



Toolkit:

Energy efficient building technologies

Buildings: Session 4

*Buildings energy
efficiency sessions
in partnership with:*



**INDO-SWISS BUILDING
ENERGY EFFICIENCY PROJECT**



**WORLD
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Energy Efficiency Training Week: Buildings Program

1. **Where to start:** Energy use in buildings
2. **Where to start:** Energy efficiency potential in buildings
3. **Toolkit:** Energy efficient building design
4. **Toolkit:** Energy efficient building technologies
Where do I get help? IEA's Technology Collaboration Programmes
5. **Toolkit:** Energy efficiency policies and target setting
6. **What are the steps?** Enabling investment with energy efficiency policies
7. **What are the steps?** Implementing building energy codes and standards
8. **What are the steps?** Building operations and procurement
Special session. The multiple benefits of energy efficiency
9. **Did it work?** Evaluation and energy efficiency indicators
Where do I get help? International and regional energy efficiency initiatives
10. **Energy efficiency quiz:** Understanding energy efficiency in buildings

4. Toolkit: Energy efficient building technologies

Trainers: Brian Dean and Pierre Jaboyedoff

Purpose: To teach the fundamentals of building technologies and energy efficiency products that can reduce energy use in buildings. This course will discuss building technologies including building envelope, HVAC systems, lighting and controls.

Scenario: Stakeholders are saying that new policies are not possible because the technology is not available that enables increased energy efficiency. *What technologies could change your market for energy efficiency?*

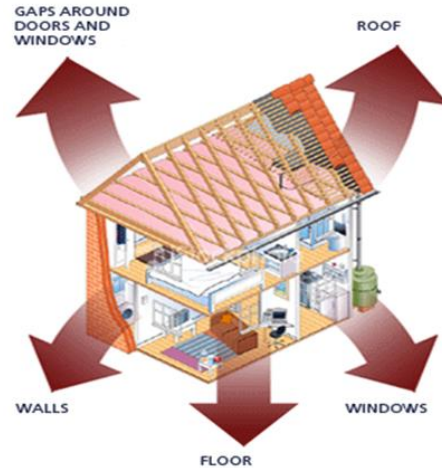
Building envelope technology

Insulation

Air sealing

Windows

Roof

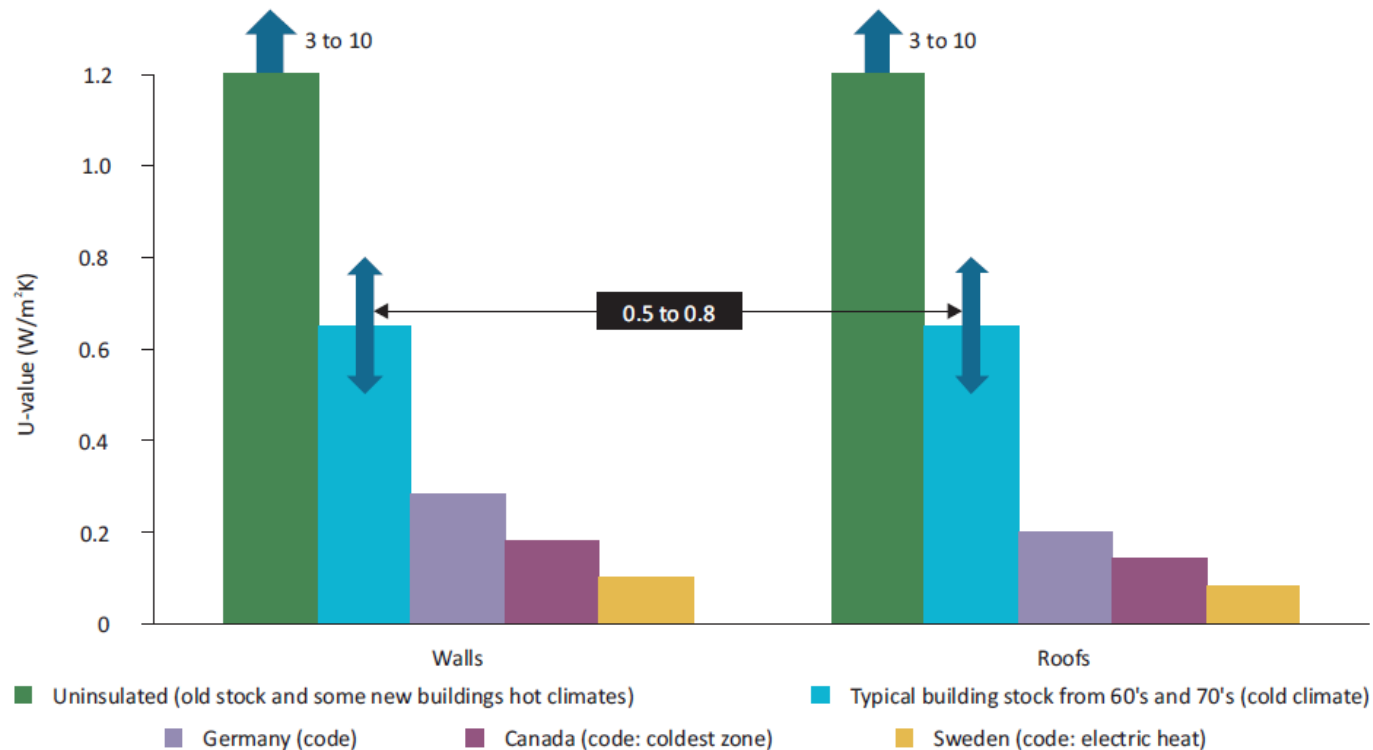


Building envelope technology: insulation

**Recommended
average wall and
roof U-values
based on lifecycle
cost effectiveness:**

**$\leq 0.15 \text{ W/m}^2\text{K}$ cold
climate**

**$\leq 0.35 \text{ W/m}^2\text{K}$ hot
climate**



**Insulation levels vary widely in the existing building stock.
Efficient new buildings have increased insulation (low u-value)**

Building envelope technology: insulation (exterior)



Before



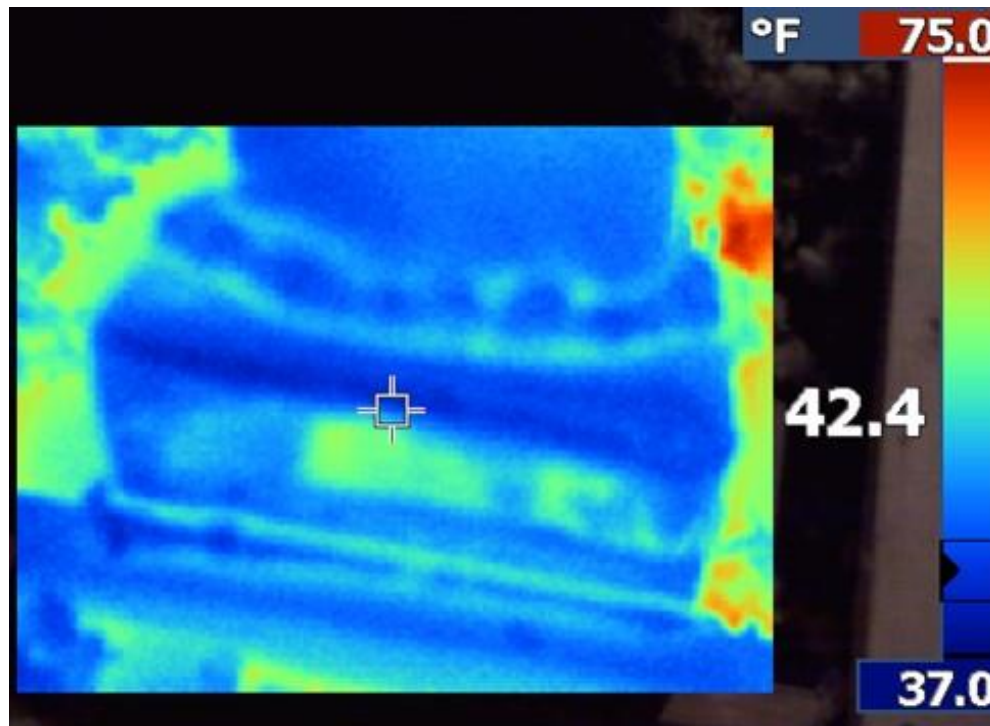
After

Exterior insulation is best approach to reduce thermal shorts/thermal bridges and can applied with external material. Applicable to all building types, but challenging for historic buildings.

