Photometric and Thermal Insulation

AG-0002

AGNORA

WHO WE ARE:

AGNORA is an award-winning glass fabricator providing the largest, high-quality architectural glass in North America.

Known as an industry leading, team-based customer service company, AGNORA employs innovative production processes and invests in leading-edge machinery to push the boundaries of what is possible in architectural glass fabrication and meet challenging design objectives brought by their customers.

Louis Moreau
Head of Technology and Innovation, AGNORA

Louis brings a unique mix of international experiences in float manufacturing, high-performance vacuum coatings, large building glazing, and high-end glass fabrication.

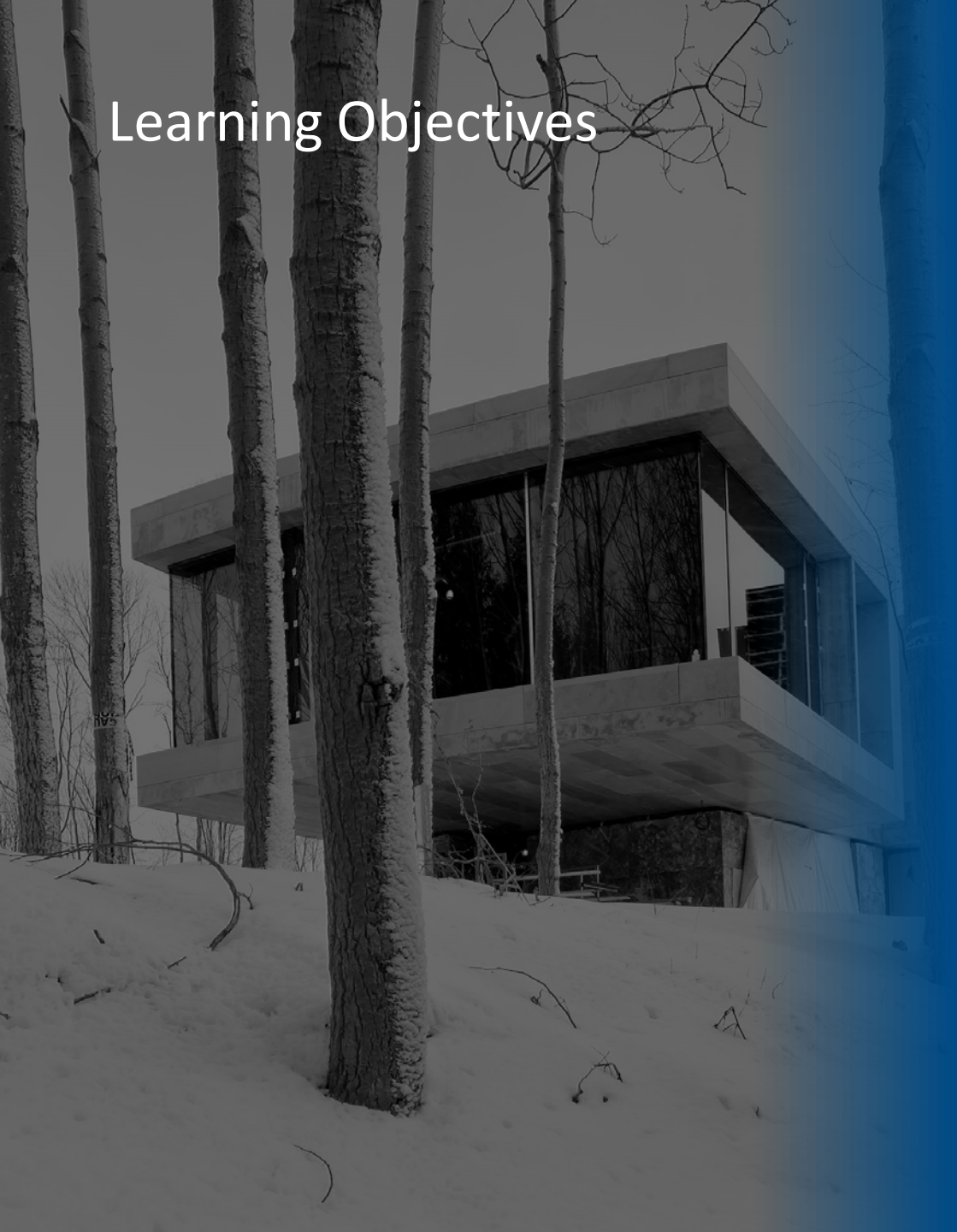
Louis considers architecture as the purest form of art and loves glass. He explores the limits of materials and processes to create innovative solutions that can be easily built.

Adam Mitchell
Marketing Manager, AGNORA

Adam is a marketing professional focused on the manufacturing sector for over 10 years. He has a strong focus on building relationships and delivering value added content that support evolving partnerships.

Today's Menu

- Introduction
- Fundamentals
  - Convection, Conduction and Radiation
  - Materials
  - Electromagnetic spectrum
- Glazing
  - Single
  - Double & triple
  - Low-e Double
- Surface Temperature and Comfort
- AGNORA Coated Product Range

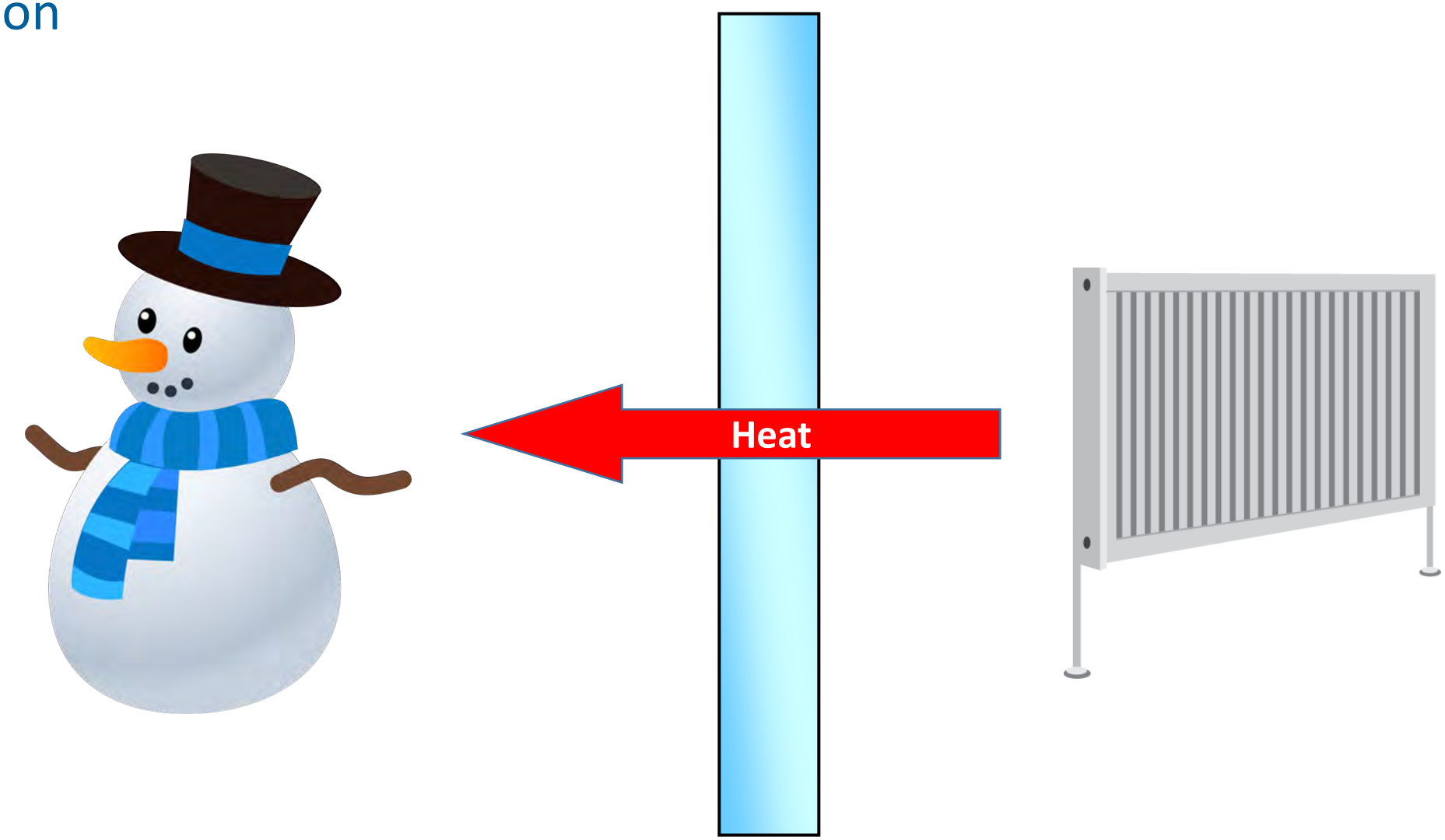


Learning Objectives

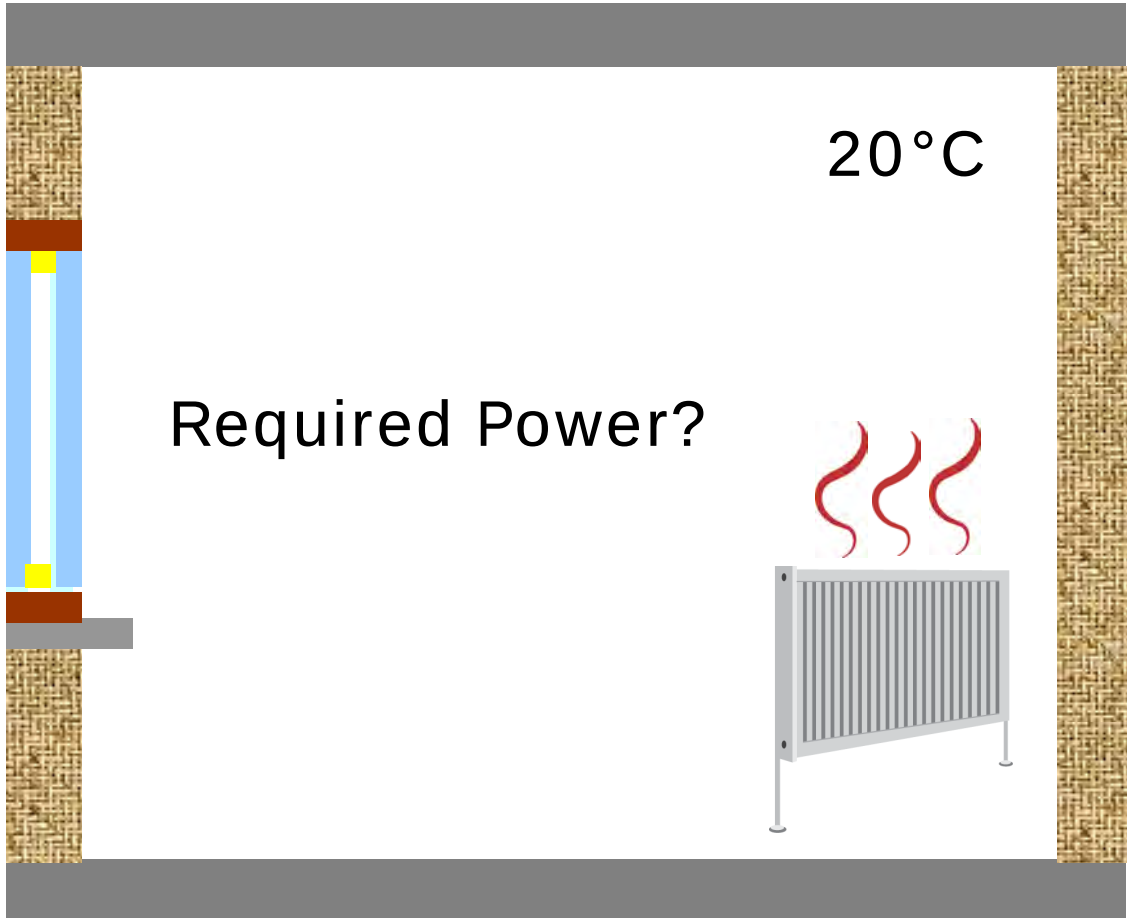
- Learning Objective 1: Fundamentals of thermal efficiency
    - a. Convection, conduction and radiation
    - b. Materials
    - c. Electromagnetic spectrum
- Learning Objective 2: Glazing and efficiency in thermal insulation
    - a. Single glazing
    - b. Double and triple glazing
    - c. Coatings and gases
- Learning Objective 3: Understanding surface temperature and its effect on comfort
- Learning Objective 4: Solar Factor
    - a. Light and energetic factors
    - b. How to decrease the solar factor
    - c. Coating types and effectiveness

Introduction

Introduction



Introduction



$$P = S\ (m^2) \times \Delta T\ (°C) \times Ug\ (W/m^2\ °C)$$

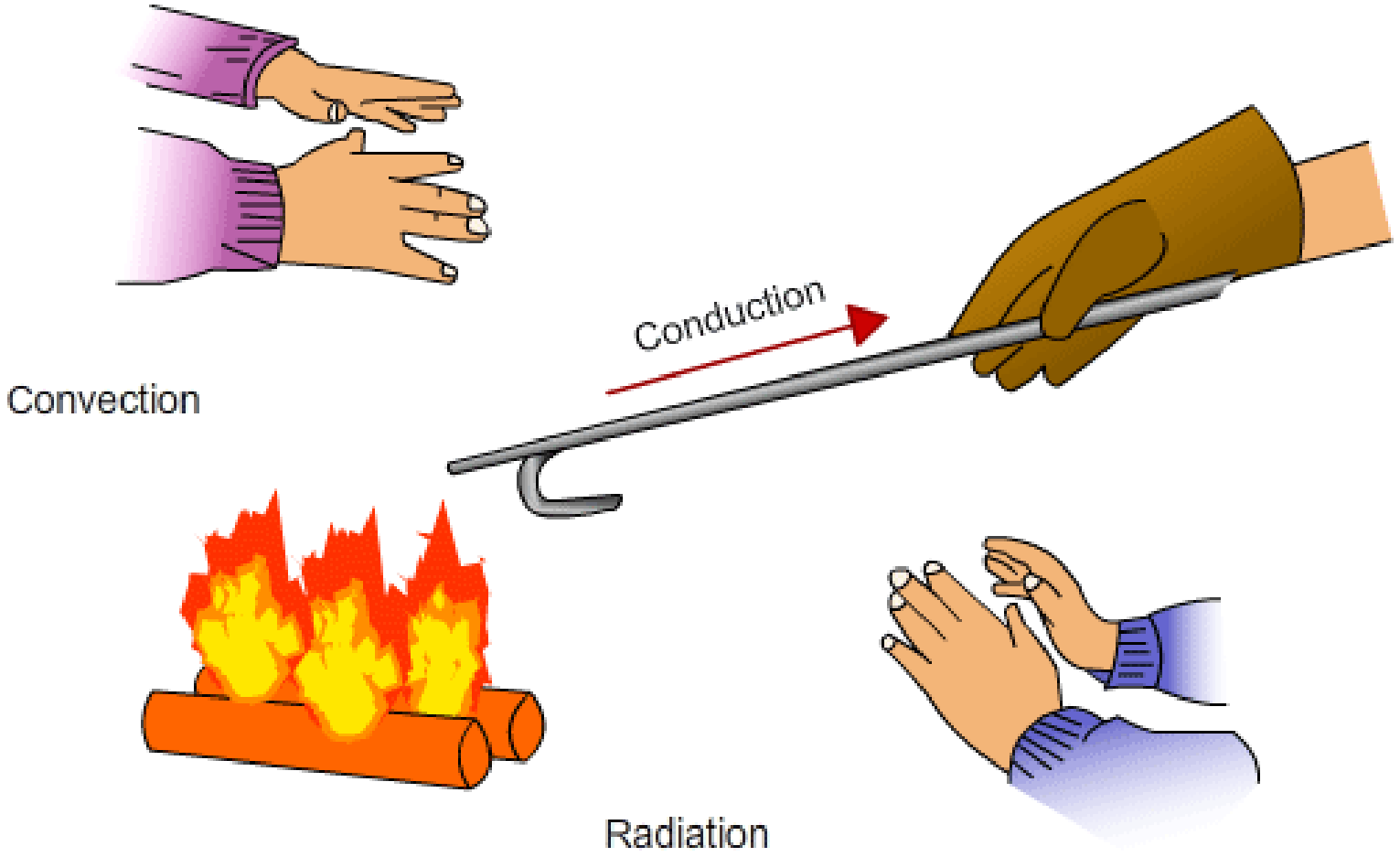
Introduction

The Thermal Loss of a Dwelling

Windows account for about 35% !

