	US-best	Canadian
R-value W#5	0.99	2.69	5.73	8.68	6.09	8.64	5.9
Heat Dem # (kBTU/ft2yr)	13.7	7.63	6.97	5.71	6.05	8.01	6.75
Price	/	$29,400.00	$45,344.50	$50,830.00	$35,507.42	$92,297.79	$39,852.10
Heat Dem delta	0	6.07	6.73	7.99	7.65	5.69	6.95
$ Saving/a**	0	1,736.02	1,924.78	2,285.14	2,187.90	1,627.34	1,987.70
30yr $saving	0	182.10	57,743.40	68,554.20	65,637.00	48,820.20	59,631.00
40yr $saving	0	69,440.80	76,991.20	91,405.60	87,516.00	65,093.60	79,508.00
yrs to paybk	0	16.94	23.56	22.24	16.23	56.72	20.05
30 yr CO^2 savings (lbs) ***	0	20.03	22.21	26.37	25.25	18.78	22.94

(Highest/Best rating shown in orange field.)

* The above revised 'Euro Average' cost & rating # reflects the following changes:

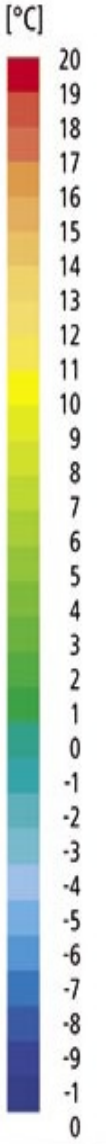
New TF Design window profile (rated at R8 value.) with triple glazing

Double glazed wood Accordian-Sliding door at Dining Room

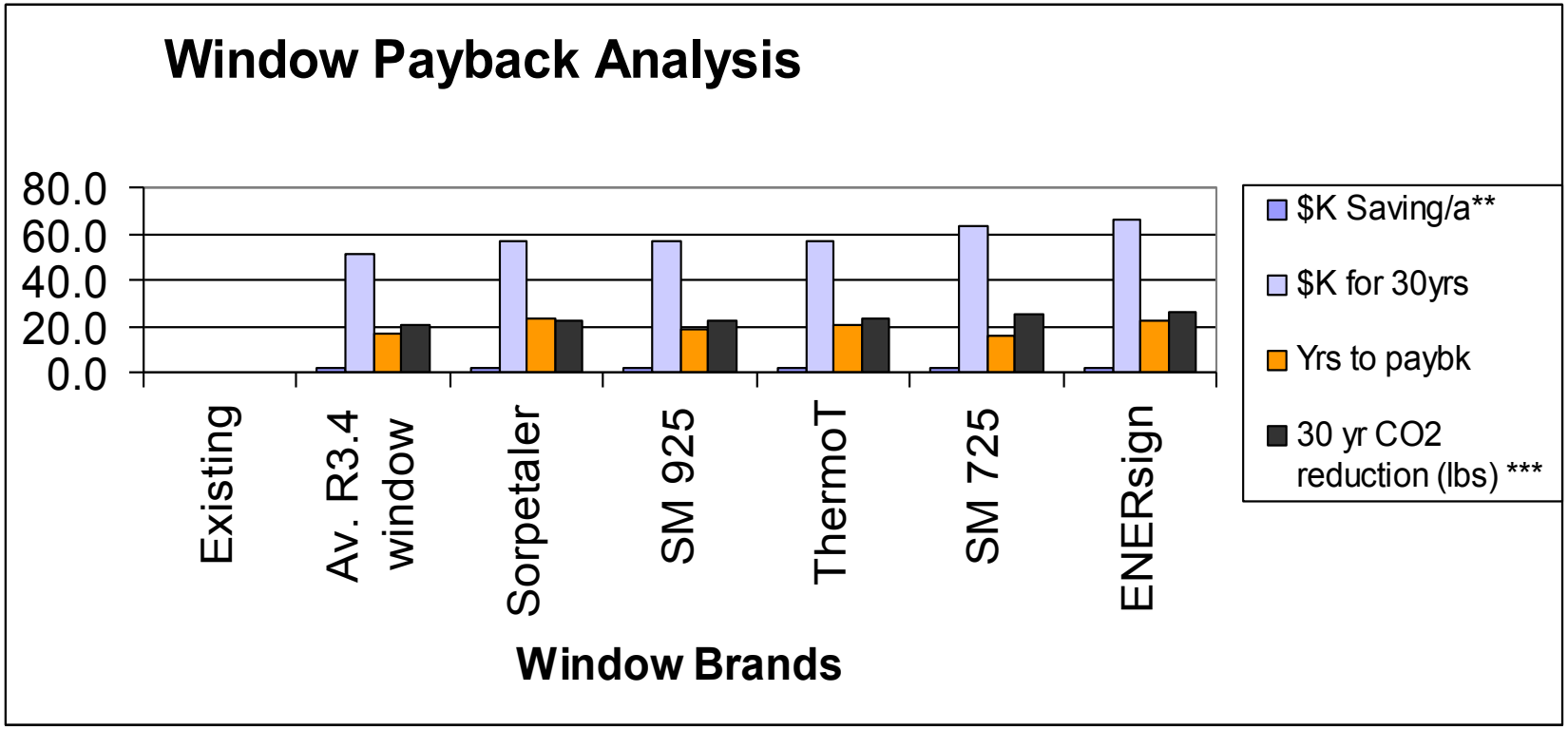
** Assuming $0.13 per kBTU/ft2yr (1 Therm = 100,000 BTUs = $1.30 @ 2,200sf =$286.00)