Building envelope technology: air sealing



Sealing the connection



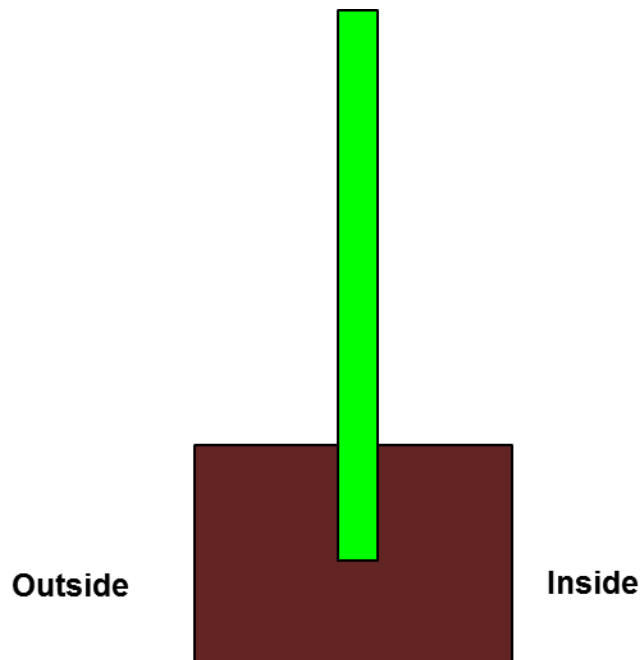
thermal image

Air sealing typically accounts for 10-30% of heating and cooling loss. However, air sealing can be easily applied and verified with infrared camera and air pressure tests.



- **Validated air sealing** is a critical measure for building codes and renovation
- Testing of large multi-family buildings can be expensive – possible to institute **sampling and workmanship criteria to reduce cost**
- More research needed to offer more affordable testing but **many low cost and simple solutions exist today**
 - New research is occurring on a whole building air-based sealant (to seal the building envelope), by the inventors of Aeroseal (for duct sealing)

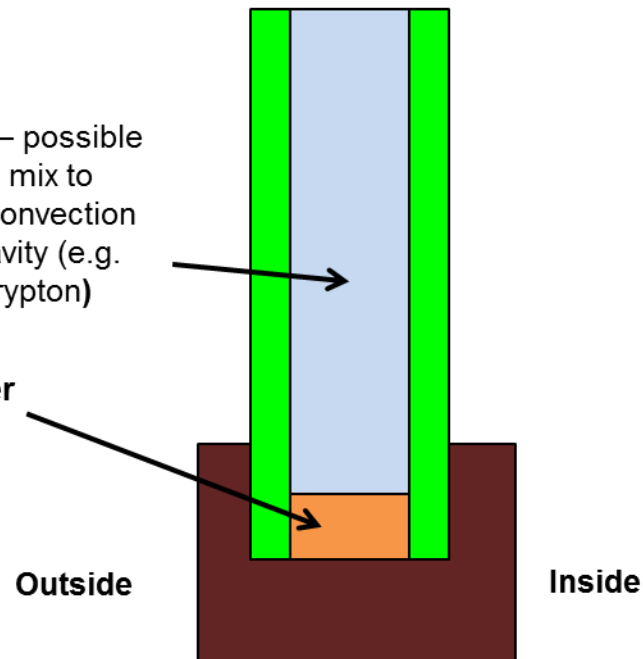
Single glazing



Double glazing

Air gap – possible inert gas mix to reduce convection within cavity (e.g. argon, krypton)

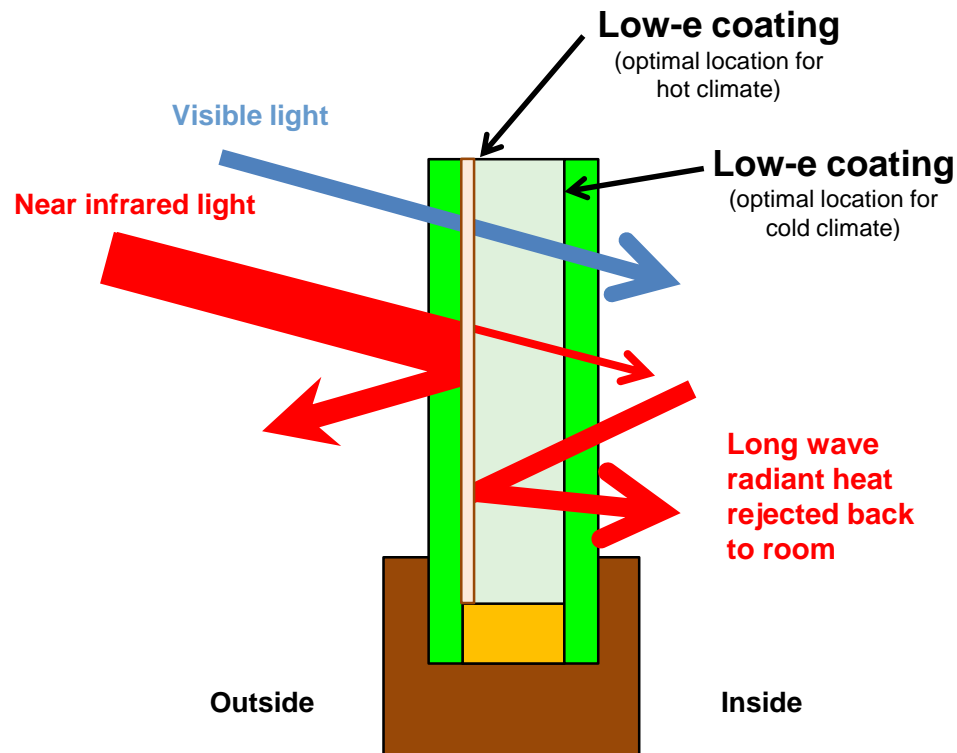
Spacer



Single glazing windows are highly inefficient in all climate types.