Convection, Conduction and Radiation

Convection, Conduction and Radiation



Convection, Conduction and Radiation

CONVECTION

Transfer of heat through a fluid (liquid or gas) caused by molecular motion

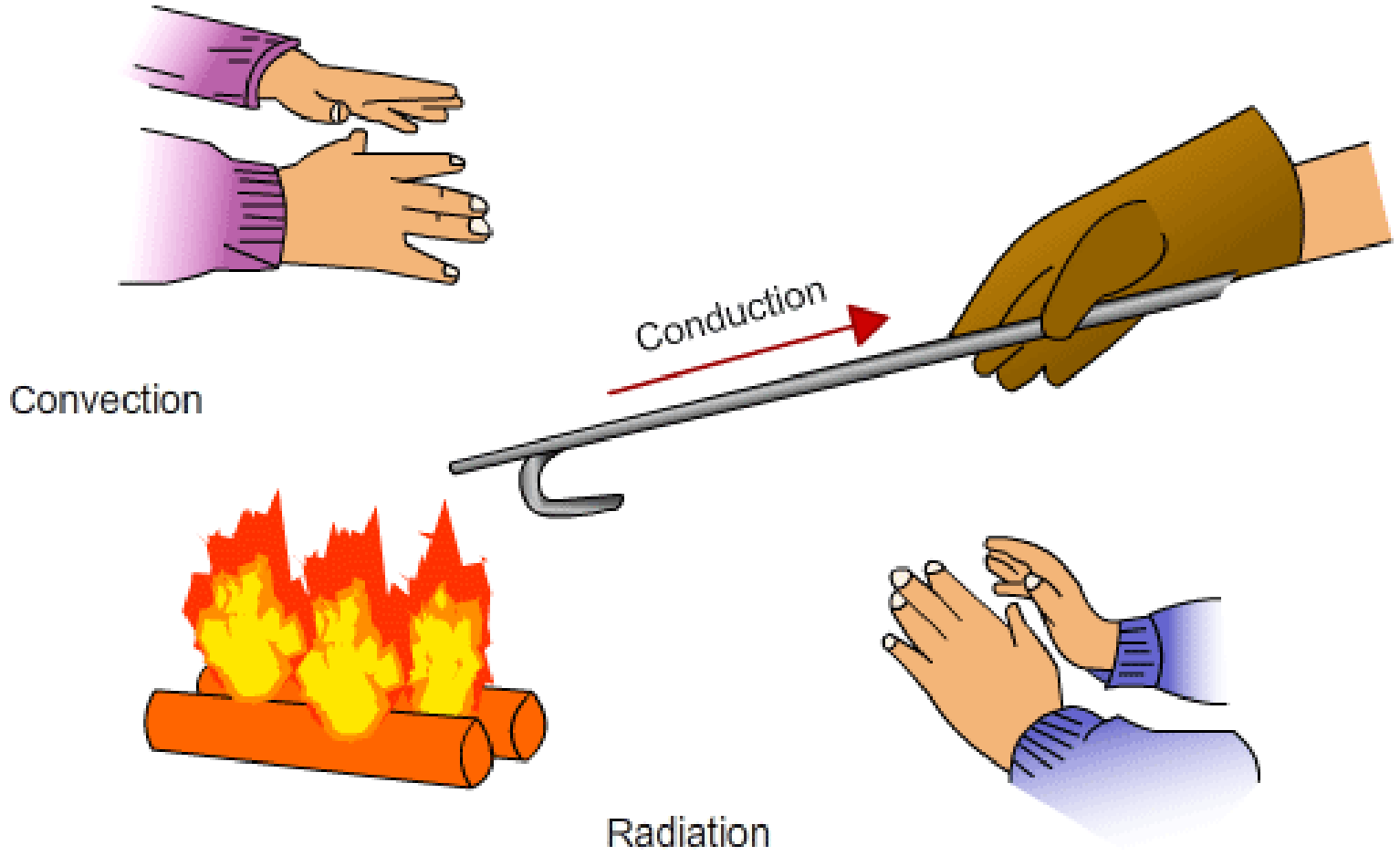
CONDUCTION

Transfer of heat or electric current from one substance to the other by direct contact

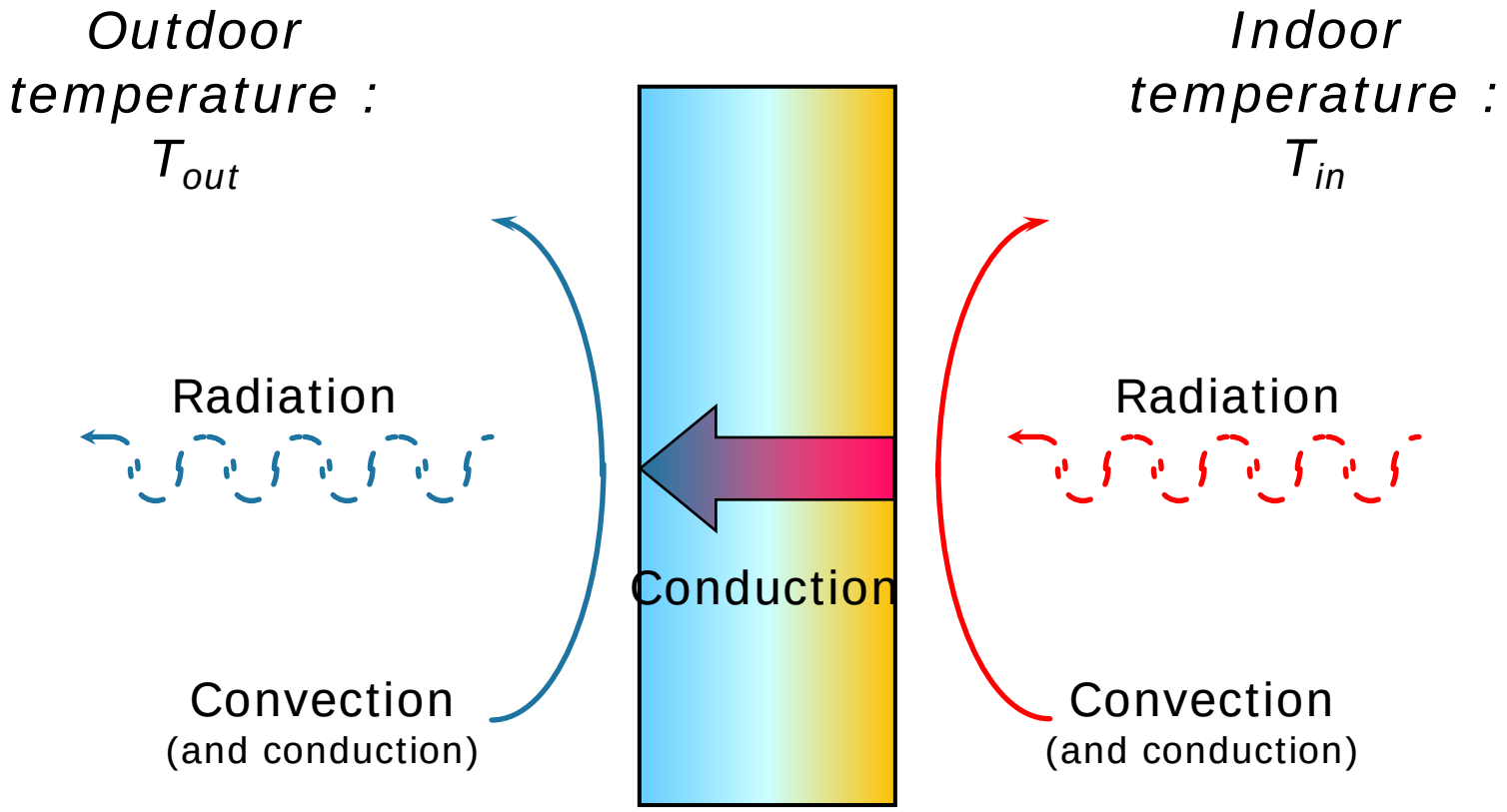
RADIATION

Energy that is radiated or transmitted in the form of rays or waves or particles

Convection, Conduction and Radiation



Convection, Conduction and Radiation



$$\text{Ug-value} = \frac{\text{Heat loss}}{\text{Temperature difference}} \quad (W/m^2.K)$$

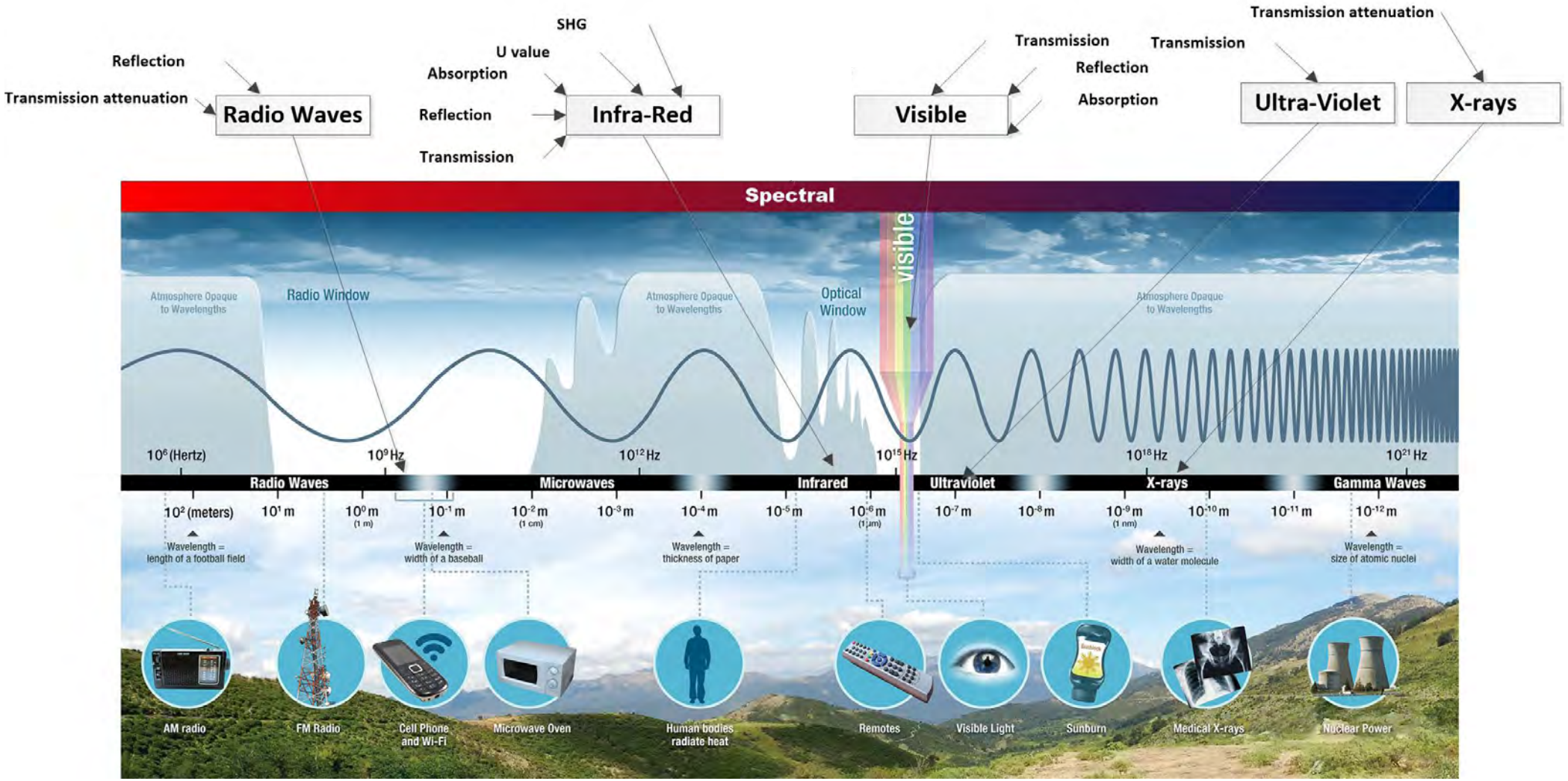
Materials

λ = Thermal conductivity of different materials

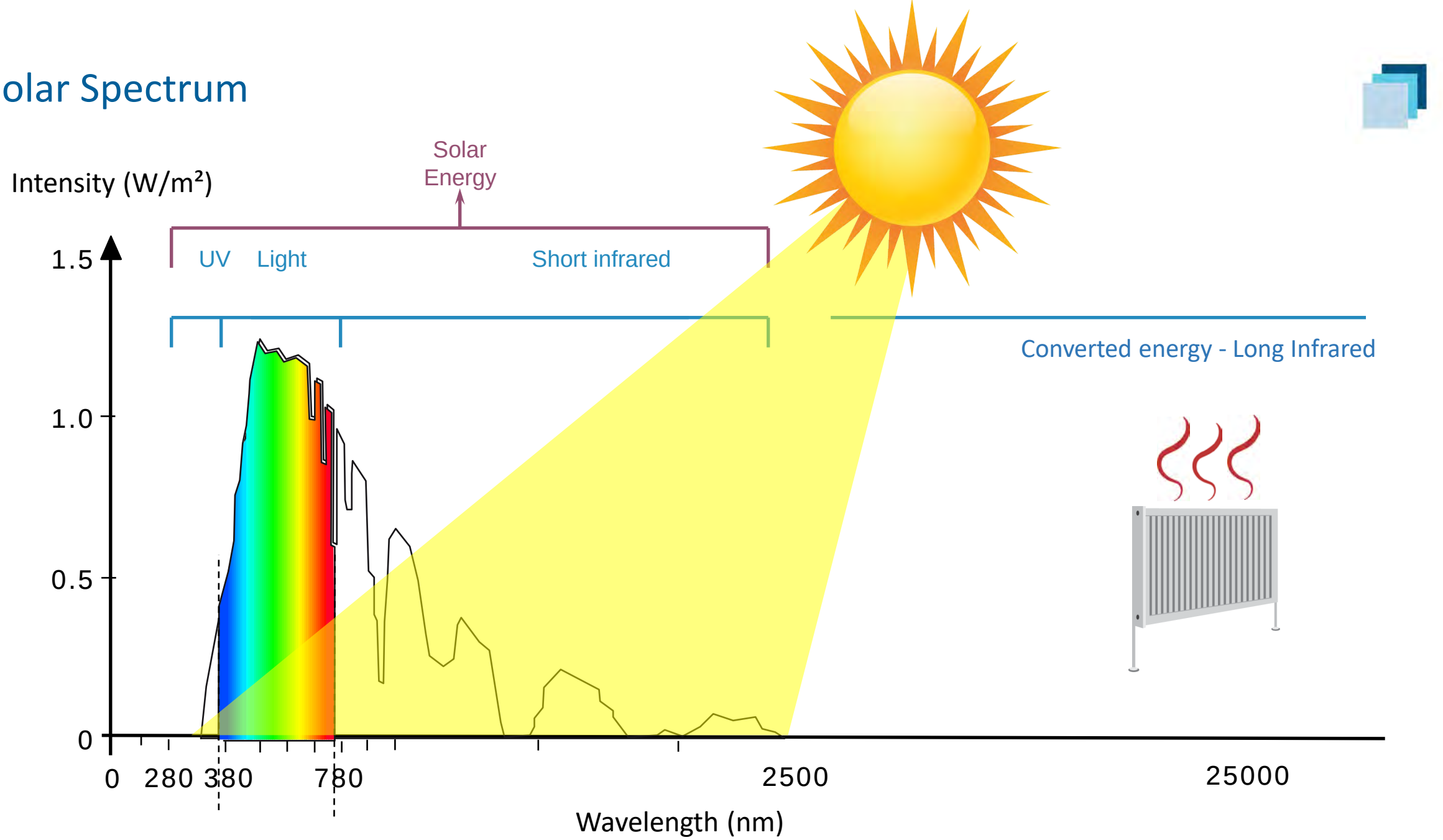
Material	W/ (m °C)	BTU/(ft h °F)
Argon	0.012	0.01
Air	0.018	0.01
Acetal (insulator)	0.2	0.1
Glass	1	0.5
Stainless Steel	15	9
Aluminum	205	118

