Toolkit:

Energy efficient technologies

Buildings

Buildings energy efficiency sessions in partnership with:

BEEP

INDO-SWISS BUILDING ENERGY EFFICIENCY PROJECT

IEA #energyefficientworld

Energy Efficiency Training Week: Buildings programme

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

   Special session. Technology demonstration

   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 technologies

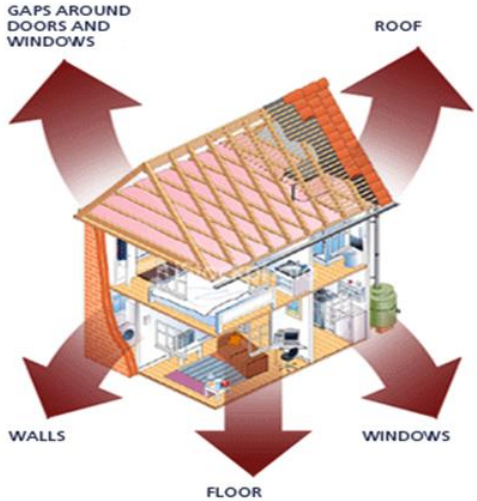
Insulation

Air sealing

Windows and doors

Shading (interior, exterior and vegetative)

Roof (roof system, cool roof and green roof)