Low emissivity films

- **Transparent metal coatings** that reflect radiant heat (long wave radiation) combined with solar selective coatings that reflect visible light and near-infrared light (heat we feel)
- **Typical savings of 30% to 40%**
- Commonly applied to new windows, but can also be installed in retrofit low-e storm panels and low-e window films when window replacement is not possible

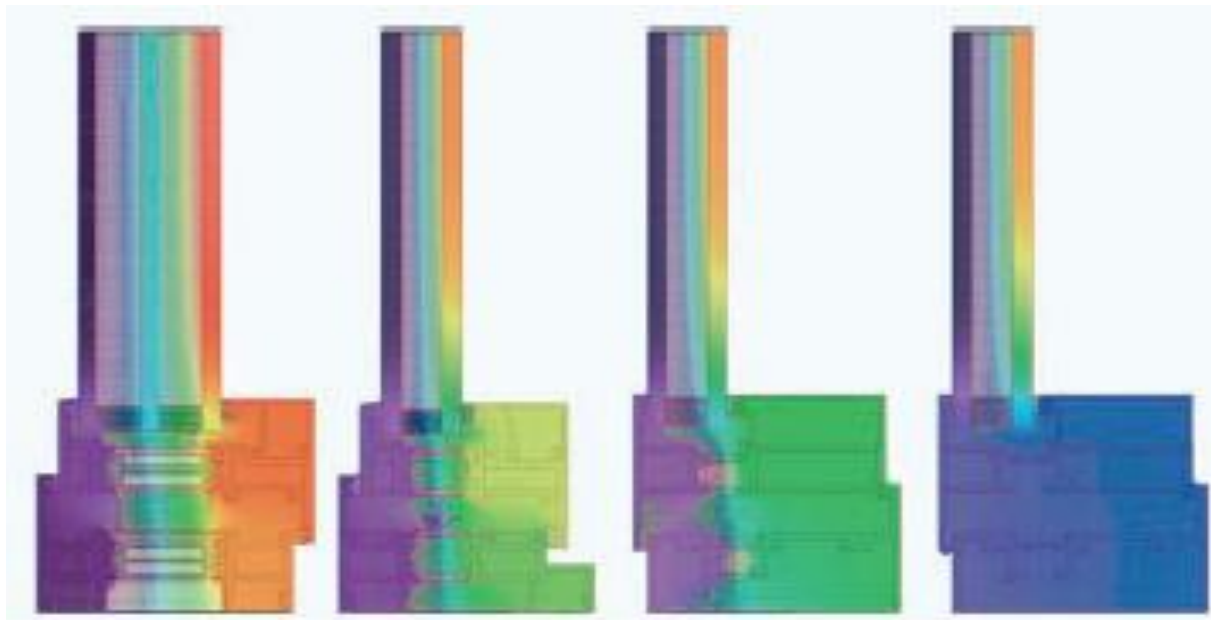


Low-e coatings can be a low cost and highly efficient addition to windows.
Do you know the market share of low-e glass in your country?

Window low conductive frames

Outside

Inside

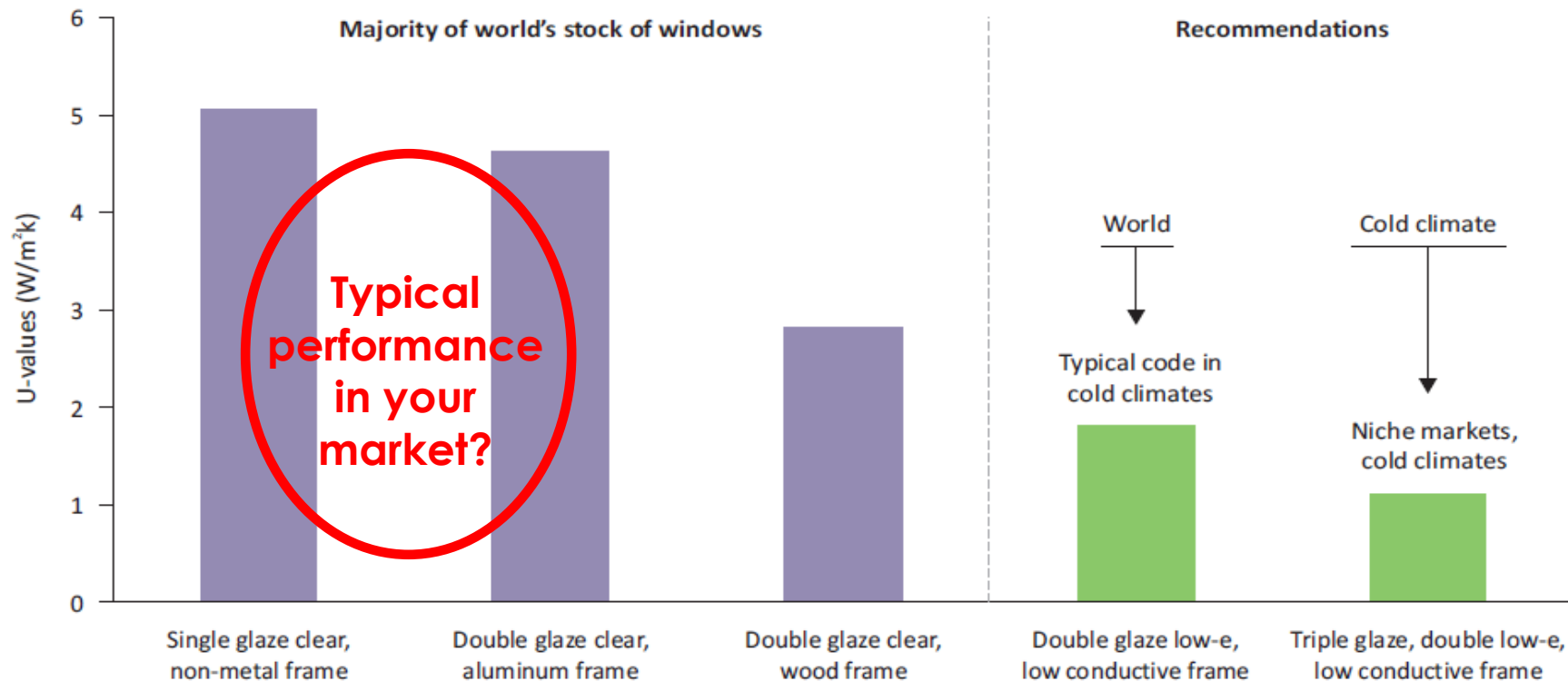


Advanced, warm
interior in winter

Improving performance

Old, no thermal break,
cold interior in winter

Building envelope technology: window market



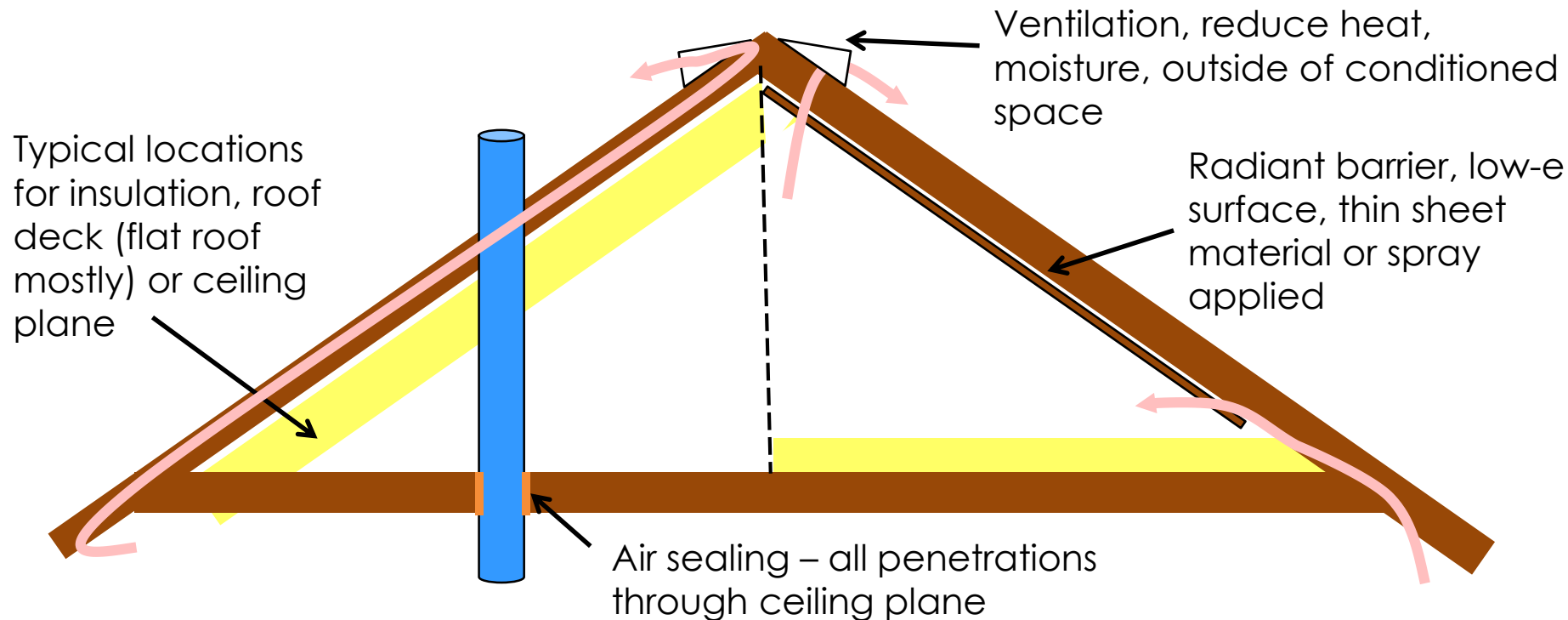
The majority of the world's installed windows can be significantly improved and more work is needed to ensure that new sales meet more stringent performance criteria.