Electromagnetic spectrum

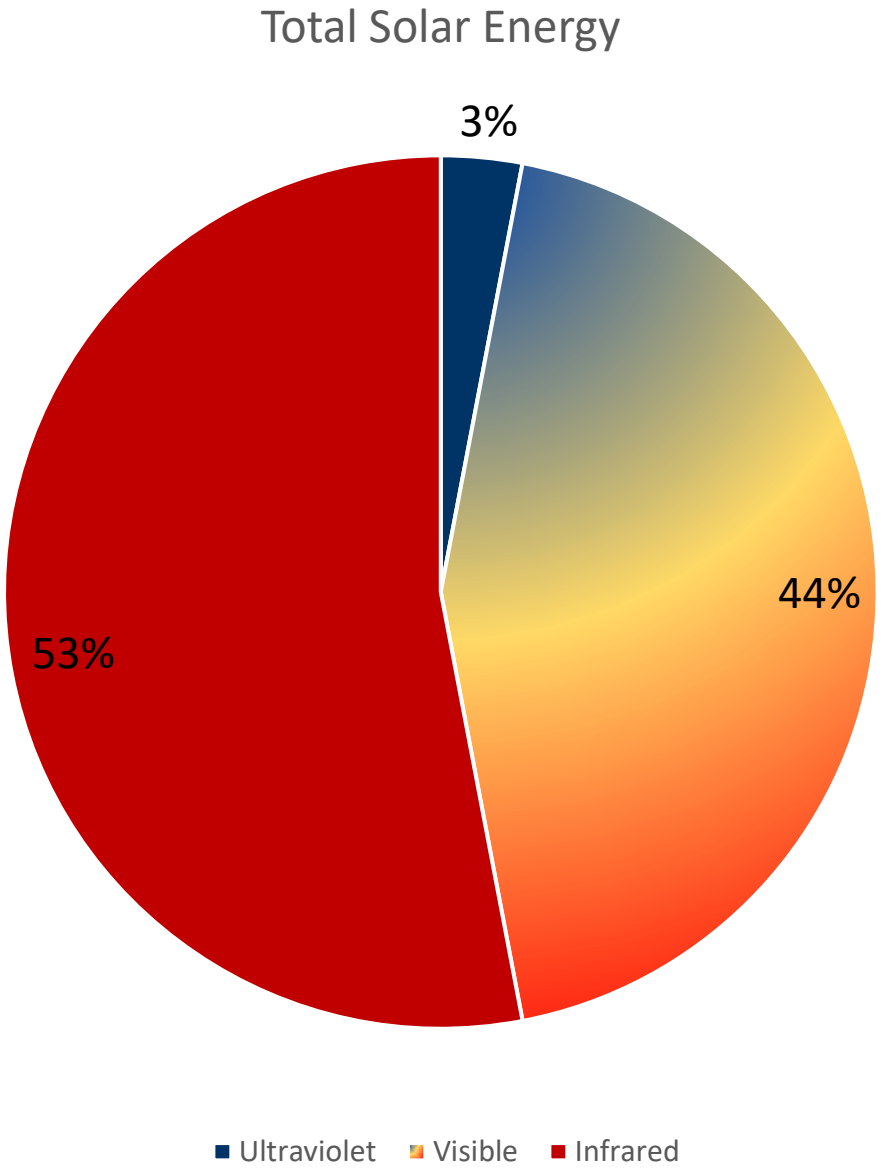
Electromagnetic Radiation Spectrum



Solar Spectrum



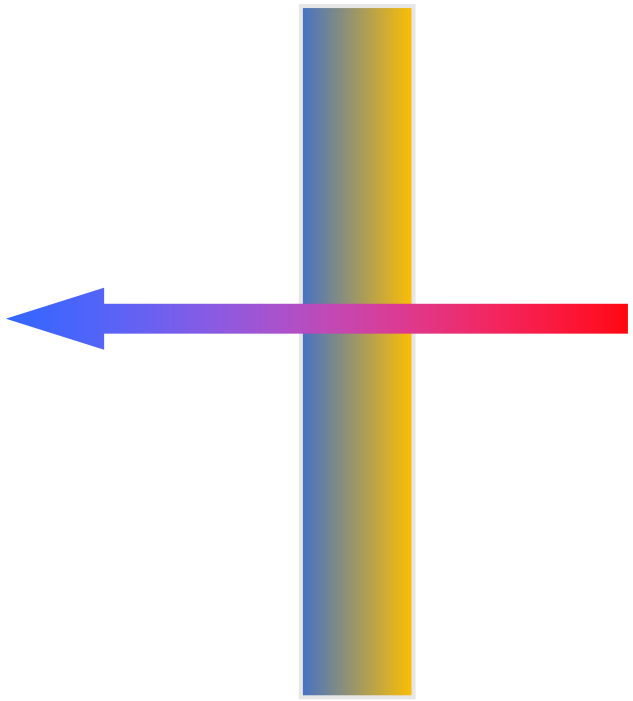
Solar Spectrum



Now, let’s apply those concepts to glazing

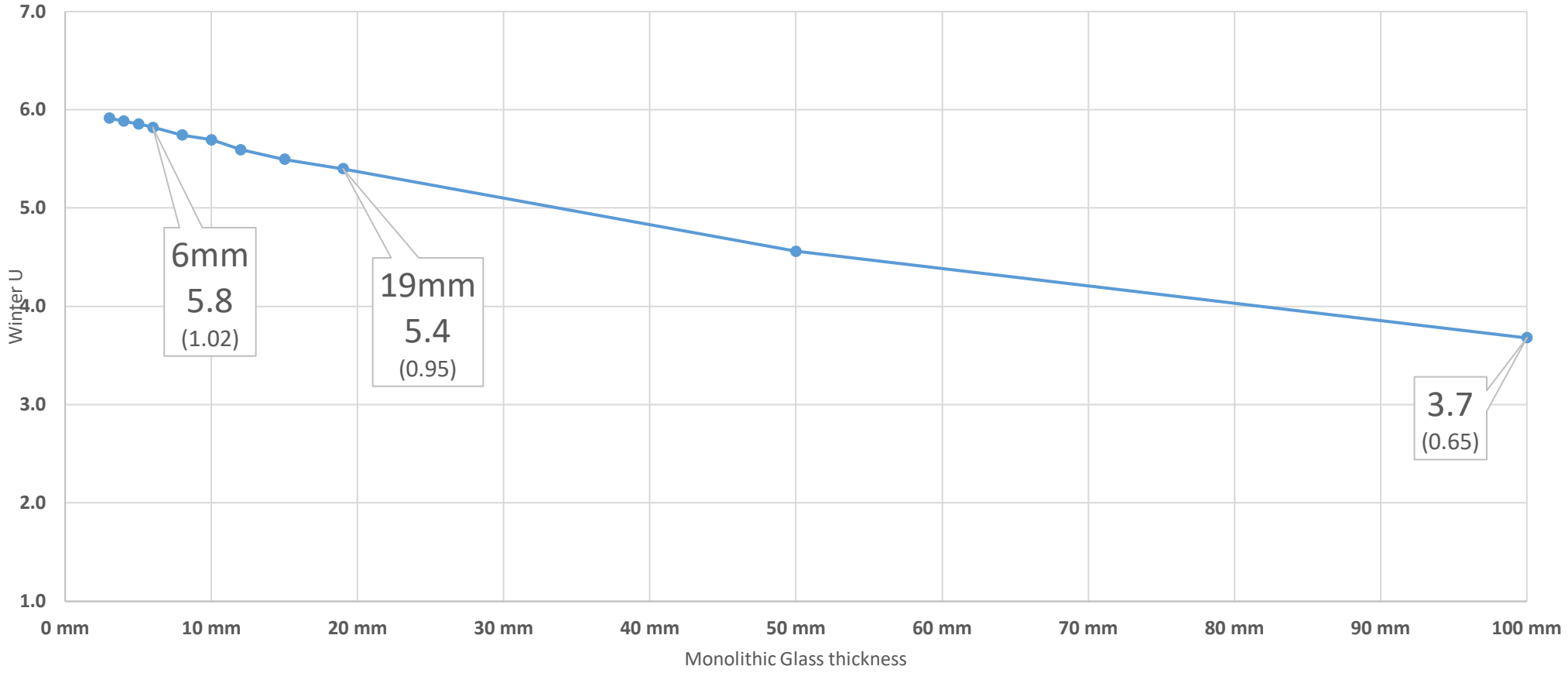
Single Glazing

Conduction



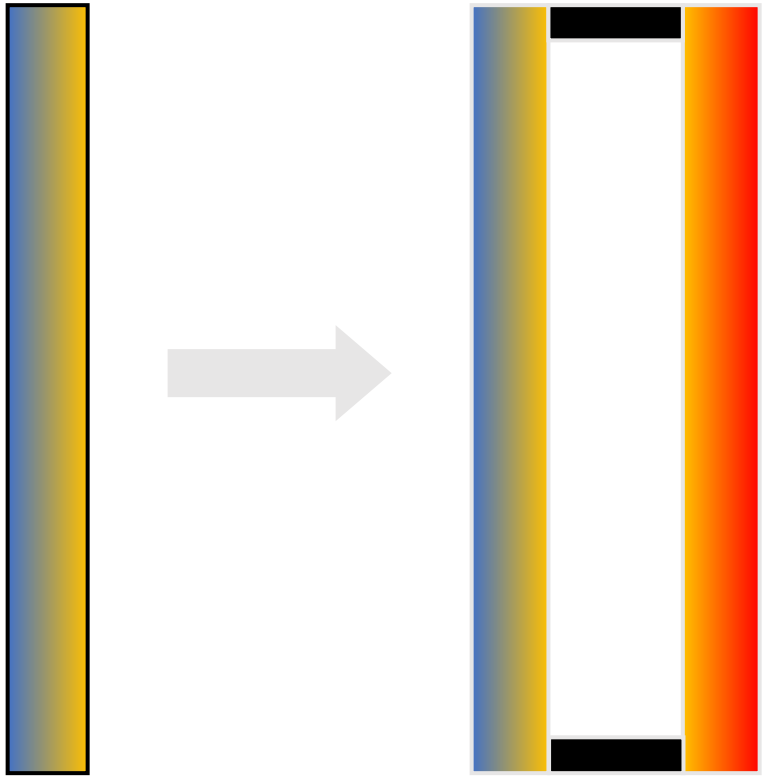
Single Glazing

Winter U value for Clear float



To get a U value of 1.4 $\frac{W}{m^2\,°C}$ / 0.25 $\frac{BTU}{Hft^2\,°C}$ you need 700 mm of glass !

Double Glazing



λ_{glass} = 1 W/(m K)

λ_{air} = 0,018 W/(m K)