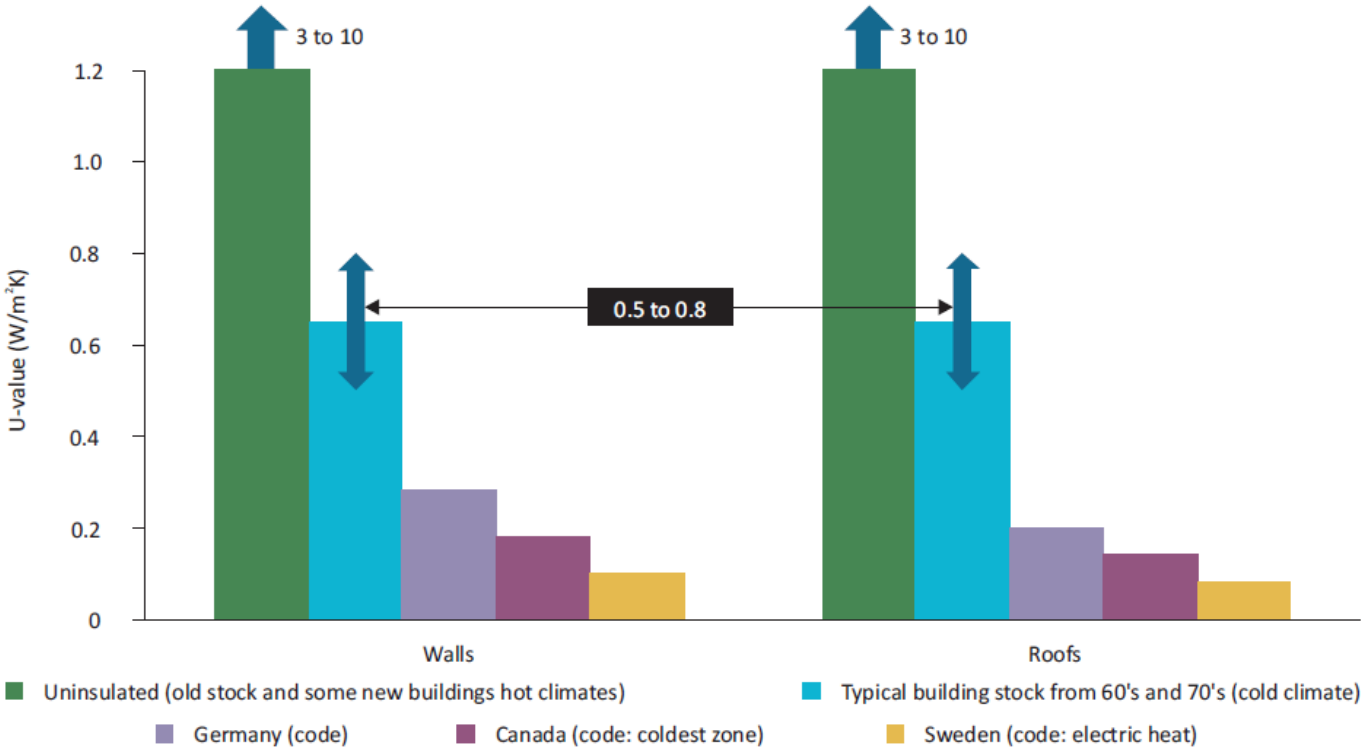


Building envelope technology: insulation

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

≤ 0.15 W/m²°C cold climate

≤ 0.35 W/m²°C hot climate



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

Source: IEA Building Codes Policy Pathway and Transition to Sustainable Buildings

Building envelope technology: insulation (exterior)

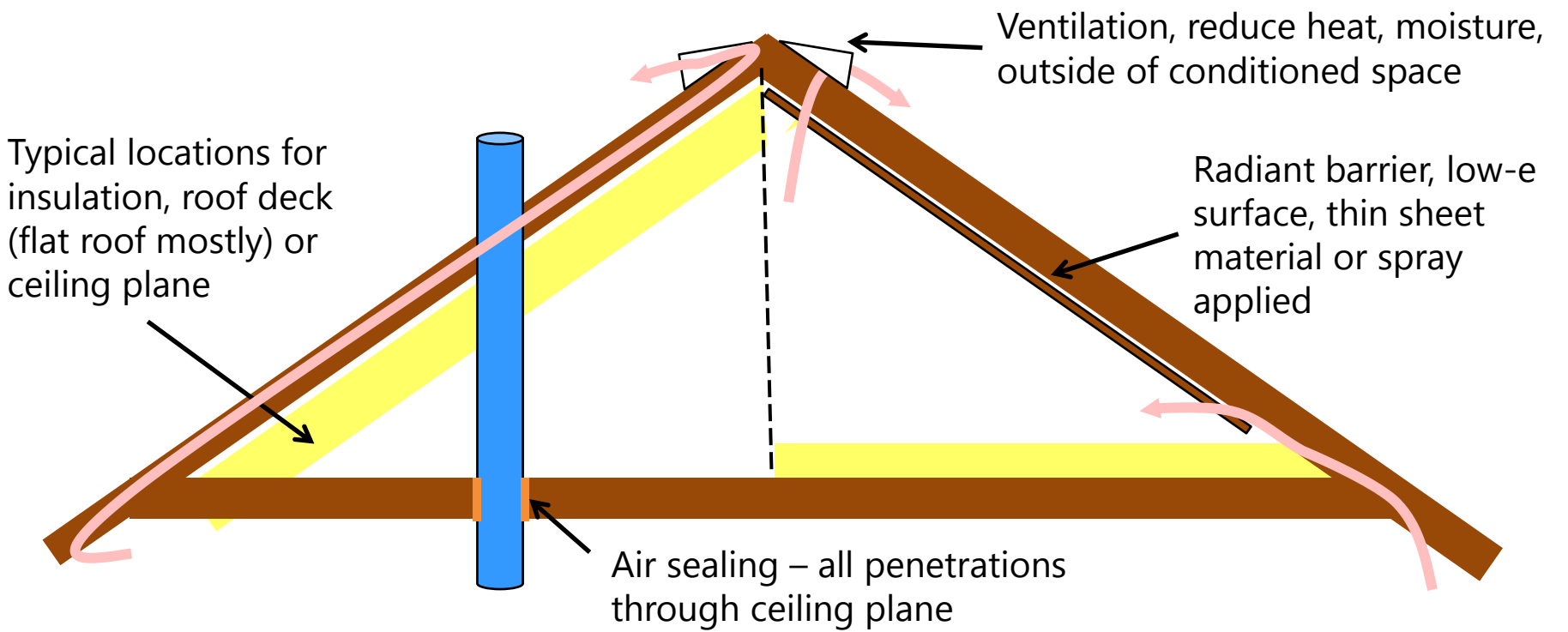
Before

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.