Building envelope technology: window and building shading



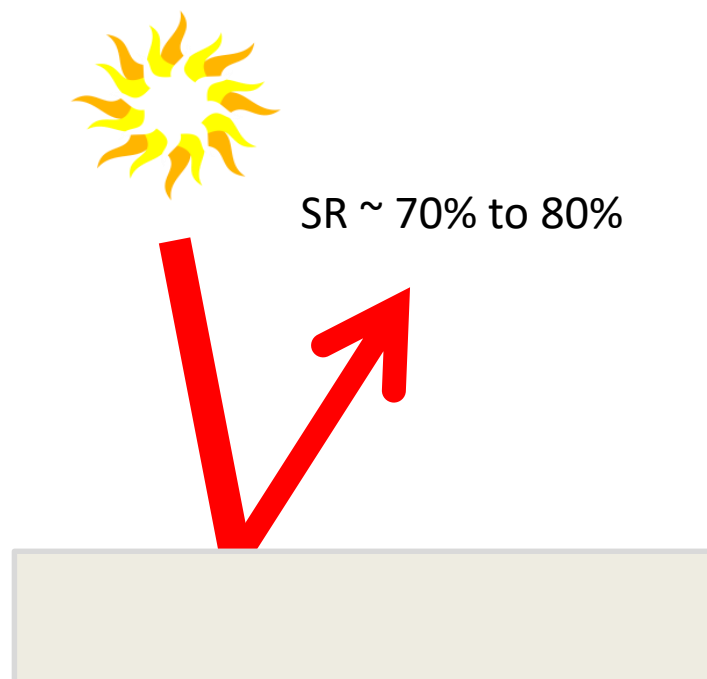
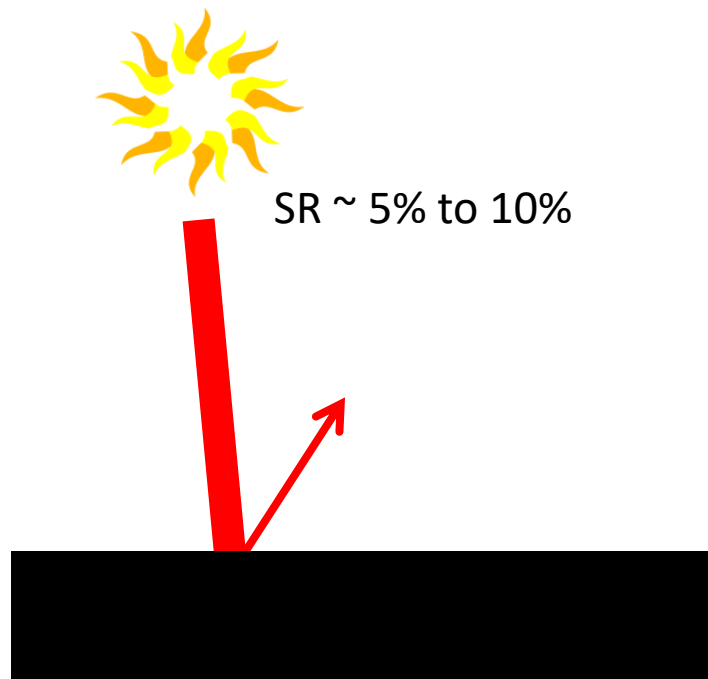
Ancient and modern shading can be a no or low cost demand efficiency measures.

Building envelope technology: roof as a system



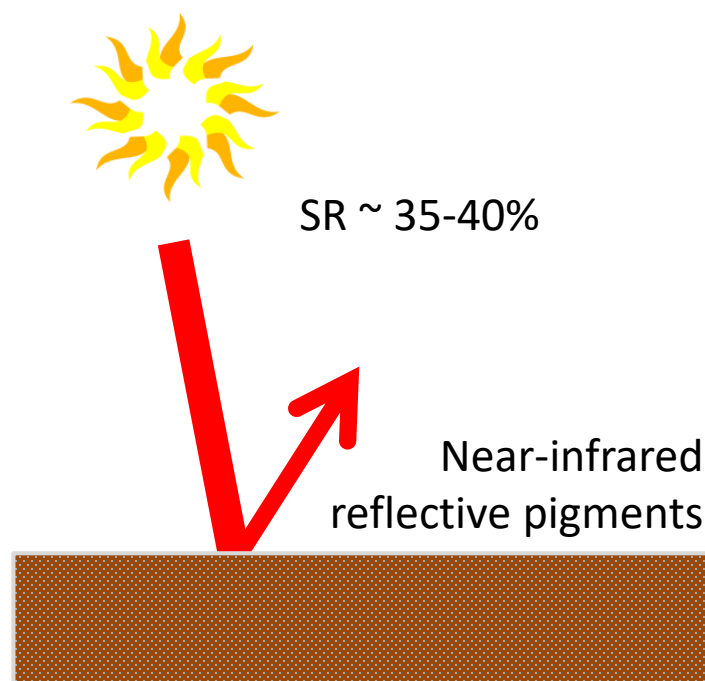
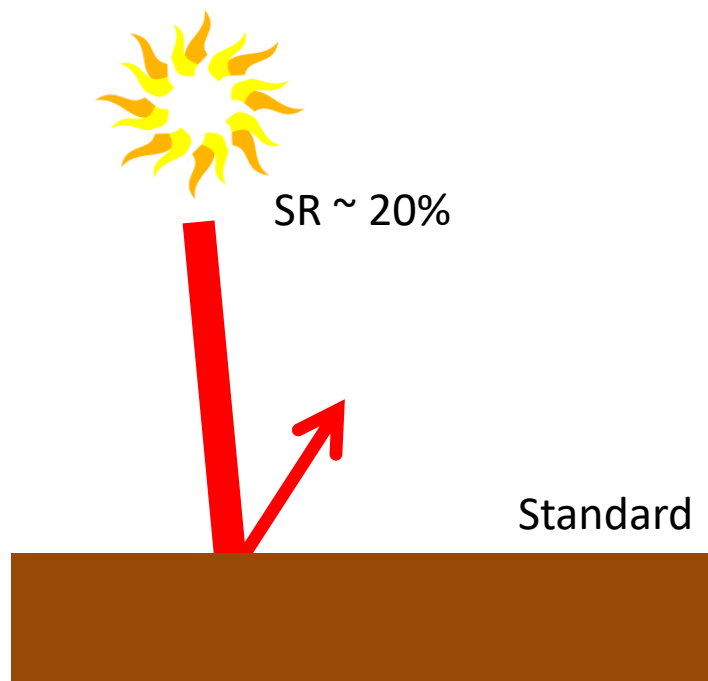
Insulation, air sealing, ventilation, radiant barriers, are all important factors, with the best approach depending on the type of roof (pitched, low-slope, or flat)