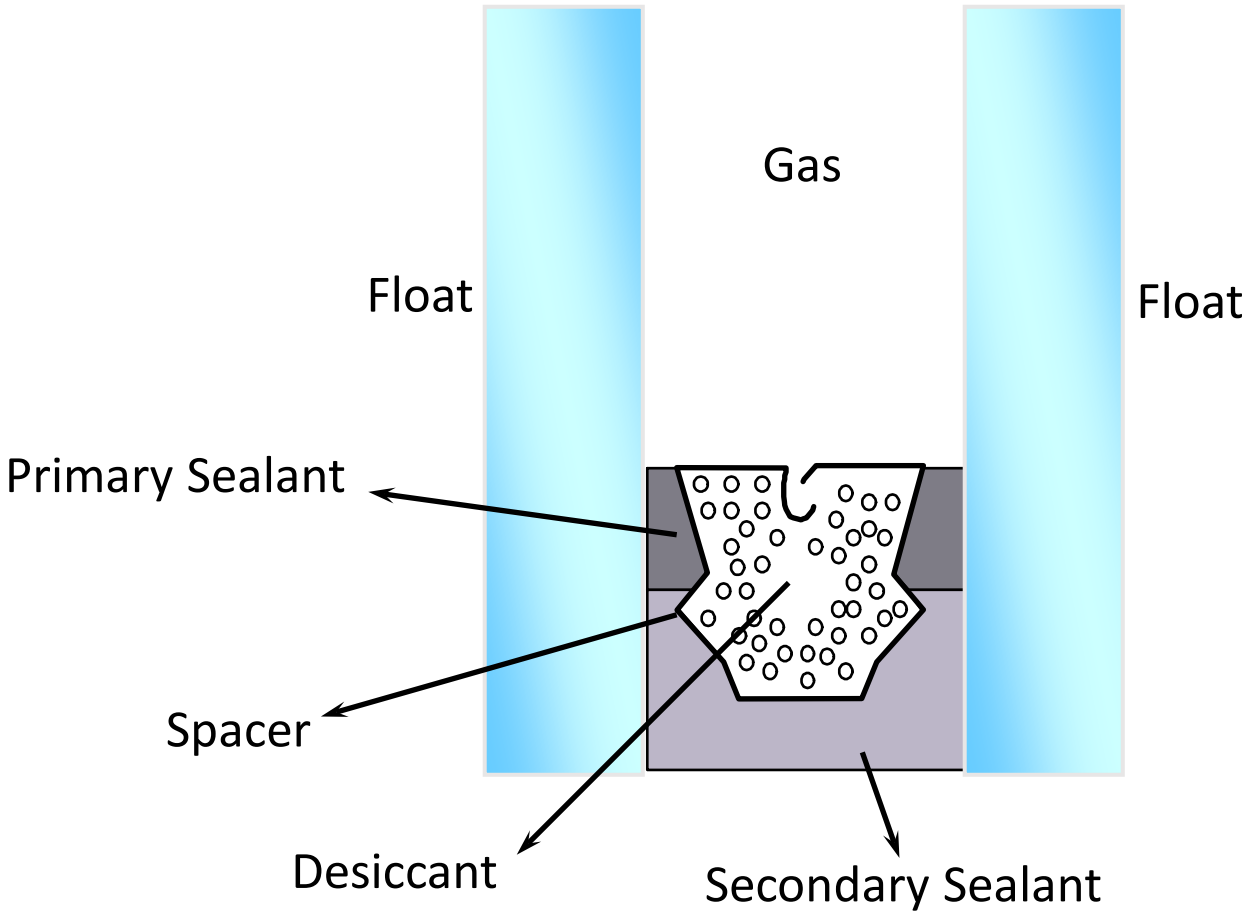
U = 5.8 $\frac{W}{m^2°C}$

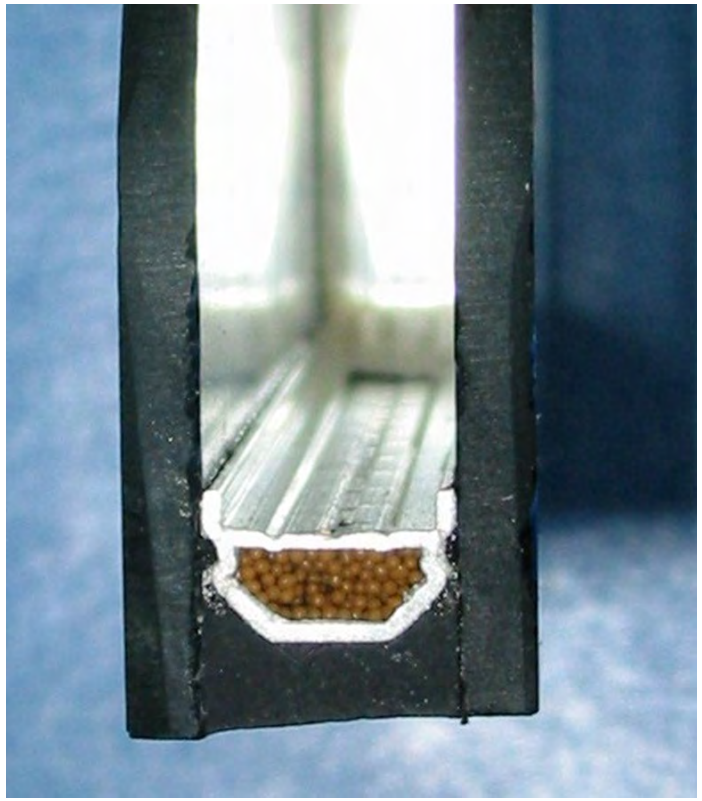
1.02 $\frac{BTU}{Hft^2°C}$

U = 2.7 $\frac{W}{m^2°C}$

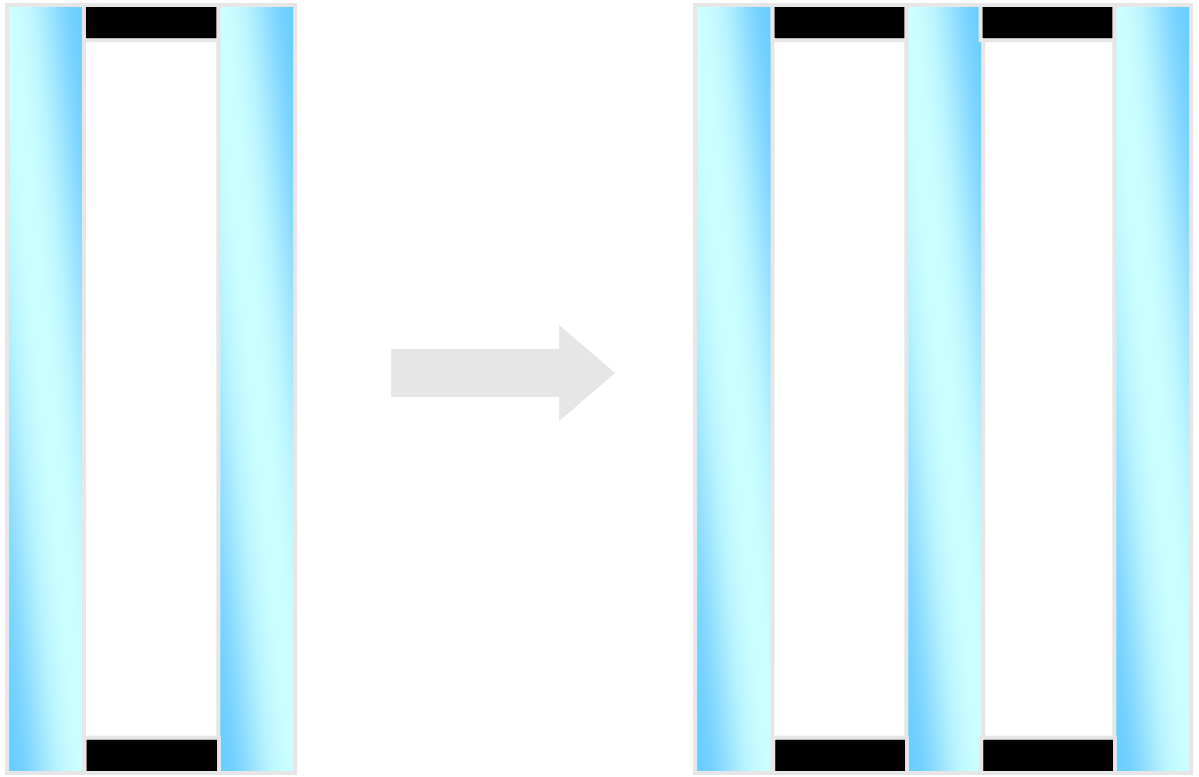
0.48 $\frac{BTU}{Hft^2°C}$

Double Glazing





Triple Glazing



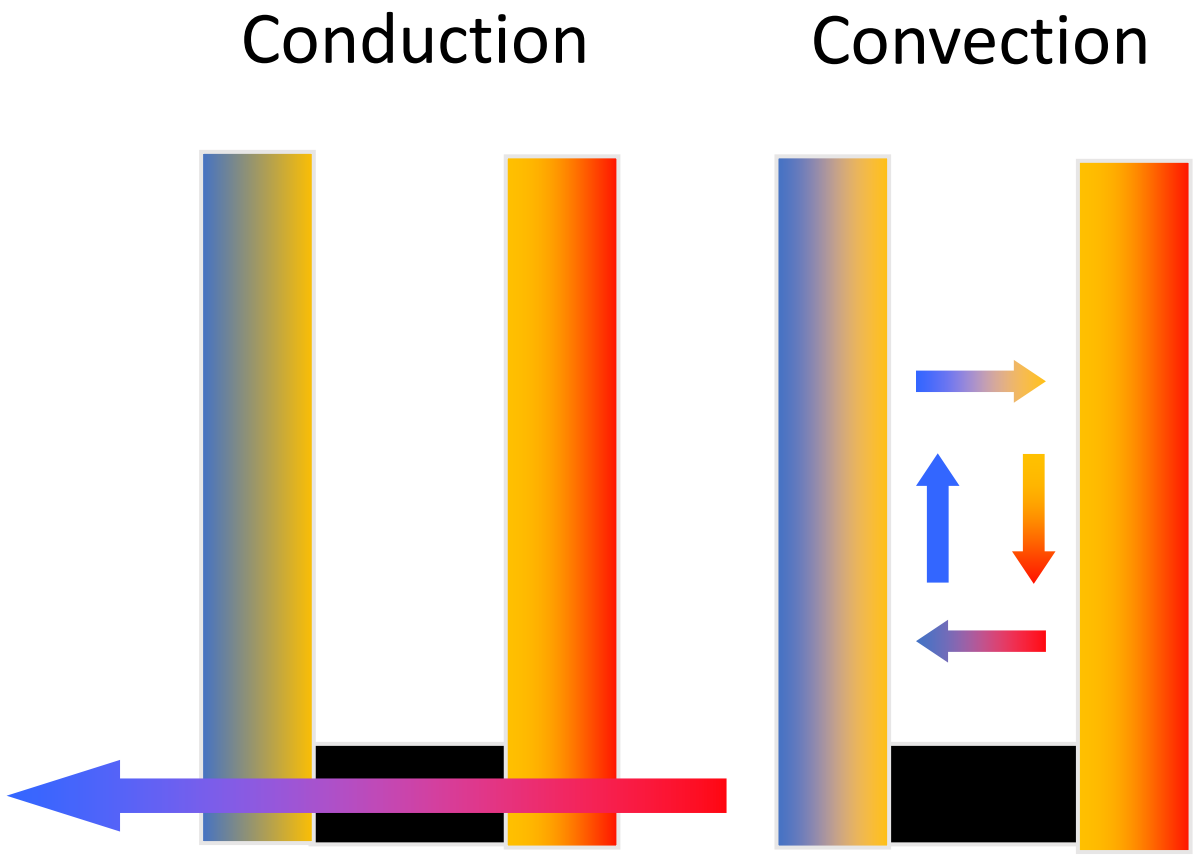
$2.7 \frac{W}{m^2 °C}$

$0.48 \frac{BTU}{Hft^2 °C}$

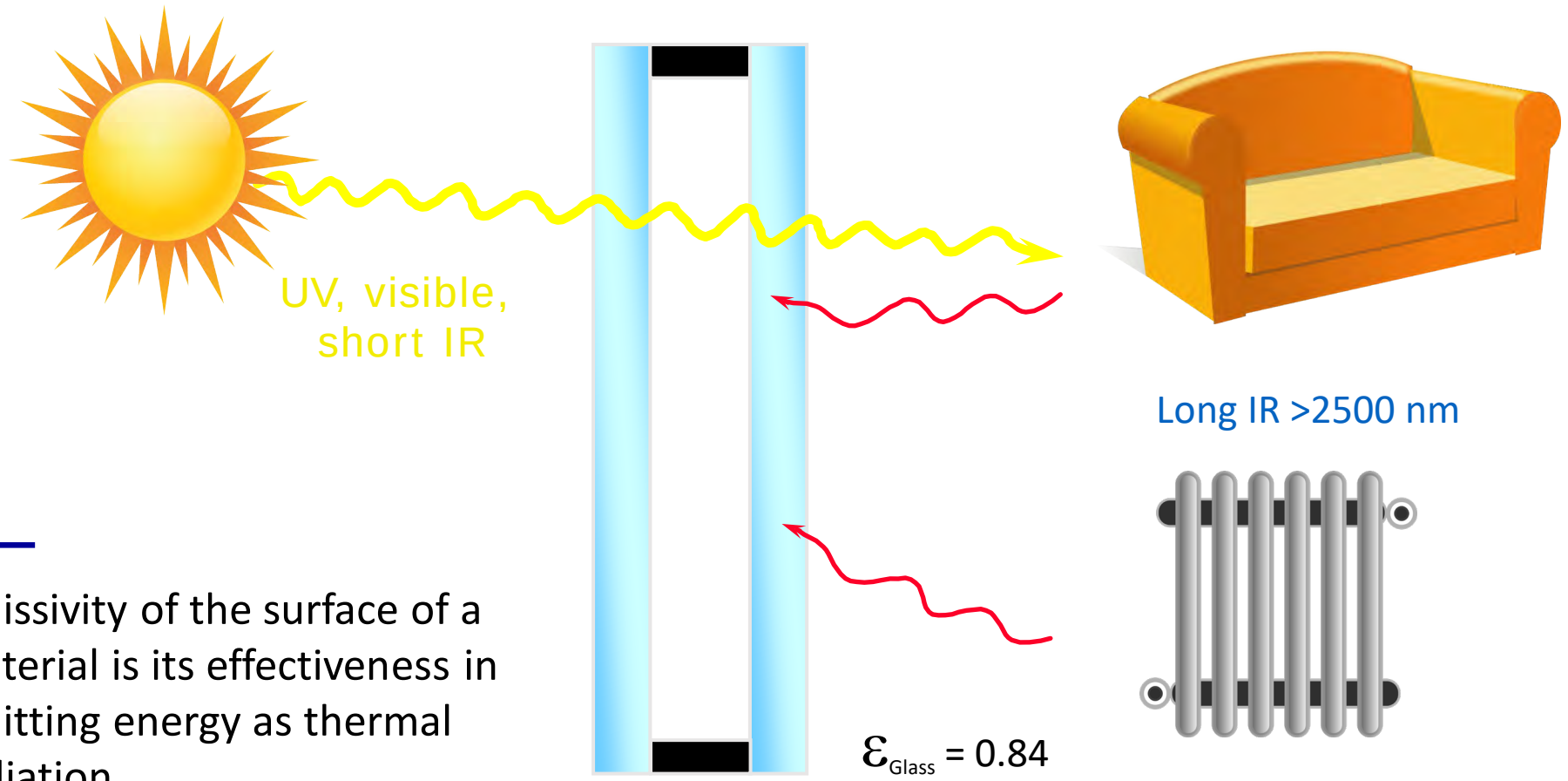
$1.8 \frac{W}{m^2 °C}$

$0.32 \frac{BTU}{Hft^2 °C}$

Convection, Conduction and Radiation



Double Glazing without Coating

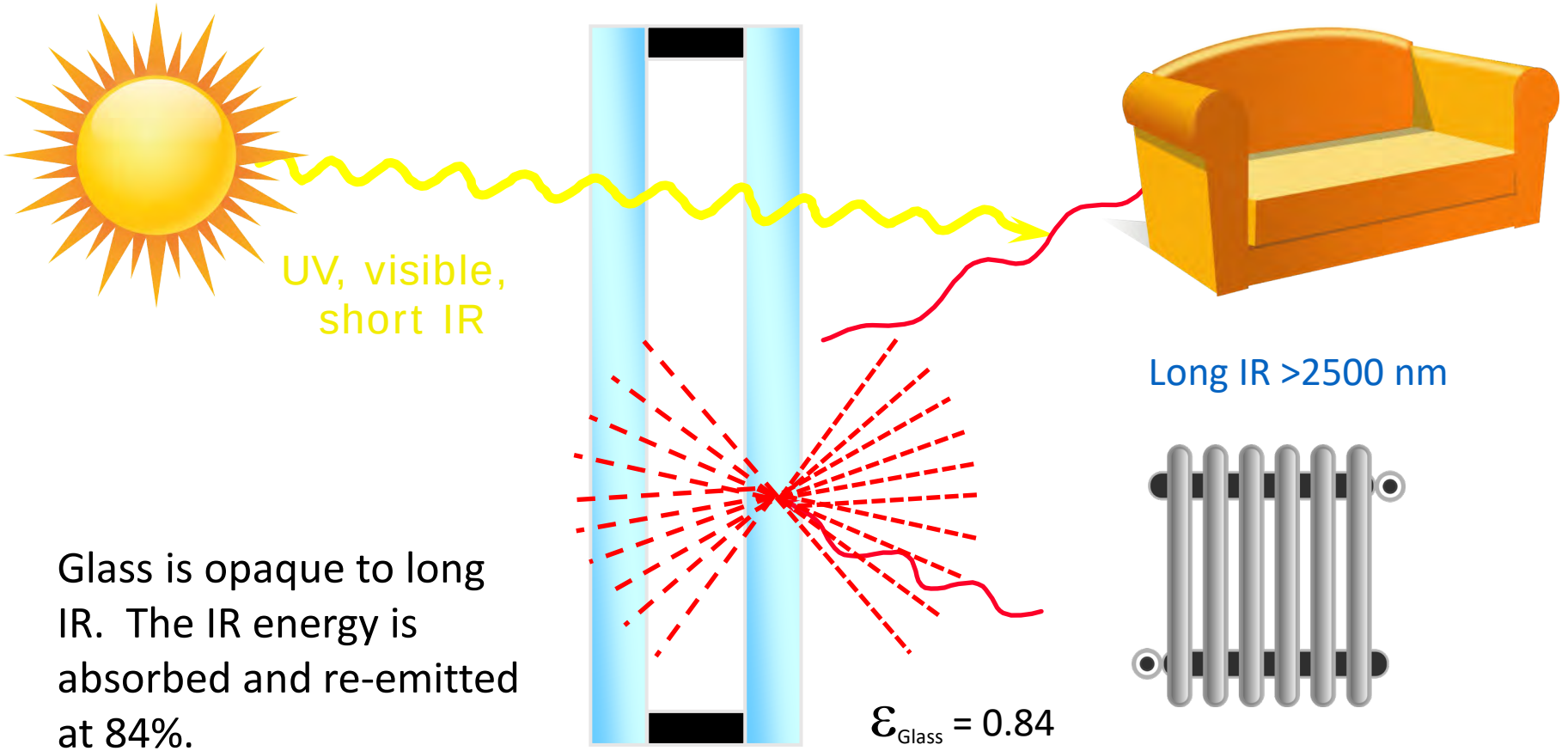


ε –

Emissivity of the surface of a material is its effectiveness in emitting energy as thermal radiation.

Double Glazing without Coating

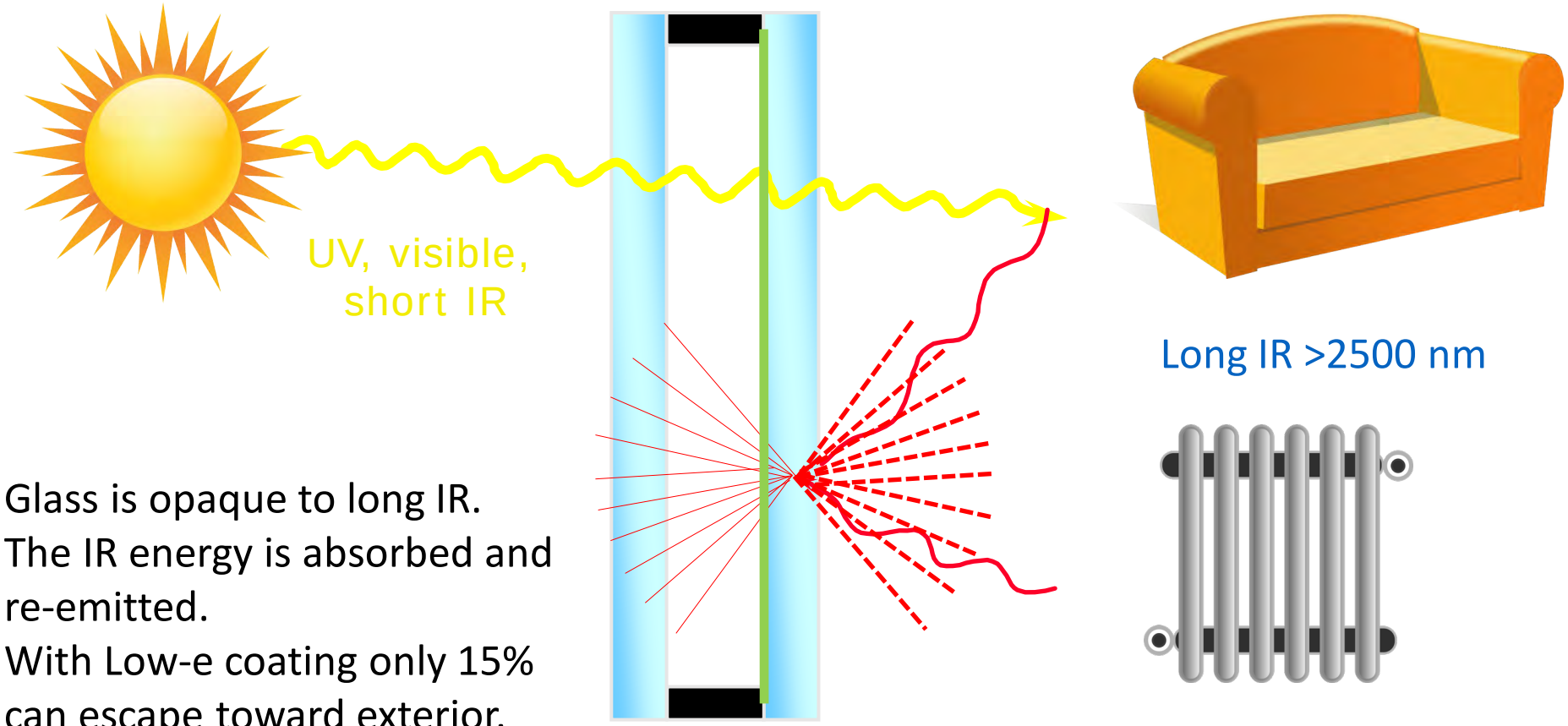
$$2.7\ \frac{W}{m^2 °C} \quad / \quad 0.48\ \frac{BTU}{Hft^2\ °C}$$



Glass is opaque to long IR. The IR energy is absorbed and re-emitted at 84%.

Double Glazing with Pyrolithic Coating

$$1.9\ \frac{W}{m^2 °C} \quad / \quad 0.33\ \frac{BTU}{Hft^2\ °C}$$

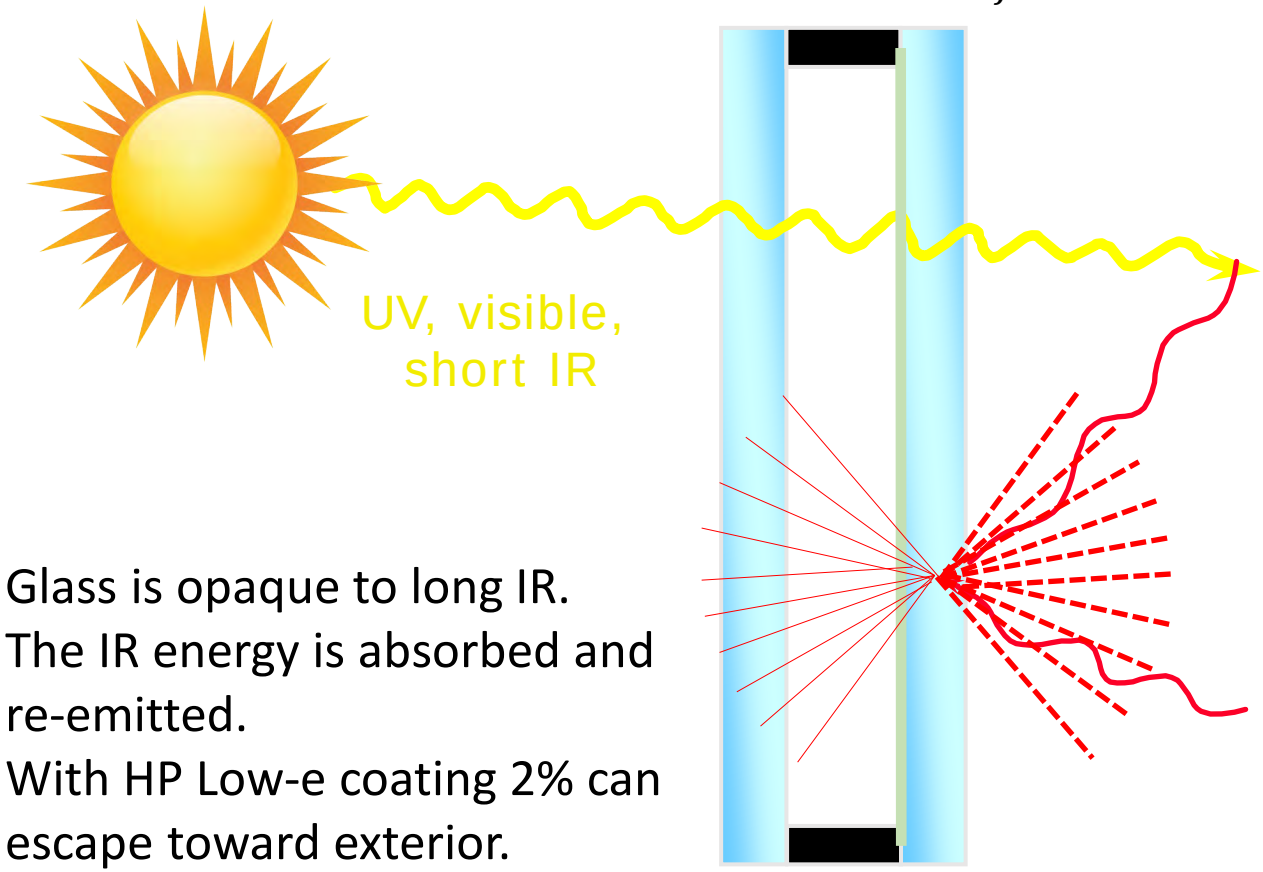


Glass is opaque to long IR.
The IR energy is absorbed and re-emitted.
With Low-e coating only 15% can escape toward exterior.