*** 11 lbs of CO2 saved for each Therm saved

Source: Cost Benefit Analysis by Bronwyn Barry, CPHC, for Quantum Builders, 2009



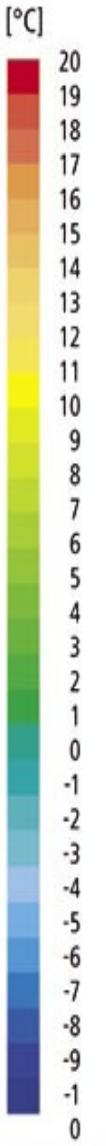
Weak economic arguments



** Assuming $0.13 per kBTU/ft2yr (1 Therm = 100,000 BTUs = $1.30 @ 2,200sf =$286.00)

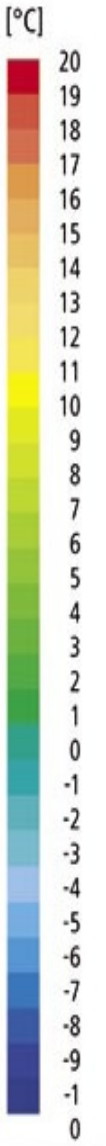
*** 11 lbs of CO2 saved for each Therm saved

Source: Compiled by author from data input into the PHPP for a project in Larkspur, Marin.



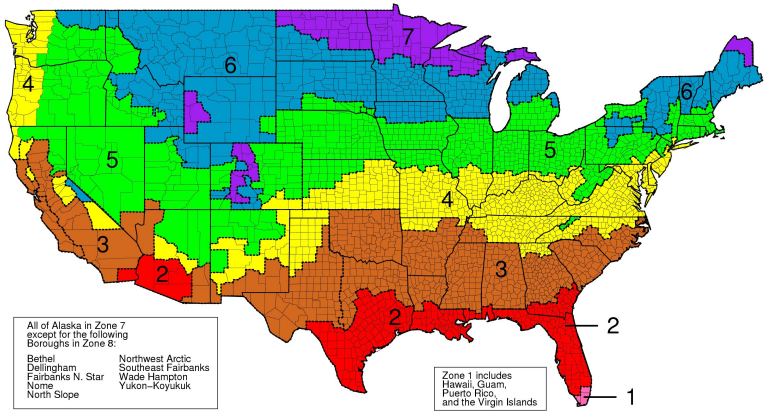
But HUGE comfort benefits

Image source: Stefan Carpentier, Berkeley, CA 2009, Project located in Berkeley, CA



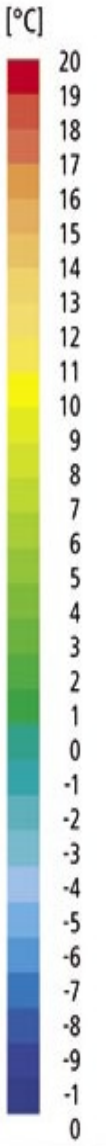
The case for triple pane

Approx. US Climate Zone	Min. Outdoor Temp (C)	Min. Outdoor Temp (F)	max. UW (W/m2-C)	max. U_w (BTU/ hr.ft2.°F)	max. R_w (hr.ft2.°F/ BTU)
Zone 2	10	50	2.1	0.37	2.70
Zone 3	0	32	1.05	0.18	5.56
Zone 4	-5	23	0.84	0.14	7.14
Zone 5	-10	14	0.7	0.12	8.33
Zone 6	-15	5	0.6	0.1	10.00
Zone 7	-20	-4	0.53	0.09	11.11



Data Source: Dariush Arasteh– LBNL, private email, 2009.

Map Source: http://resourcecenter.pnl.gov/cocoon/morf/ResourceCenter/dbimages/full/973.jpg



Applicable everywhere

Good luck!

(And Thank You)

Bronwyn Barry, Assoc. AIA, CPHC
Director, One Sky Homes
PHCA Co-President
2012

1:DI Wilhelm Hofbauer via Austria Passive House Whistler, 2: Maschin Architektur, Photo: Peter Jacadofsky, 3: Corey Saft