Building envelope technology: roof reflectance (visible colour)



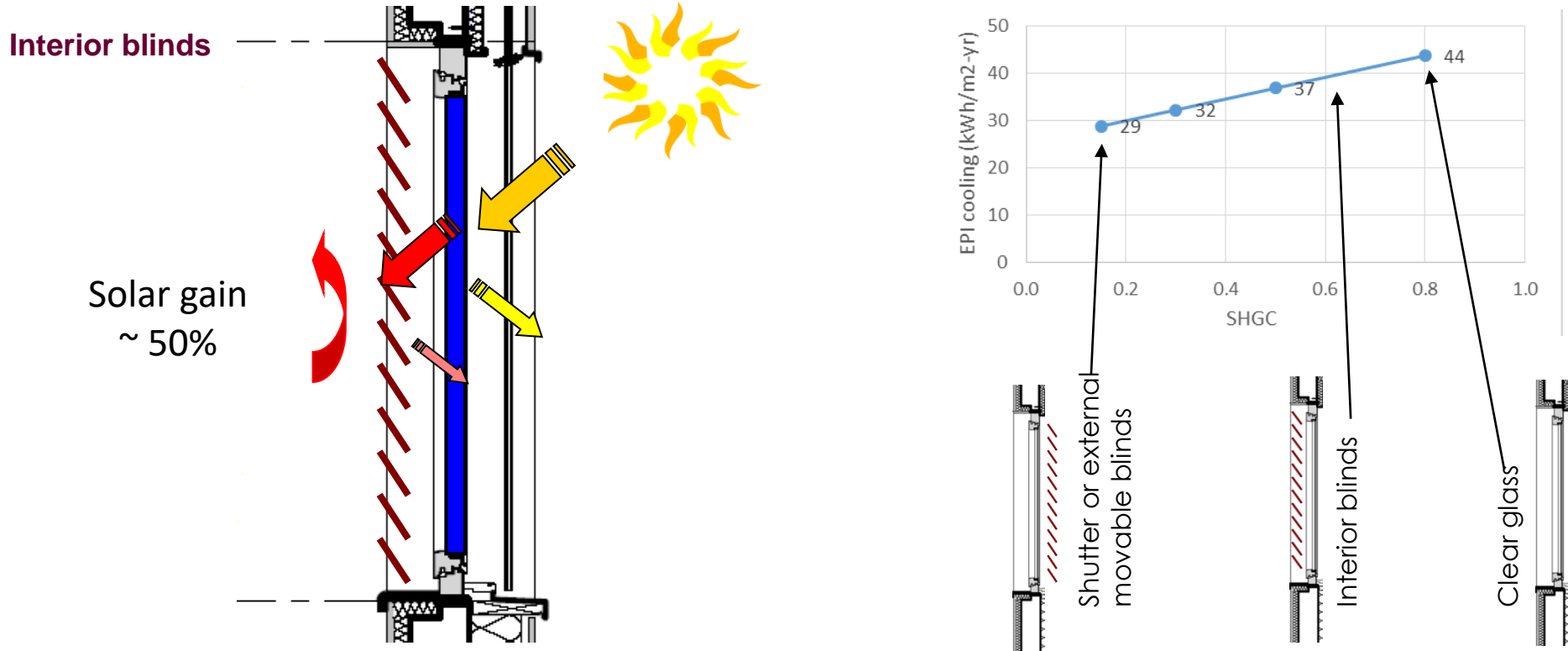
**Solar reflectance rejects heat from sun.
Visible colour can change the amount of heat that enters the building.**

Building envelope technology: roof reflective pigments



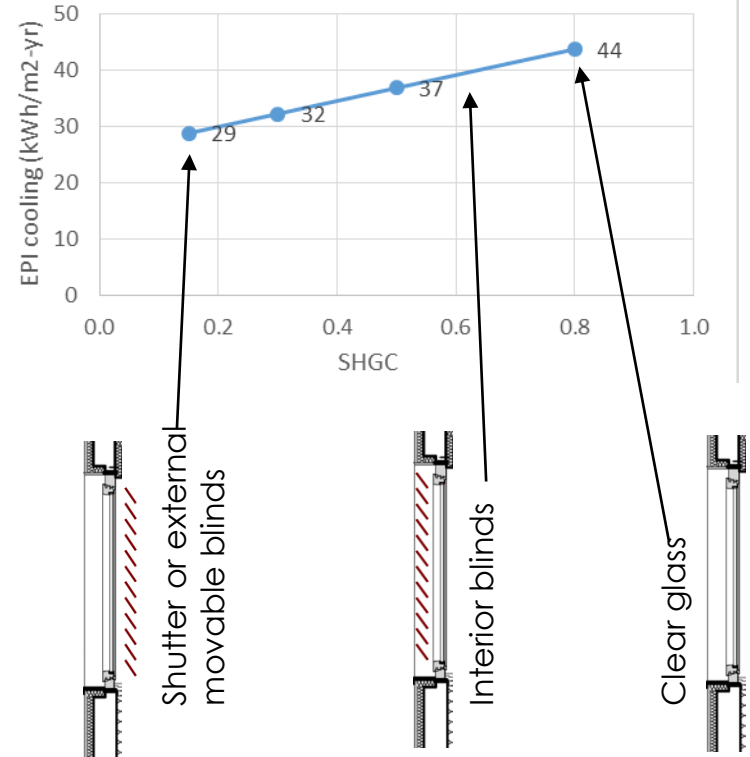
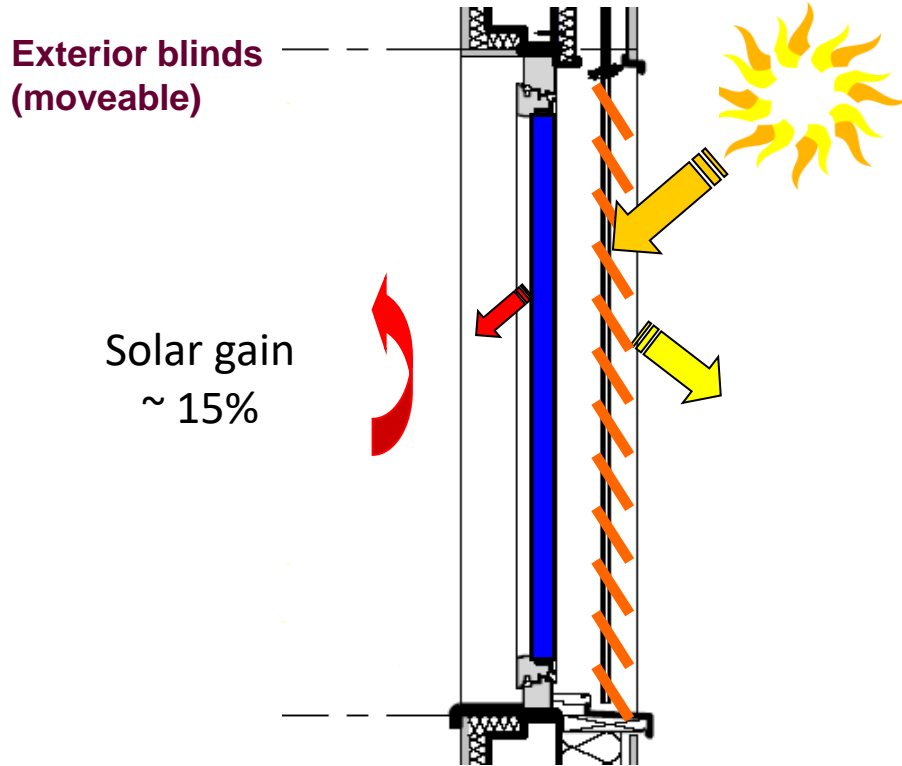
Near infrared reflective pigments reflect the heat we feel, not the visible light.