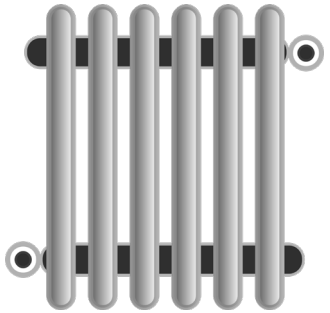
$\varepsilon_{\text{low-e EADV}} = 0.15$ $\varepsilon_{\text{Glass}} = 0.84$

Double Glazing with HP Coating

$1.7\ \frac{W}{m^2 °C}$ / $0.30\ \frac{BTU}{Hft^2\ °C}$



Long IR >2500 nm



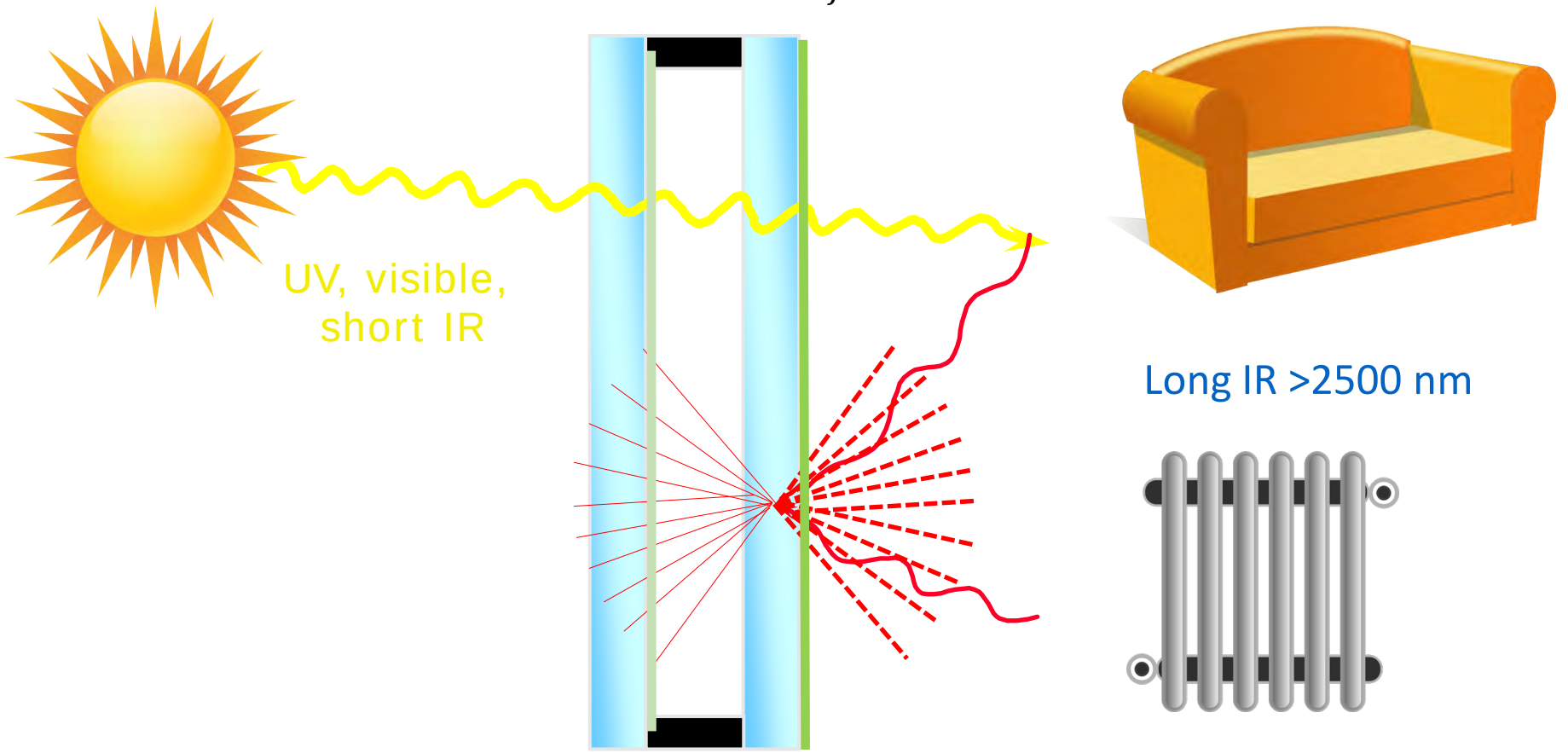
Glass is opaque to long IR.
The IR energy is absorbed and re-emitted.
With HP Low-e coating 2% can escape toward exterior.

$\varepsilon_{\text{low-e XNII}} = 0.02$ $\varepsilon_{\text{Glass}} = 0.84$


Glass Washing

Double Glazing with HP + Pyrolithic Coating in Position #4

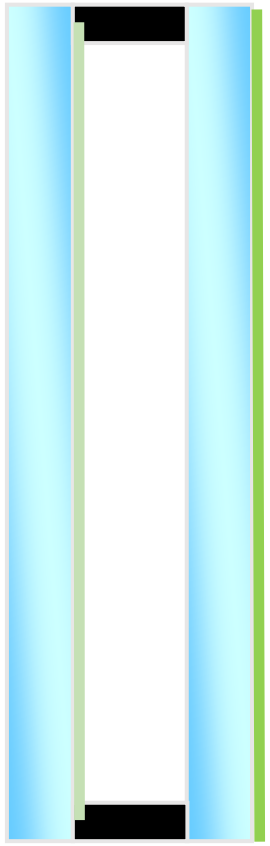
$$1.3\ \frac{W}{m^2 °C} \quad / \quad 0.23\ \frac{BTU}{Hft^2\ °C}$$



$\varepsilon_{HP\ low\text{-}e} = 0.02$ $\varepsilon_{EADV} = 0.15$

Double Glazing with HP + Pyrolithic Coating in Position #4

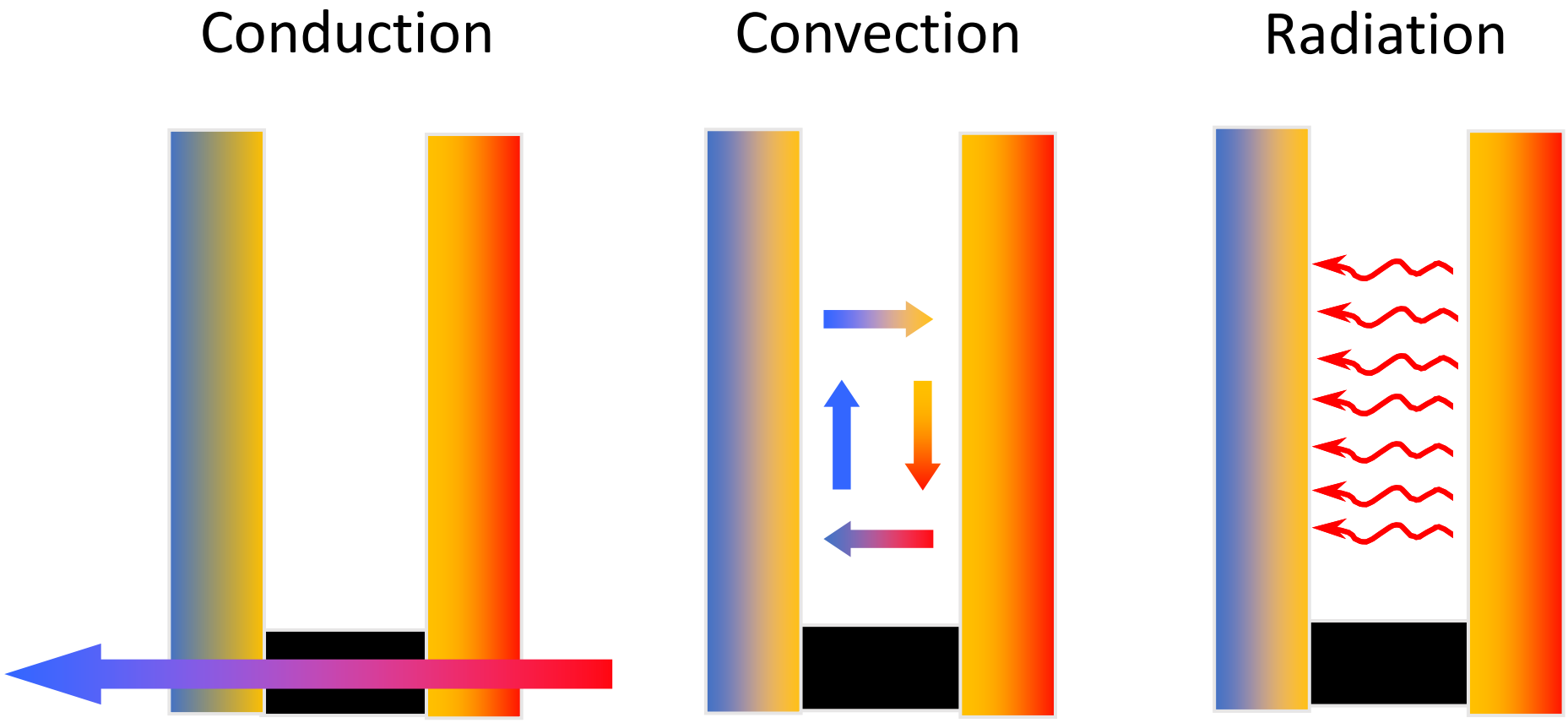
$$1.3\ \frac{W}{m^{2}°C} \quad / \quad 0.23\ \frac{BTU}{Hft^{2}\,°C}$$



- Improvement on U value
  - In some area, will allow to pass energy code
  - Ex: Aspen w/o Argon
- Difficult to clean
- Lower inside glass temperature
  - More condensation risk

$\varepsilon_{\text{HP low-e}} = 0.02$ $\varepsilon_{\text{EADV}} = 0.15$

Convection, Conduction and Radiation



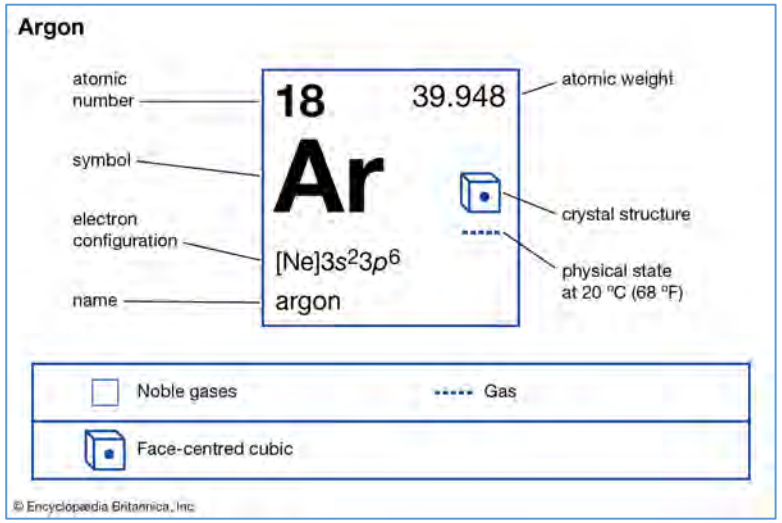
Icing on the cake

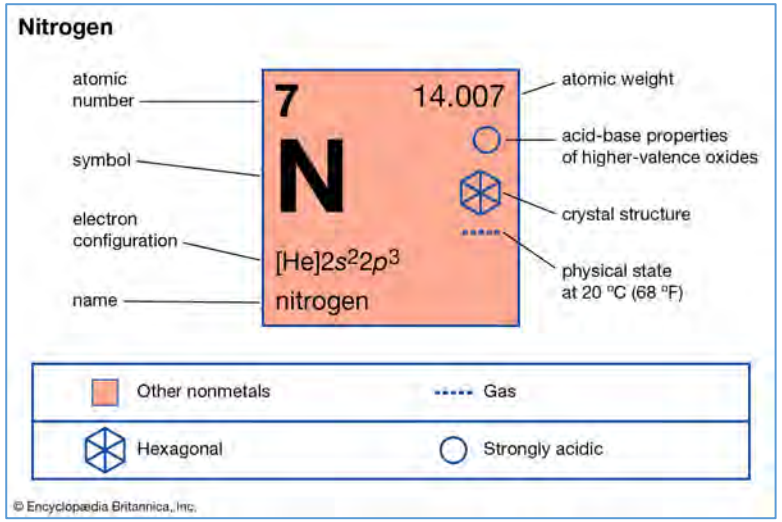
Material	W/ (m °C)	BTU/(ft h °F)
Argon	0.012	0.01
Air	0.018	0.01
Acetal (insulator)	0.2	0.1
Glass	1	0.5
Stainless Steel	15	9
Aluminum	205	118

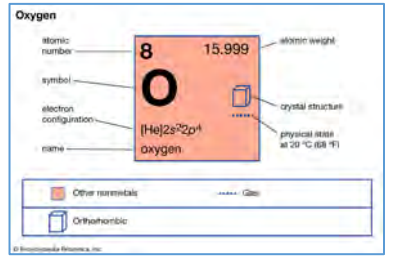
λ = Thermal conductivity of different materials

Argon

- Is less conductive
- Heavier 40 Vs 15
- Bigger molecules
- Less convection inside the cavity

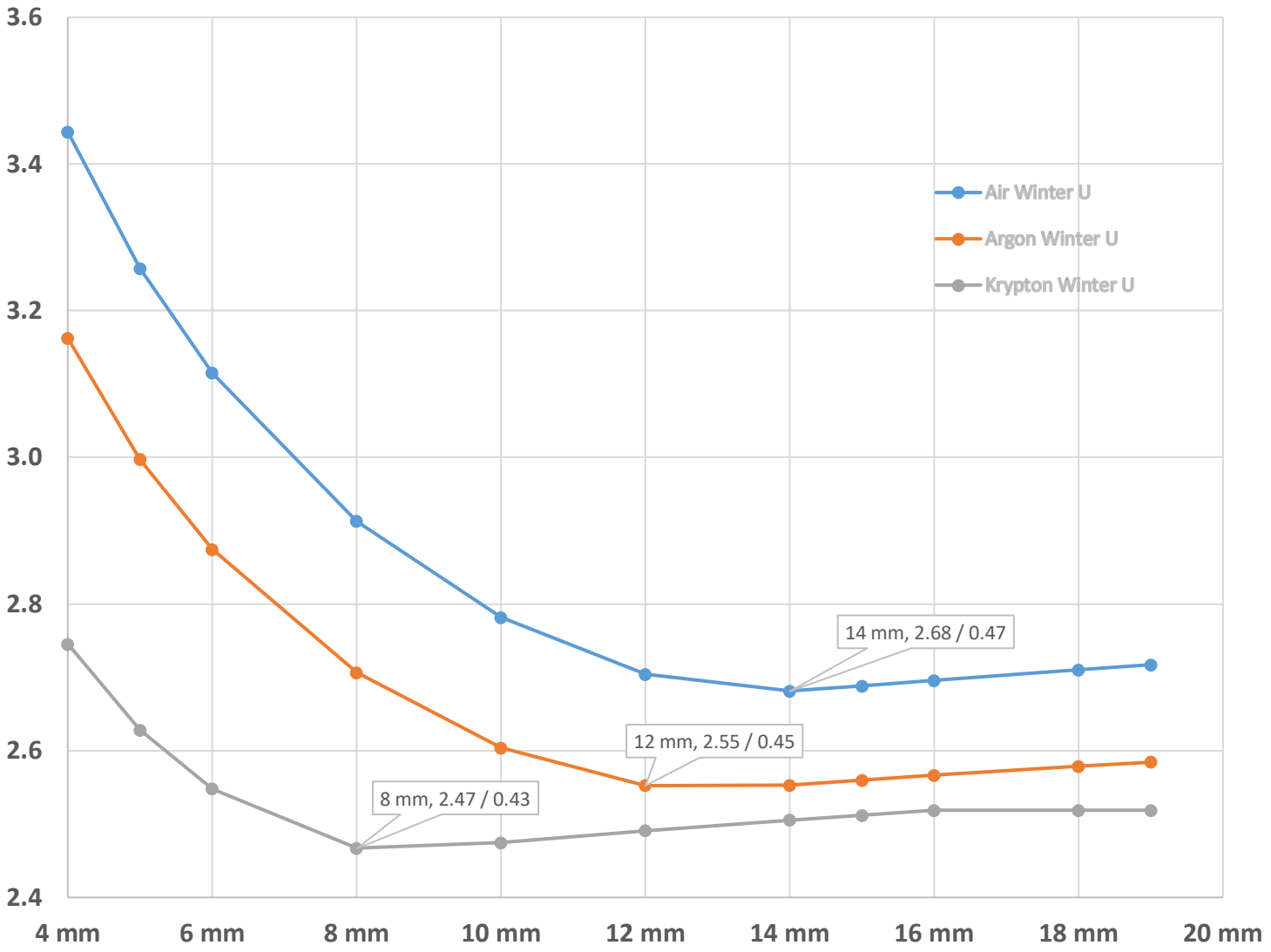






Double Glazing

Spacer width and gas.
The effect on Winter U.



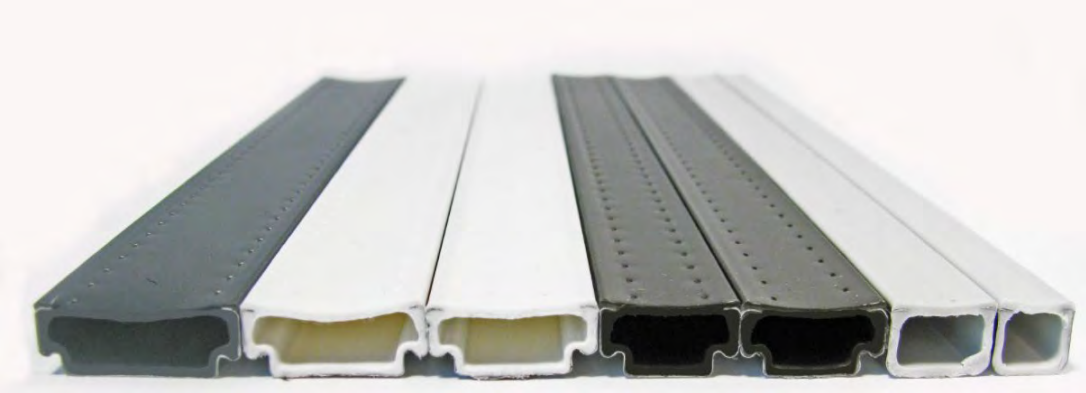
Don’t be fooled…Europe does not have better U values

- Europe
  - EN673
  - Environmental conditions
    - 0°C / 32°F
- North America
  - NFRC
  - Environmental conditions
    - 0°F / -18°C

Double glazed unit

- 6mm /16mm Argon /6 mm Planitherm XN
- Values
  - U EN673 1.1 / 0.19
  - U NRFC 1.5 / 0.26

Cherry on the icing - Warm Edge Spacer



Composite material

- Plastic
- Metal foil

Improves perimeter (frame) U value

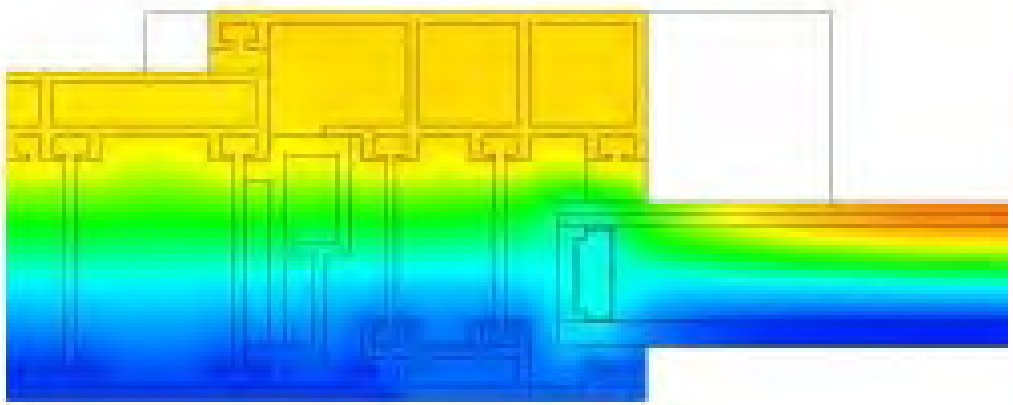
- Very small effect on COG U value

Reduces internal condensation in residential environment

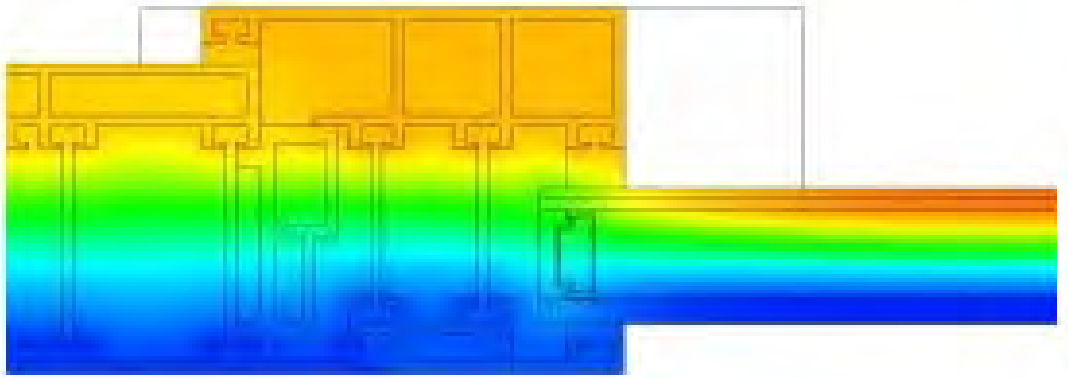
- Small windows
- High humidity

Double Glazing with Warm Edge Spacer

Aluminum spacer



Warm edge



How to Improve Insulation ?

- Assembly in double or triple
  - Largest improvement
- Low-e coating inside cavity
  - Large improvement
- Argon
  - Small improvement

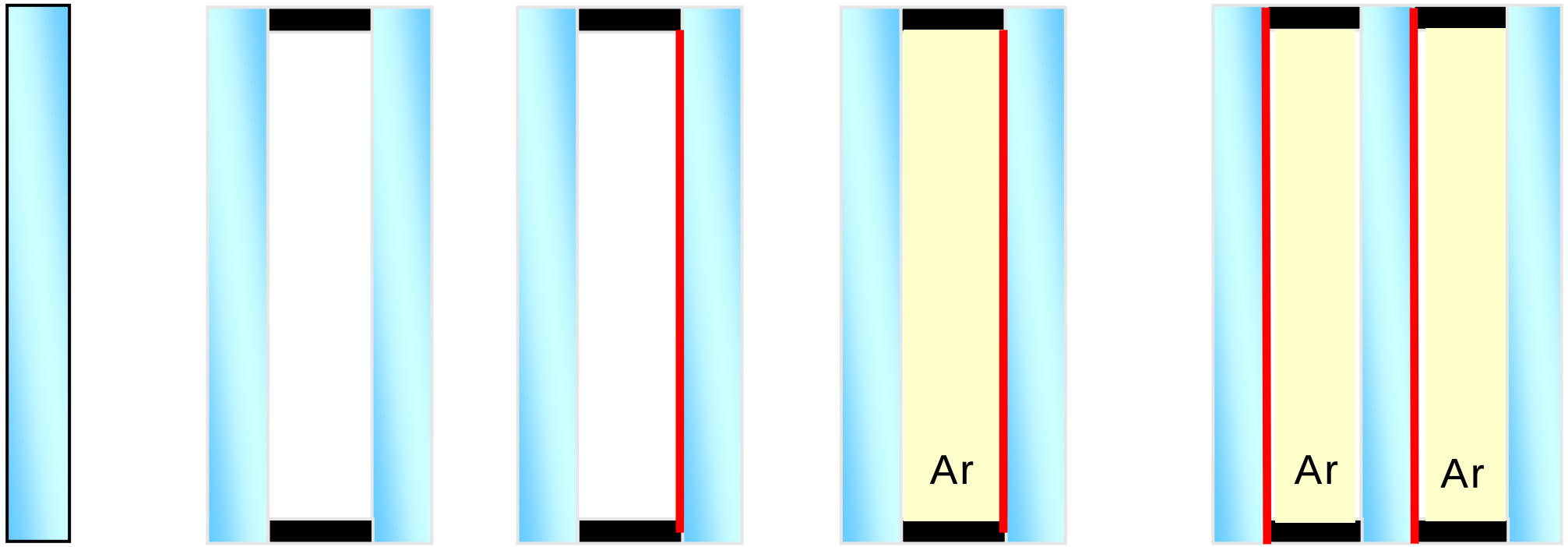
Warm edge spacer
  - Helps in the frame insulation

Glass thickness
  - Insignificant

Low-e coating surface #4
  - Band Aid solution

Triple Glazing is the way to go!
  - It is the law in all Scandinavian Countries

How to improve insulation?



5.80 / 1.02

2.90 / 0.51

1.90 - 1.70

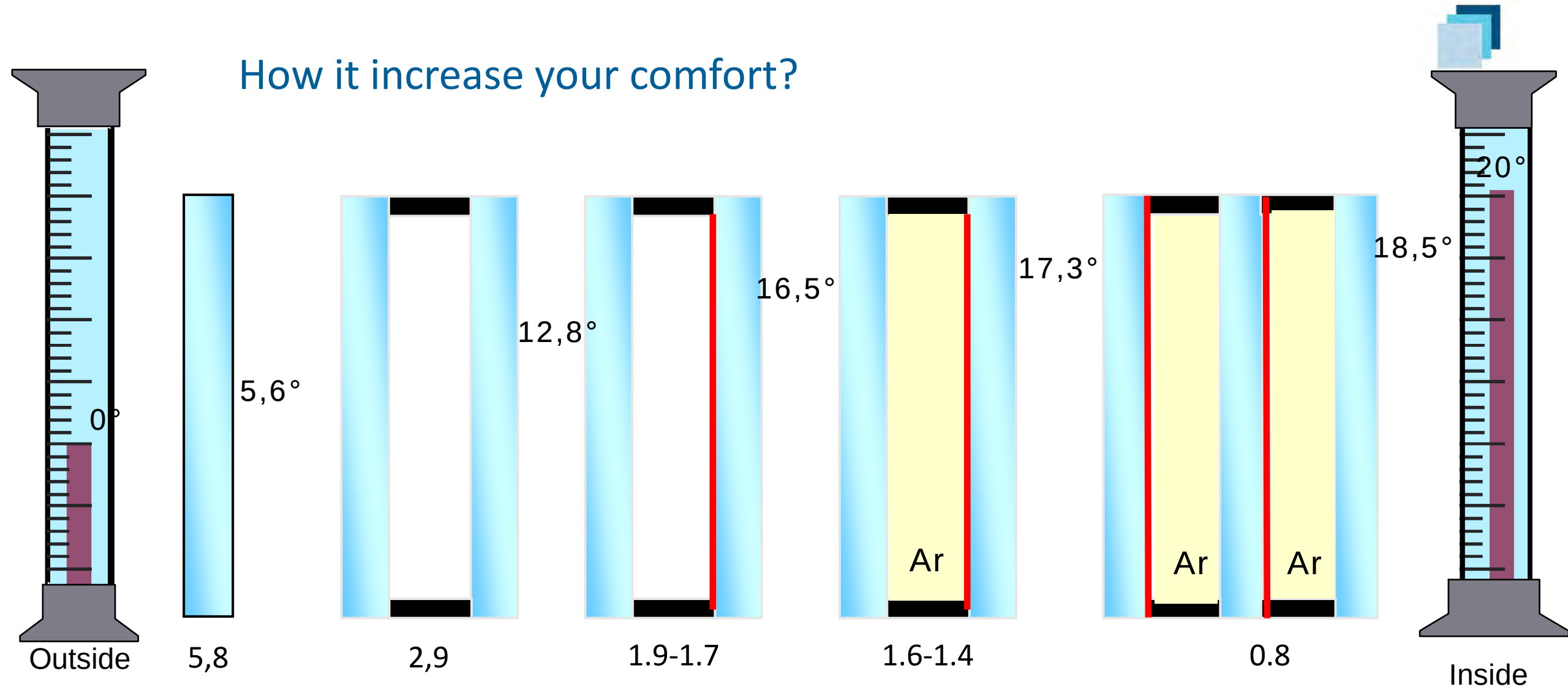
0.33 - 0.30

1.60 - 1.40

0.28 - 0.25

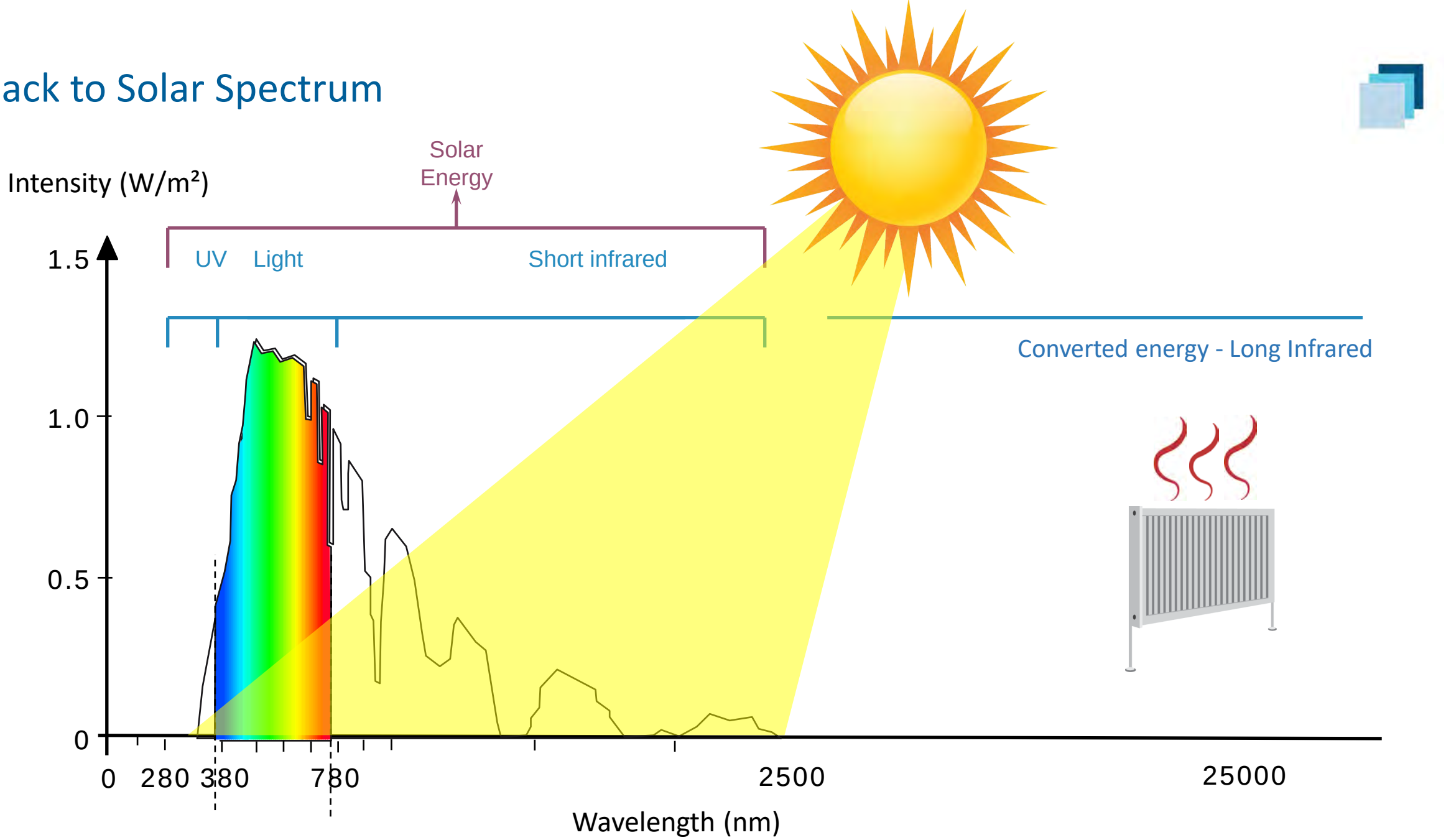
0.8 / 0.14

How it increase your comfort?