Building envelope technology: internal vs. external shading



Internal shades still allow the solar heat gain to enter the building.

Building envelope technology: internal vs. external shading



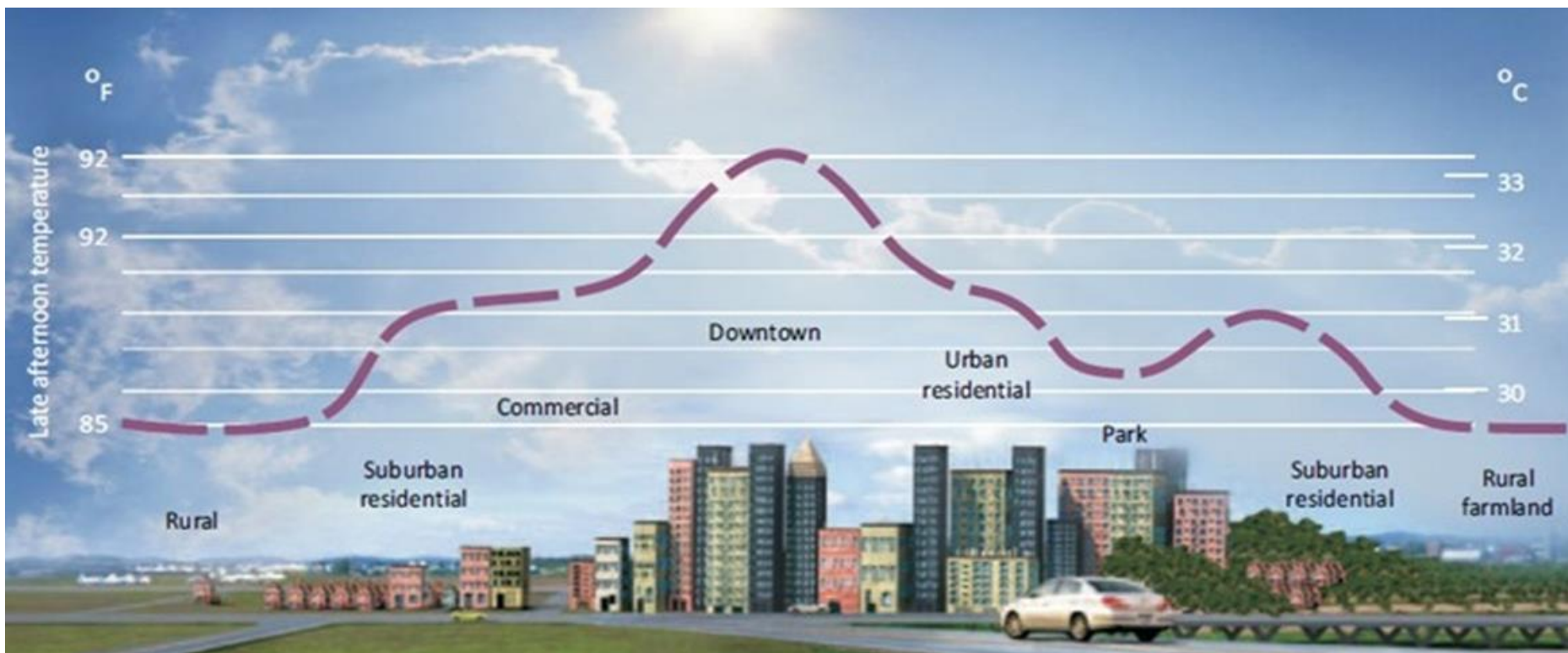
External shades keep out much more heat than internal shades.

Building envelope technology: integrated solutions



Dynamic windows, dynamic shading, renewable integration (passive and active)

Building envelope technology: reflectance impact on heat island



High density of low solar reflectance surfaces increases the heat absorption and heat islands in cities.

Examples of some of the newest technologies

- **Sealing:**
 - Aeroseal for ducts
 - Aeroseal for building envelopes
- **Windows:**
 - Dynamic glazing (tinting)
 - Solar PV integrated clear windows
- **Insulation:**
 - Vacuum insulated panels
 - Aerogel insulation
 - Phase-change material insulation
- **Data collection and energy models:**
 - Drive by image collection and satellite image collection translated to building energy models

Building equipment and systems

Heating (space and water)

Cooling

Ventilation

Lighting



Building equipment and systems: heating



Shifting to more efficient and renewable integrated technologies.

Heat pump R&D

Cold climate

Small gas thermal COP > 1.2 up to 1.8

Standards

Ban electric resistance heaters

Require condensing gas boilers

Promote solar thermal systems

Lower costs systems

R&D for cooling

Integrated district heating

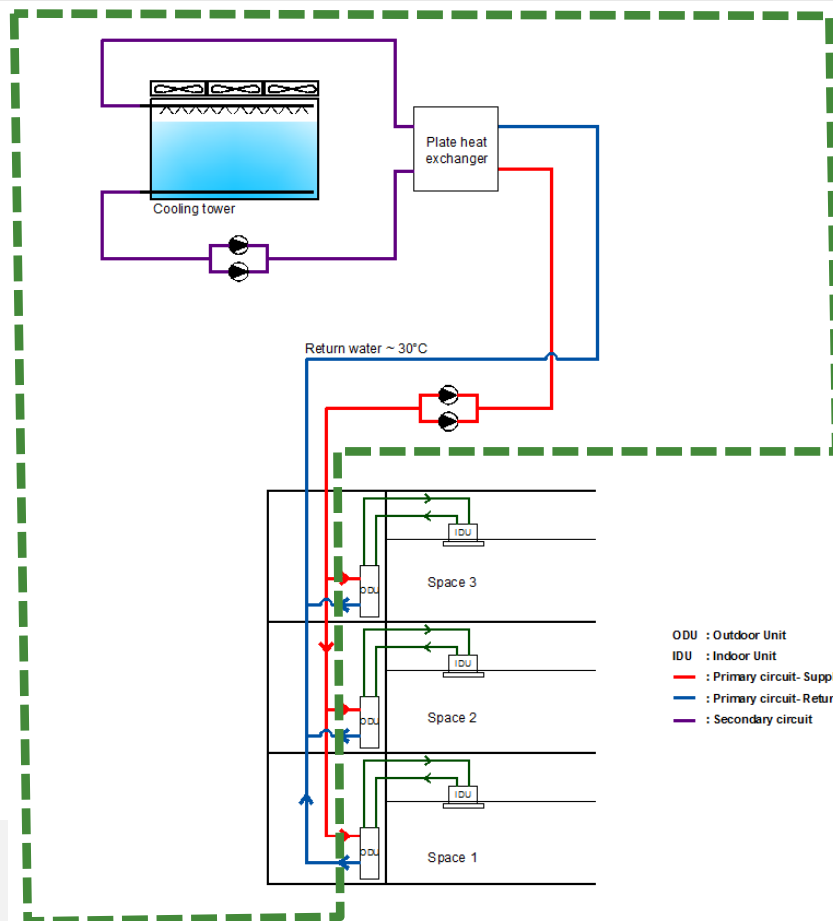
Greater renewables, waste heat & co-generation