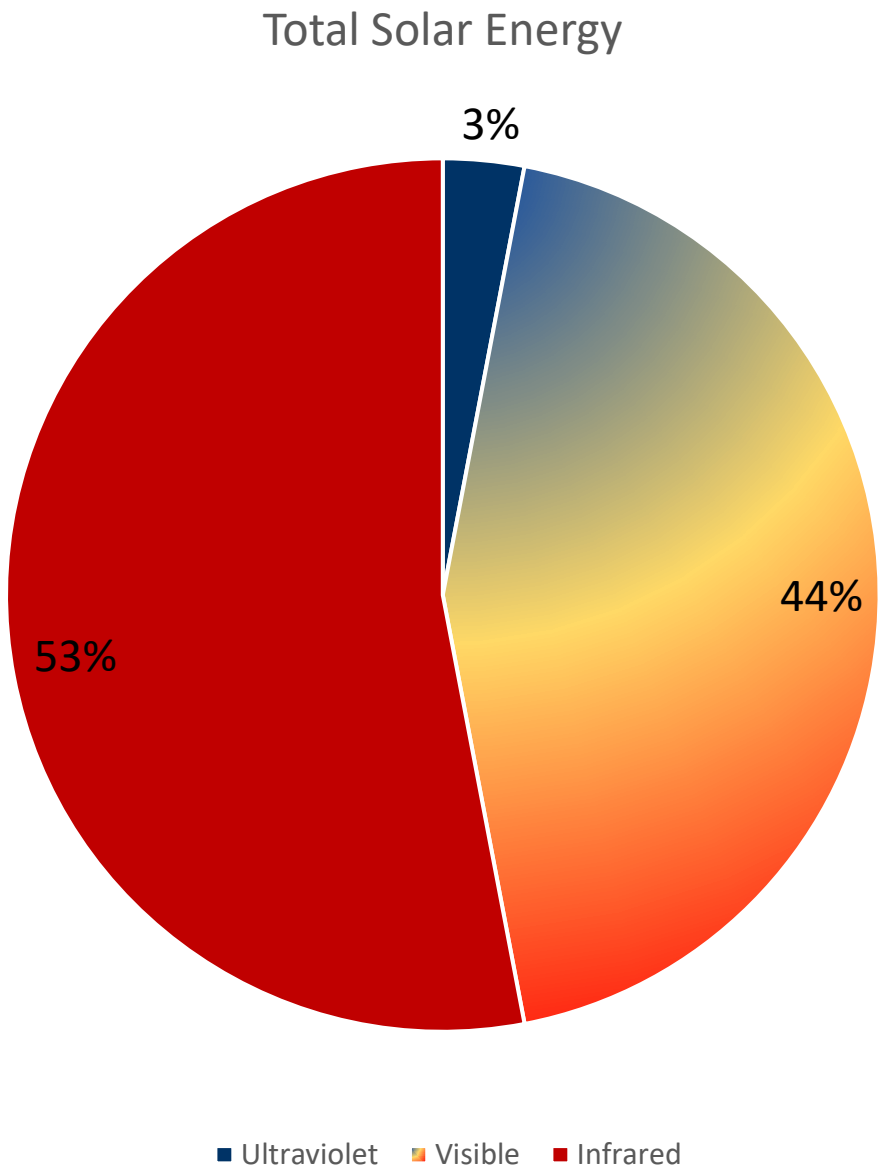


Solar control

Back to Solar Spectrum

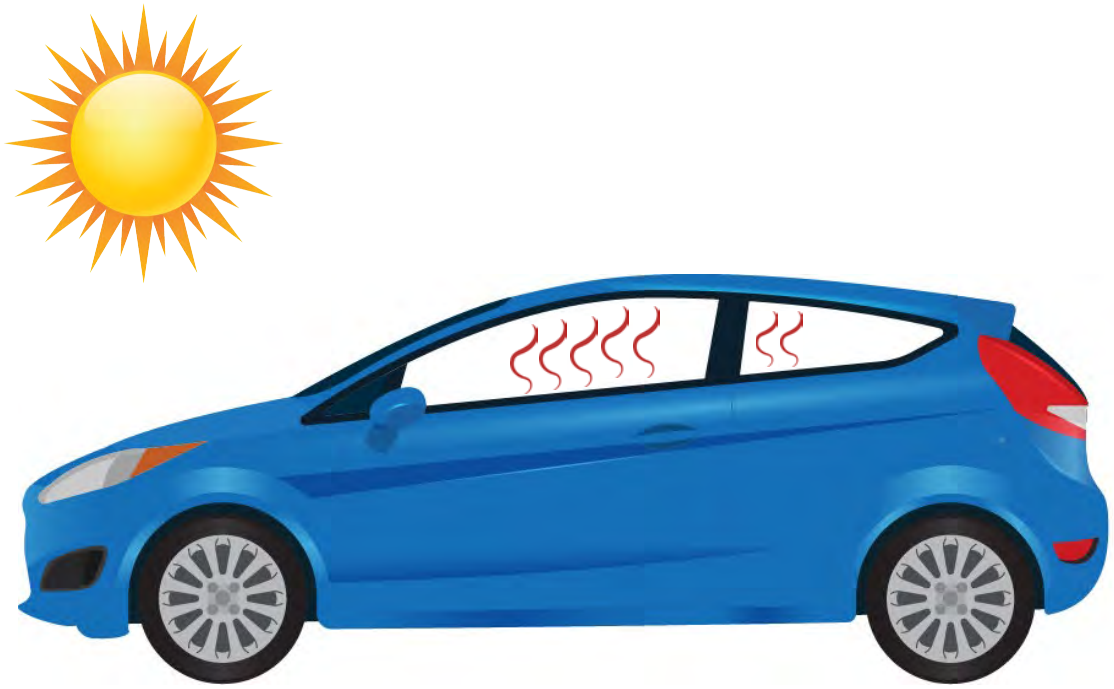


Back to Solar Spectrum



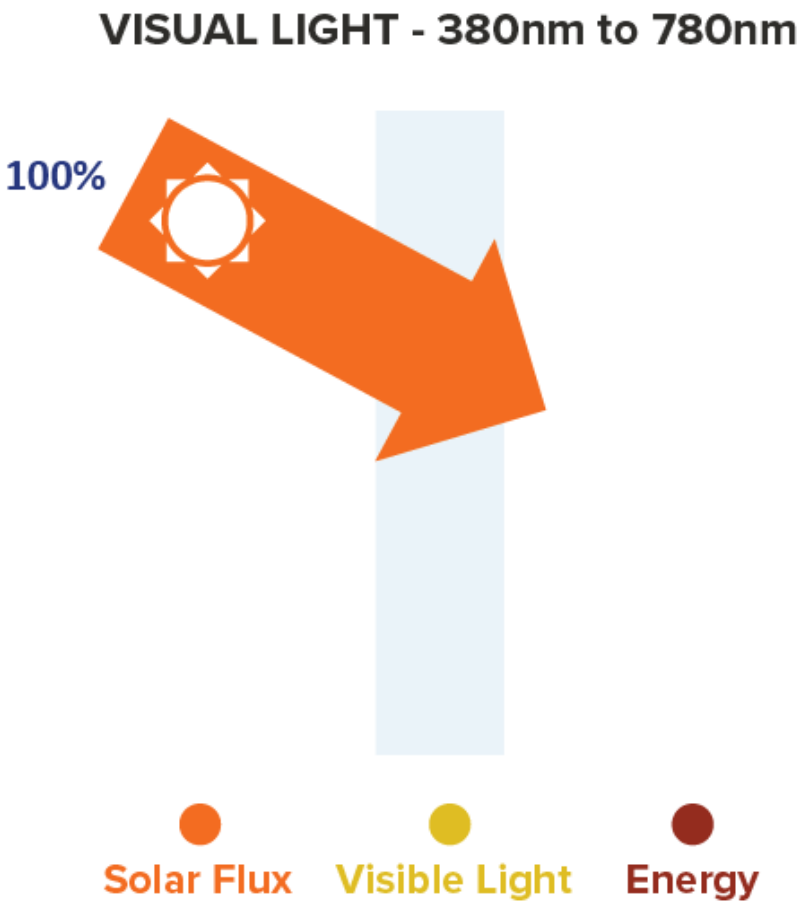
Greenhouse Effect

Greenhouse Effect



1. 300 – 2500 nm radiation enters the car
2. Interior objects absorb this energy
3. Objects re-emit that energy in the 15000-25000 nm range
4. Glass is opaque to long IR so this energy is absorbed and re-emitted at 84% inside the car
5. Heat buildup

Light and Solar Energy Factors



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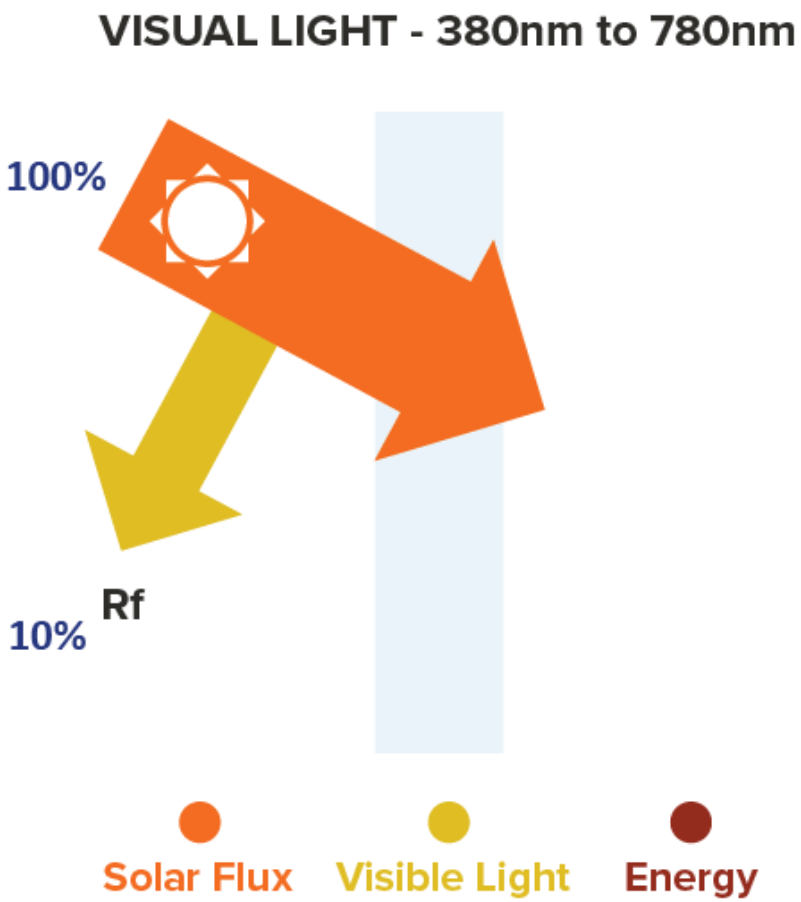

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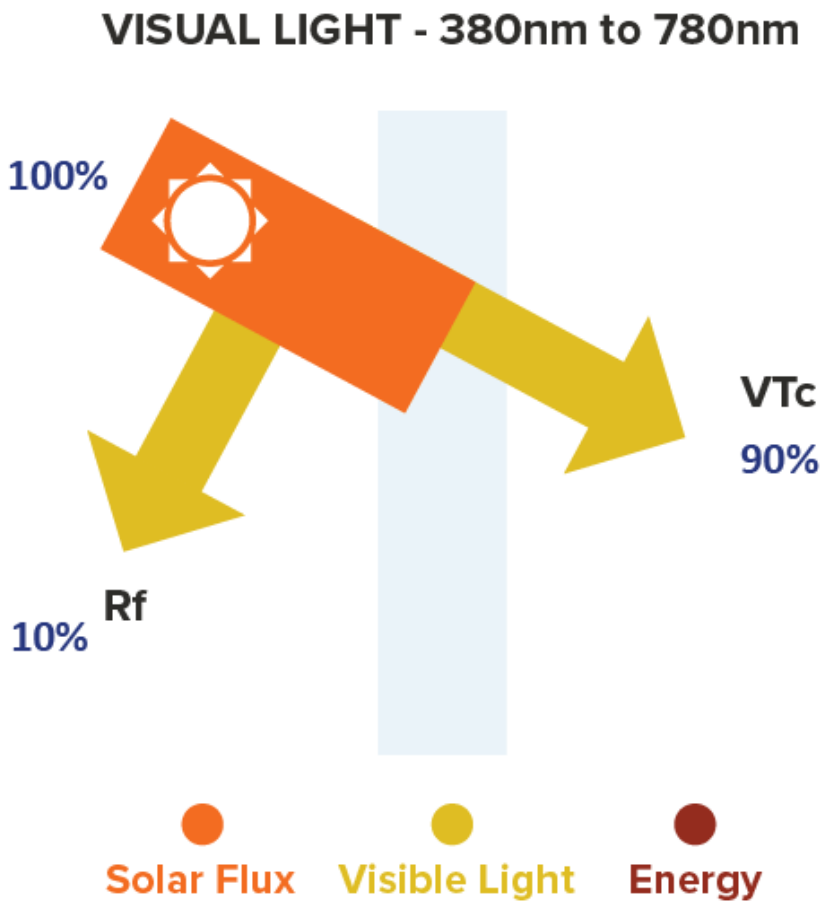
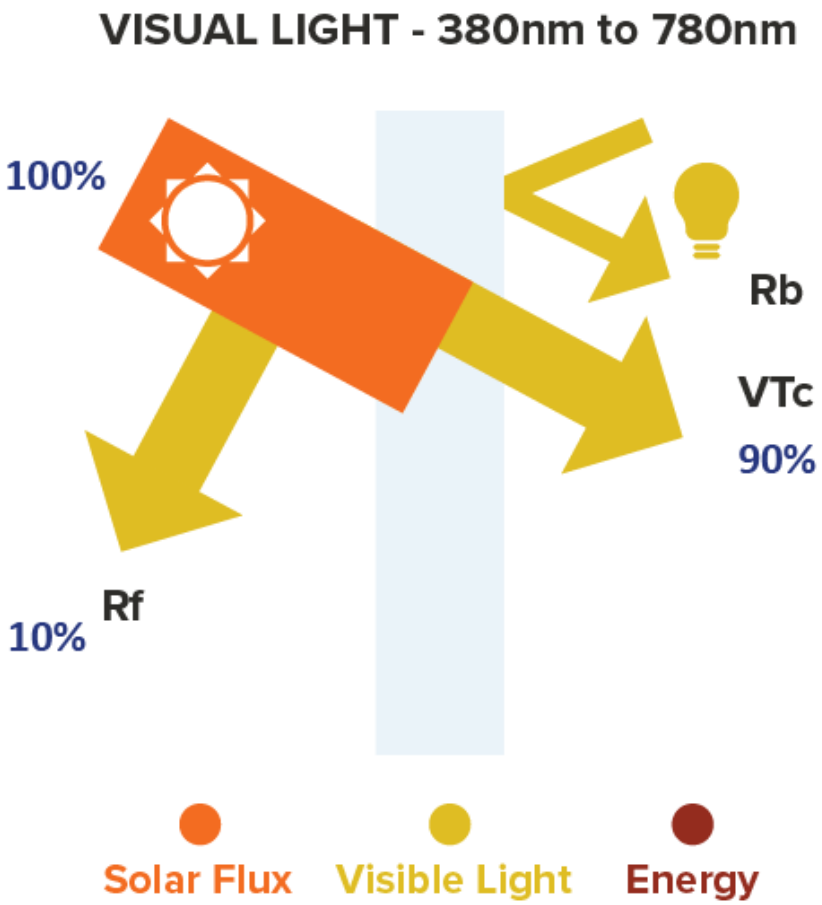


Light and Solar Energy Factors



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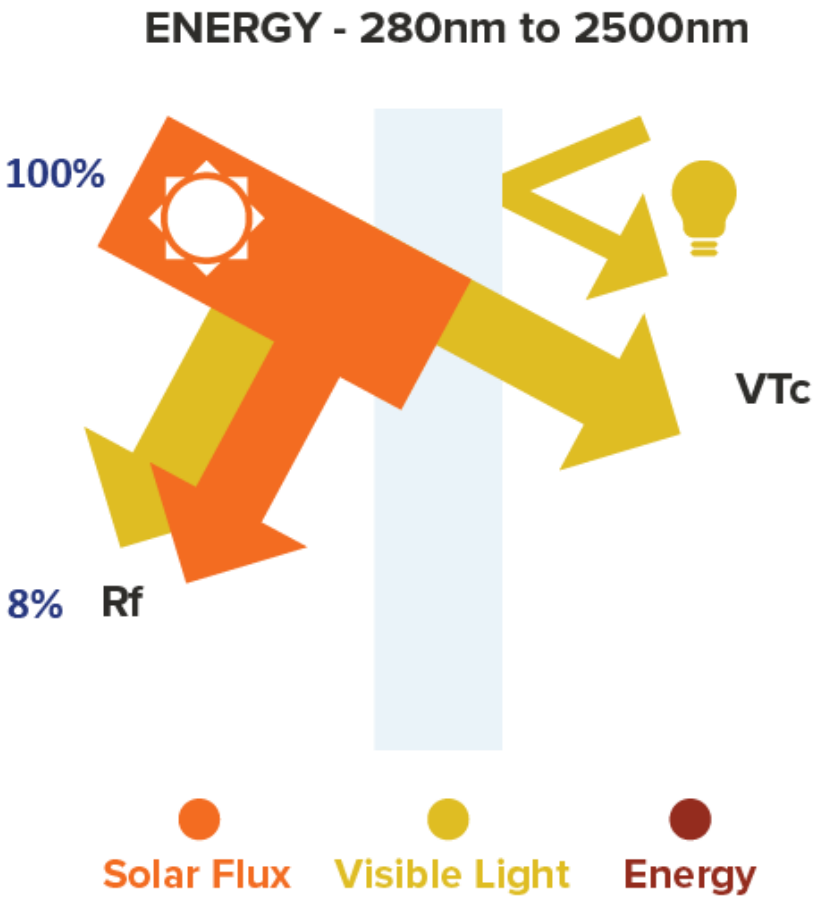