Advanced district heating with efficient building envelopes



For Residential: Water cooled multi-split

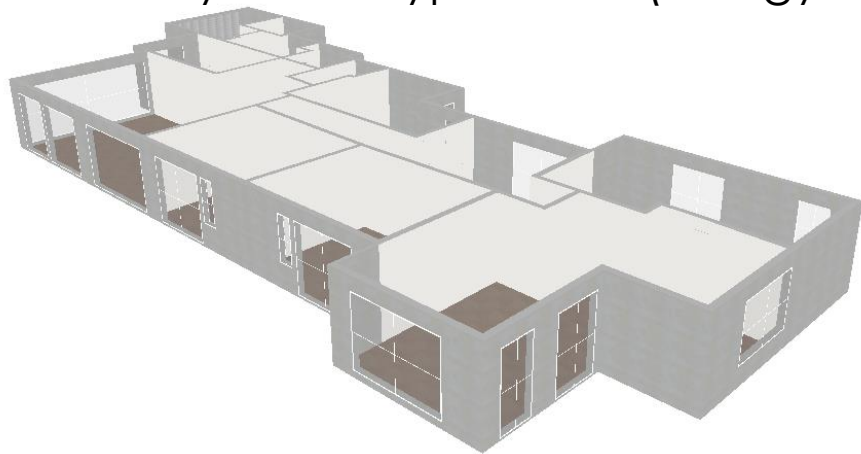
- Water is cooled in a cooling tower.
- This cooled water is supplied in a centralized water loop to the split units to cool the condensers.
- The indoor unit (evaporator) remains the same as that in an air-cooled split air-conditioner.
- The outdoor unit is replaced by a connected water-cooled condensing unit. The condensing unit houses a compressor and a heat exchanger with a provision of letting water in and out connected to the cooling tower.



30-50% reduction for cooling

Example design: High end Tower energy and comfort optimisation

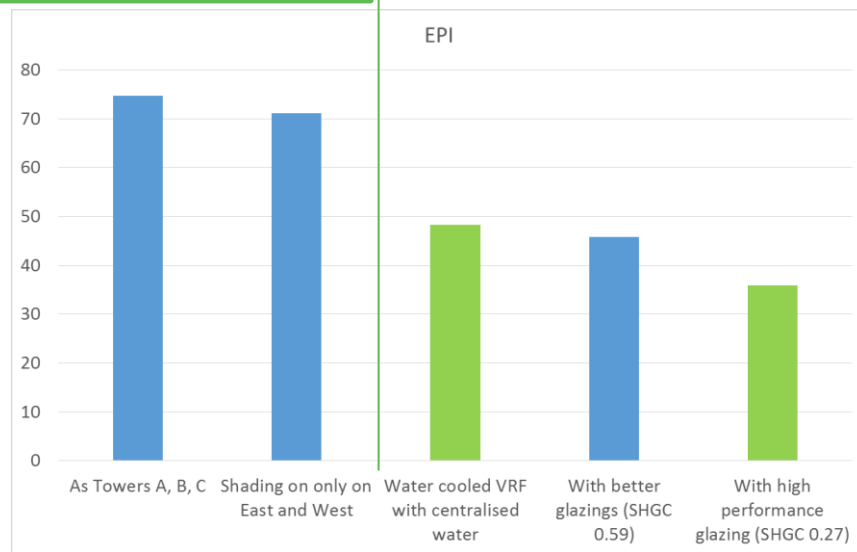
- Analysis of a typical flat (EnergyPlus+TRNSYS simulations)



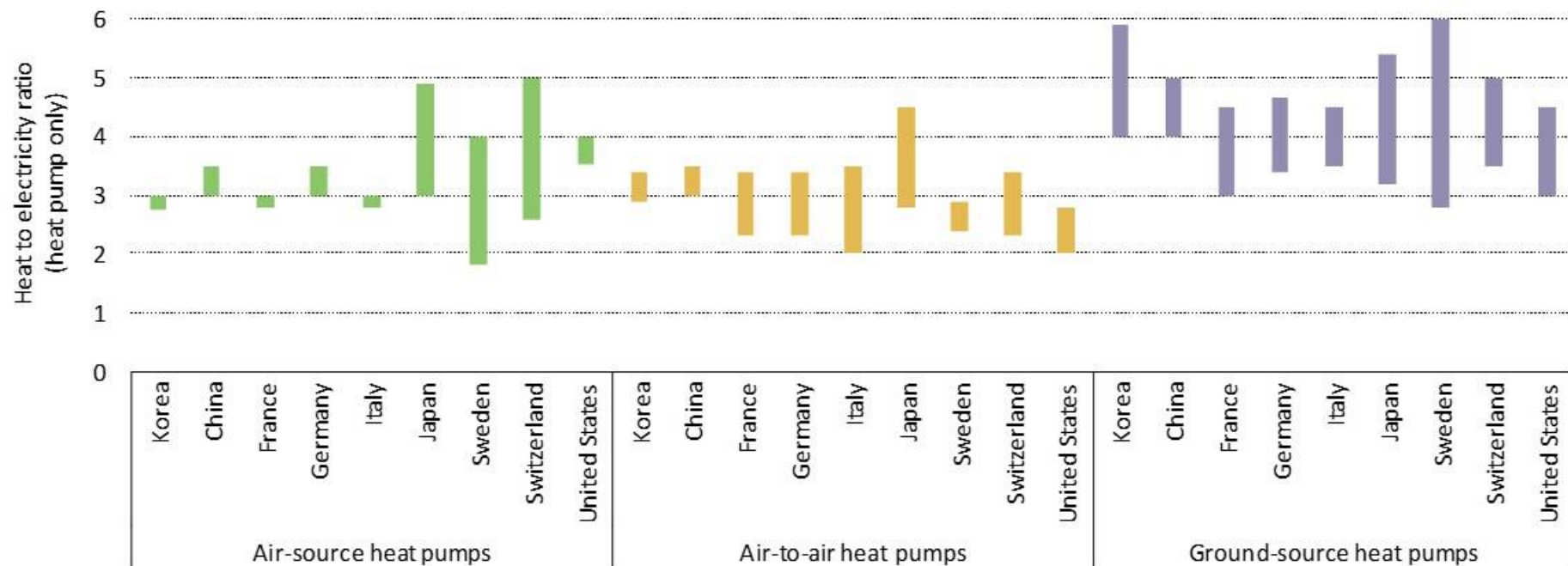
Small architectural improvement
Real potential much higher

Improvement through cooling technology and reduced solar heat gains

Through simple measures to improve the envelope and use of water cooled VRF systems, the electricity consumption can be reduced by ~50%