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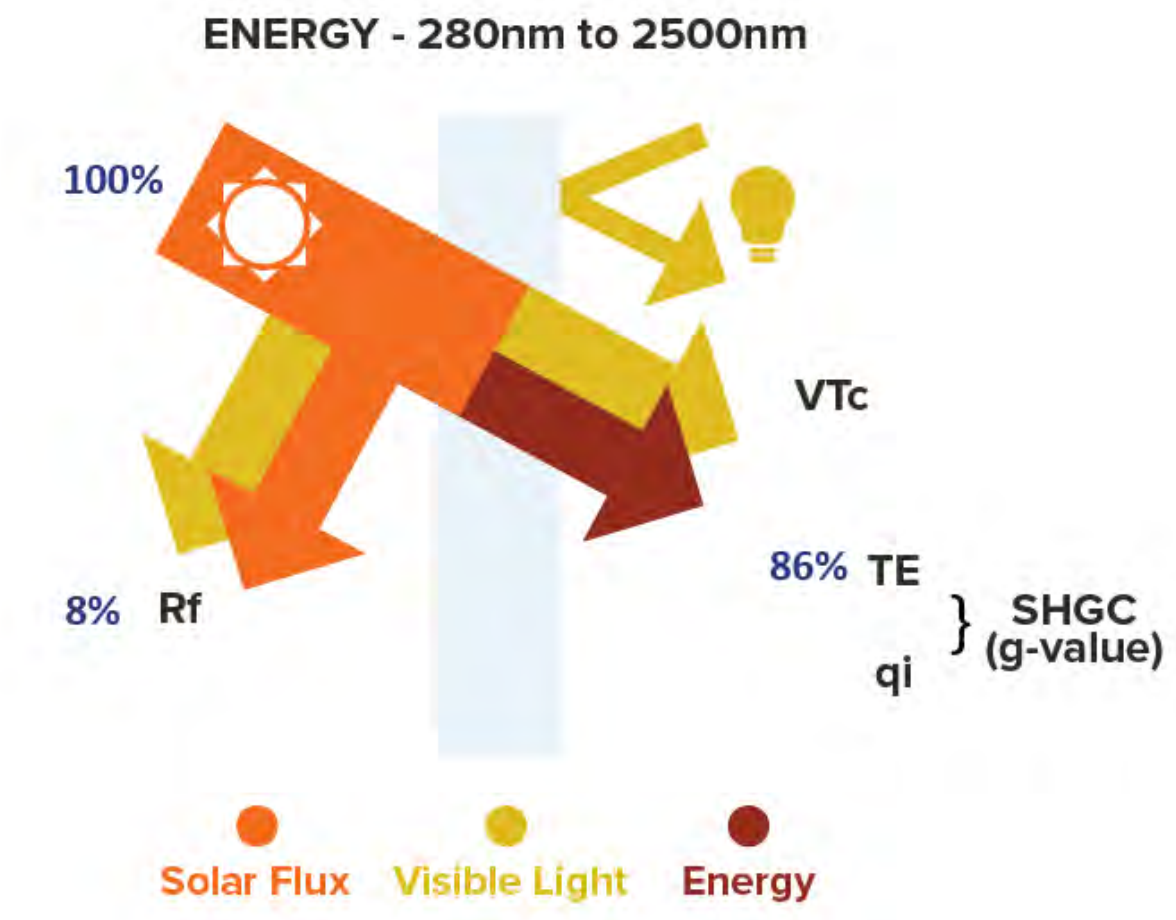
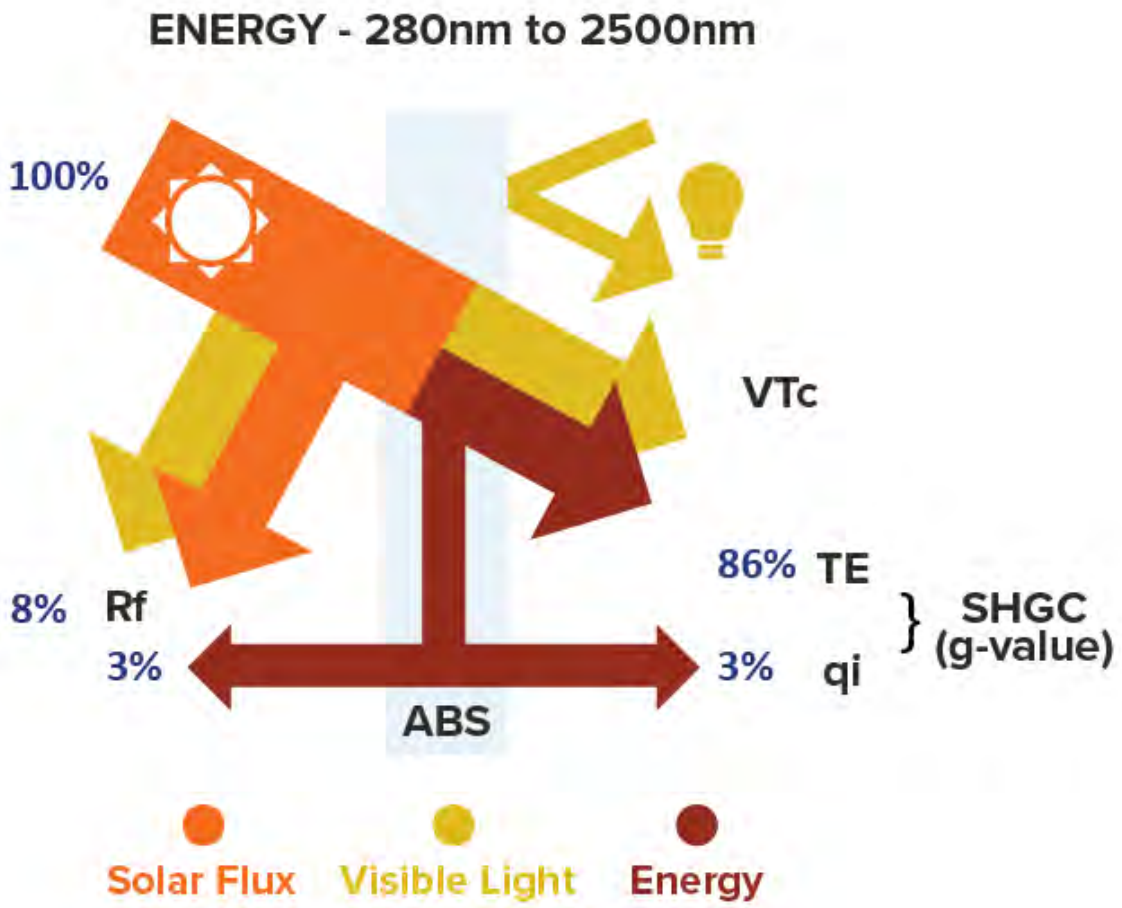


Light and Solar Energy Factors



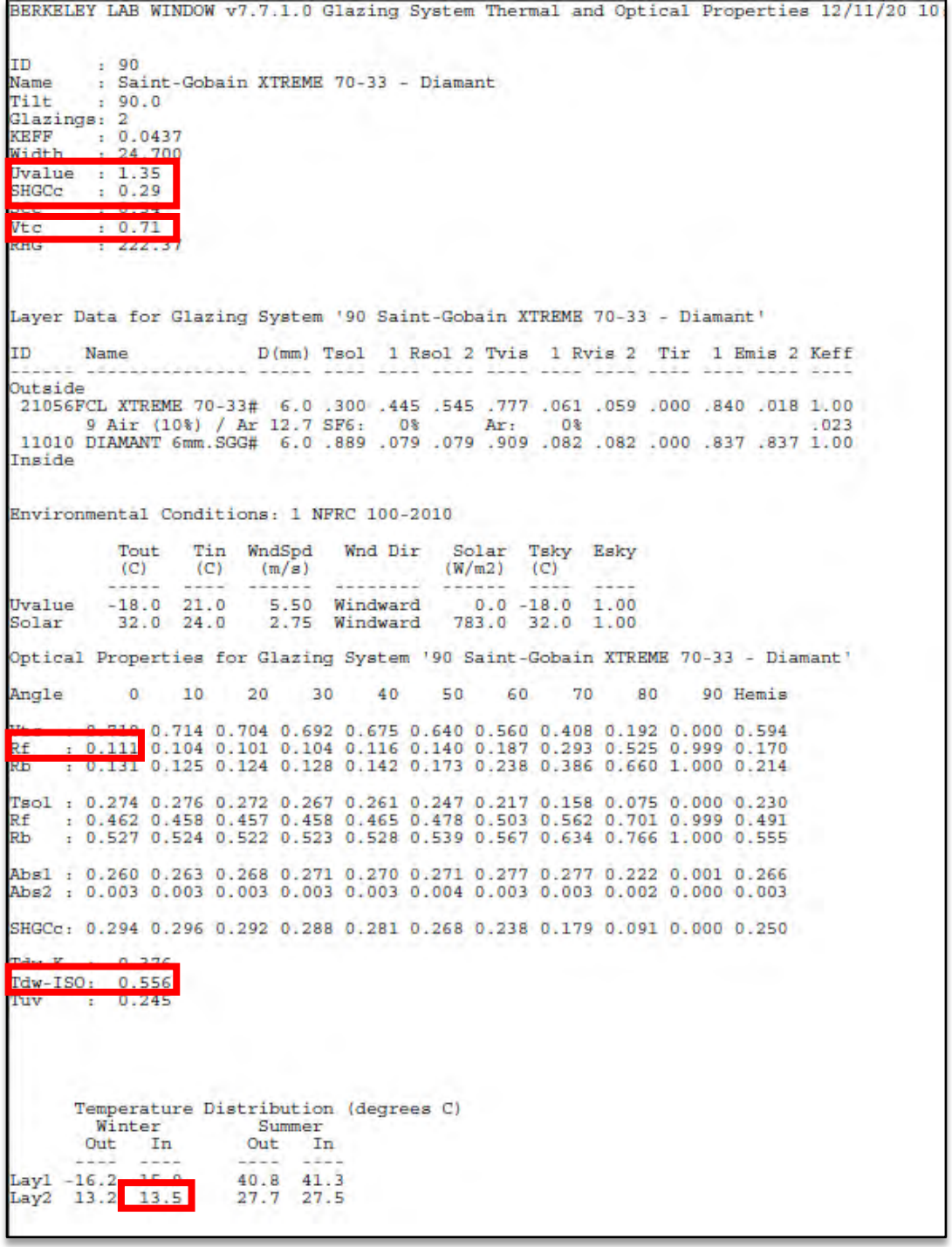
History of Solar Control

- 1950 - 1990
  - Tinted Glass
    - Green
    - Bronze
    - Grey
    - Lower the light transmission
    - Lower the SHG
- 1970-2000
  - Reflective
    - Increase Outside Reflection
    - Combine with Tinted
    - Bright Colourful Buildings
- 1990-Now
  - High Performance Coatings
    - High Light Transmission
    - Neutral colour
    - Low outside reflection
    - High selectivity
      - VLT / SHG > 2
    - Follow the Gillette evolution
      - Single/Double/Triple Silver
      - Cardinal Launches 4 layers

Free calculation tools – USA made at **Berkeley Lab**

- Global database of all glass products
- Updated regularly
- Handles all cases: electrochromic, quadruple, laminated assembly
- Sister program: Optics
- https://windows.lbl.gov/software/window

Sampler Berkeley Lab Window Report



```
BERKELEY LAB WINDOW v7.7.1.0 Glazing System Thermal and Optical Properties 12/11/20 10

ID       : 90
Name     : Saint-Gobain XTREME 70-33 - Diamant
Tilt     : 90.0
Glazings: 2
KEFF     : 0.0437
Width    : 24.700
Uvalue   : 1.35
SHGCc    : 0.29
Vtc      : 0.71
RHG      : 222.37

Layer Data for Glazing System '90 Saint-Gobain XTREME 70-33 - Diamant'

ID     Name             D(mm) Tsol  1 Rsol 2 Tvis  1 Rvis 2  Tir  1 Emis 2 Keff
------ ---------------- ----- ---- ---- ---- ---- ---- ---- ---- ---- ---- ----
Outside
 21056FCL XTREME 70-33#  6.0 .300 .445 .545 .777 .061 .059 .000 .840 .018 1.00
       9 Air (10%) / Ar 12.7 SF6:   0%      Ar:    0%                      .023
 11010 DIAMANT 6mm.SGG#  6.0 .889 .079 .079 .909 .082 .082 .000 .837 .837 1.00
Inside

Environmental Conditions: 1 NFRC 100-2010

          Tout   Tin  WndSpd   Wnd Dir   Solar  Tsky  Esky
           (C)    (C)   (m/s)            (W/m2)  (C)
         -----  ----  ------  --------  ------  ----  ----
Uvalue   -18.0  21.0    5.50  Windward     0.0 -18.0  1.00
Solar     32.0  24.0    2.75  Windward   783.0  32.0  1.00

Optical Properties for Glazing System '90 Saint-Gobain XTREME 70-33 - Diamant'

Angle      0    10    20    30    40    50    60    70    80    90 Hemis

Rf    : 0.111 0.104 0.101 0.104 0.116 0.140 0.187 0.293 0.525 0.999 0.170
Rb    : 0.131 0.125 0.124 0.128 0.142 0.173 0.238 0.386 0.660 1.000 0.214

Tsol  : 0.274 0.276 0.272 0.267 0.261 0.247 0.217 0.158 0.075 0.000 0.230
Rf    : 0.462 0.458 0.457 0.458 0.465 0.478 0.503 0.562 0.701 0.999 0.491
Rb    : 0.527 0.524 0.522 0.523 0.528 0.539 0.567 0.634 0.766 1.000 0.555

Abs1  : 0.260 0.263 0.268 0.271 0.270 0.271 0.277 0.277 0.222 0.001 0.266
Abs2  : 0.003 0.003 0.003 0.003 0.003 0.004 0.003 0.003 0.002 0.000 0.003

SHGCc: 0.294 0.296 0.292 0.288 0.281 0.268 0.238 0.179 0.091 0.000 0.250

Tdw-ISO:  0.556
Tuv    :  0.245

      Temperature Distribution (degrees C)
        Winter          Summer
       Out    In       Out   In
      ----   ----     ----  ----
Lay1 -16.2   15.9     40.8  41.3
Lay2  13.2   13.5     27.7  27.5
```

Sample Saint-Gobain Report

SAINT-GOBAIN

AGNORA

Calumen III 1.15.

Friday, December 11, 2020

Pane 1	DIAMANT (6 mm) COOL-LITE XTREME 70-33
Cavity 1	ARGON (90%) / AIR (10%) / 13 mm
Pane 2	DIAMANT (6 mm)

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Innovation & Technology

LUMINOUS FACTORS

CIE (15-2004)

Light transmission (TL %)	71.0 %
Outdoor reflection (RLe %)	11.2 %
Indoor (RLi %)	13.1 %

SOLAR FACTORS

NFRC

SHGC	0.3016
RHG	227.41 W/m²
Shading Coefficient (SC)	0.3467

COLOR RENDERING

CIE (15-2004)

Transmission (Ra)	95.6
Reflection (Ra)	89.0

ENERGY FACTORS

NFRC

Transmission (Te)	28.2 %
Reflection (Ree)	44.9 %
Indoor (Rei)	53.3 %
Absorption (AE1)	26.5 %
Absorption (AE2)	0.3 %

THERMAL TRANSMISSION

NFRC100

Ug - Winter	1.346 W/m².K
Ug - Summer	1.151 W/m².K

0° related to vertical position

MANUFACTURING SIZES

Nominal thickness	25.0 mm
Weight	30.0 kg/m²

ACOUSTICS

EN12758

Acoustic simulated values	Rw(C;Ctr) = 30(-1;-5) dB

AGNORA Coated Product Range

- Low-e High Light transmission (80%)
- Solar Double silver (70%)
- Solar Triple Silver (70%)
- Solar Triple Silver (60%)

- Planitherm XNII
- SKN076
- XTREME 70-33
- XTREME 60-28
- Mirror

SAINT-GOBAIN

- Clarity (Anti-Reflective)
- Bird 1st
- SN 68
- SNX 62/27
- IS20 (4th)

GUARDIAN GLASS

- Energy Advantage
- Mirropane
- Optiview
- Optiwhite

PILKINGTON

NSG GROUP

- LoĒ180
- LoĒ²272
- LoĒ³366

CARDINAL Glass Industries

Thank you!


AGNORA