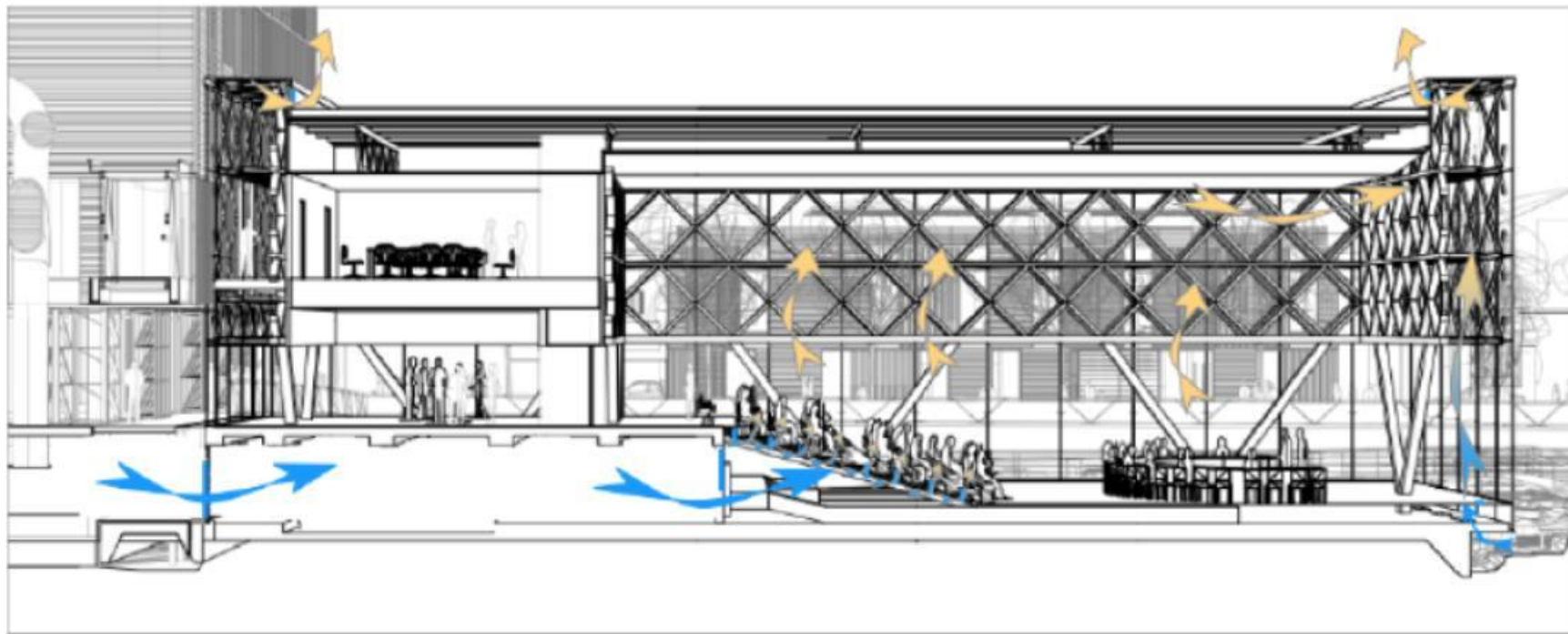
Building equipment and systems: water & space heating/cooling



**Heat pumps reduce energy consumption > 60%.
Free up electricity for other uses (e.g. electric vehicles).**

- Mechanical
 - Fan exhaust or supply
 - Heat/energy recovery ventilation
- Natural
 - Cross ventilation
 - via wind
 - via temperature
 - Stack ventilation
 - via air stratification
 - via temperature induced exhaust
- Hybrid





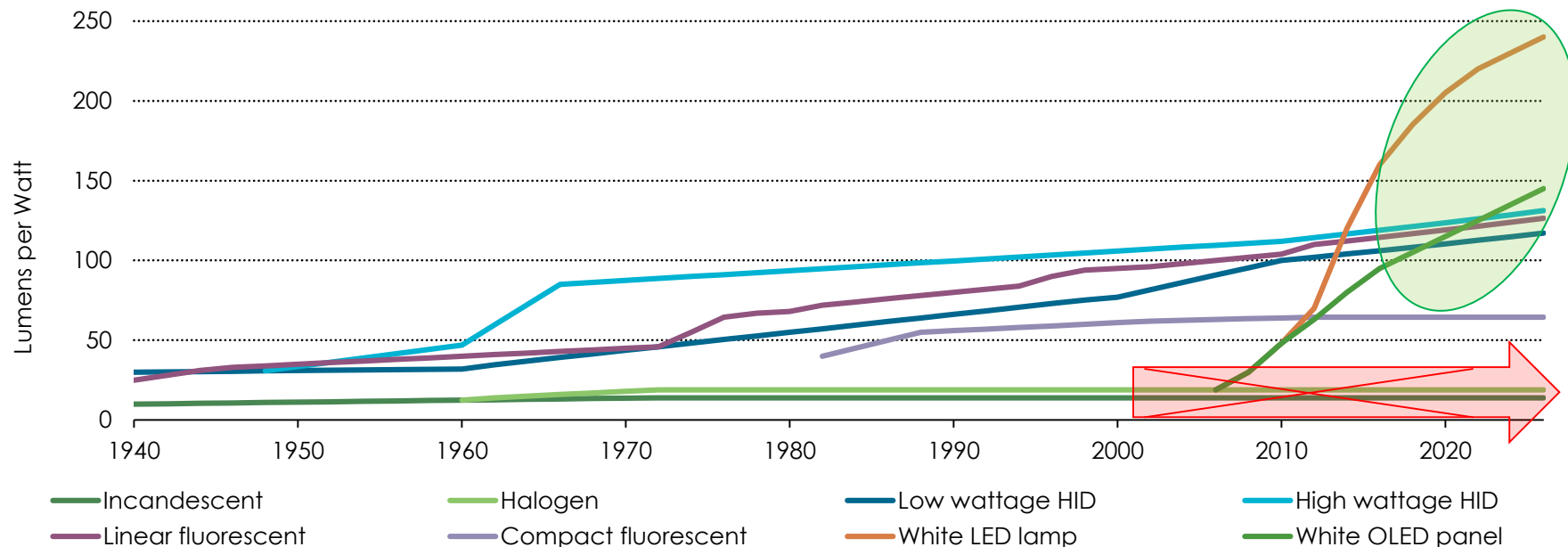
Natural ventilation (stack/stratification) in combination with mechanical ventilation to enable comfort

- Hot and dry climates, composite
 - Evaporative cooling
 - Direct
 - Indirect
 - Passive Downdraft Evaporative Cooling
- Hot and humid climates
 - Present HVAC technology
 - Dehumidification by cooling below the dew point
 - Future ?
 - Isothermal membrane based dehumidification



Shifting to high performance technologies

Lighting equipment performance



Technology performance improvements continue to drive energy efficiency, but energy policy needs to keep up with the technology...

Building equipment and systems: lighting (passive)



**Passive solar lighting can reduce lighting energy use.
But shading can increase lighting energy use.**

Examples of some of the newest technologies

- **HVAC:**

- Natural gas heat pumps
- Cold climate heat pumps
- Modulating refrigerant to optimize EER/COP of HVAC systems
- Building control optimization
- Fault detection automation
- Seasonal thermal storage with heat pumps

- **Lighting:**

- Advanced LED lighting with sensors and controls

- **Data centers:**

- Immersion cooling
- Liquid cooling direct to computer chip

Summary

Technology roadmaps

Advanced technologies

What can change your market?



Building technology roadmaps

- Construction transformation strategy
- Technical, economic and strategic framework
- Assessment of high priority areas for 12 regions of the world
- Policy criteria and evaluation



Technology Roadmap
Energy efficient building envelopes



Technology Roadmap
Energy-efficient Buildings: Heating and Cooling Equipment

Each roadmap sets an approach to identify how to transition to new more efficient technologies.

Whole building

- High-performance envelope components and whole building packages
- nZEB(+) building construction across all countries
- Low-cost deep energy renovation solutions
- Zero-carbon building energy communities

Heating and cooling equipment

- Improved thermal distribution and control
- High-performance heat pumps and solar thermal solutions
- Responsive and affordable thermal energy storage
- Integrated, flexible district energy solutions

Lighting and appliances

- High-performance, lower cost solid state lighting
- Integrated design and control for lighting service
- High-efficiency appliance technologies
- Performance standards for plug loads and smarter use of connected devices

Cooking and energy access

- Clean, affordable cooking solutions for developing countries
- Low-cost solar thermal and storage solutions
- Efficient, low-polluting biomass solutions

What can change your market?

Scenario:

Stakeholders are saying that new policies are not possible because the technology is not available that enables increased energy efficiency.

What technologies could change your market for energy efficiency?

Group Activity: *Break into a team of 4-5 people. As a team, identify key technology features that can make a new building in your region or country energy efficient.*



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