Source: Sto Corporation

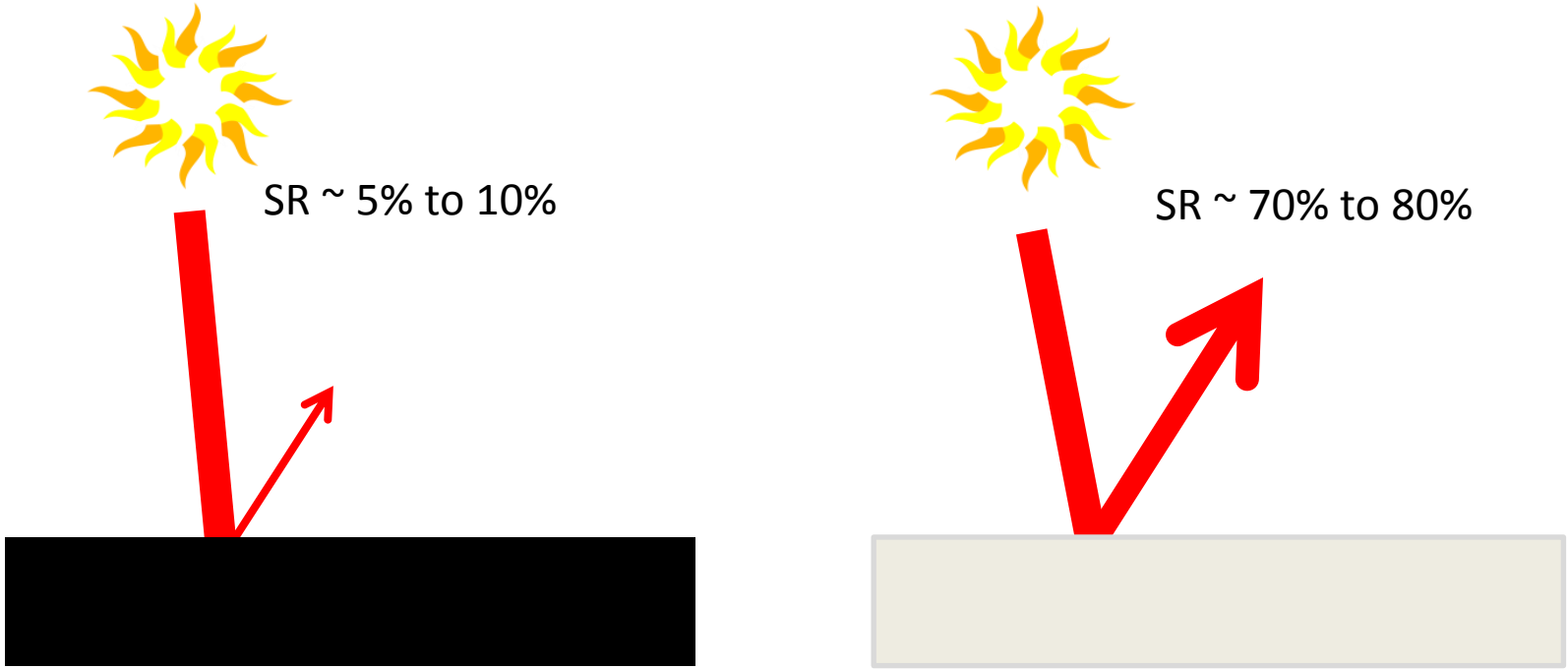
Building envelope technology: roof as a system



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)

Source: IEA Energy Efficiency Training Week

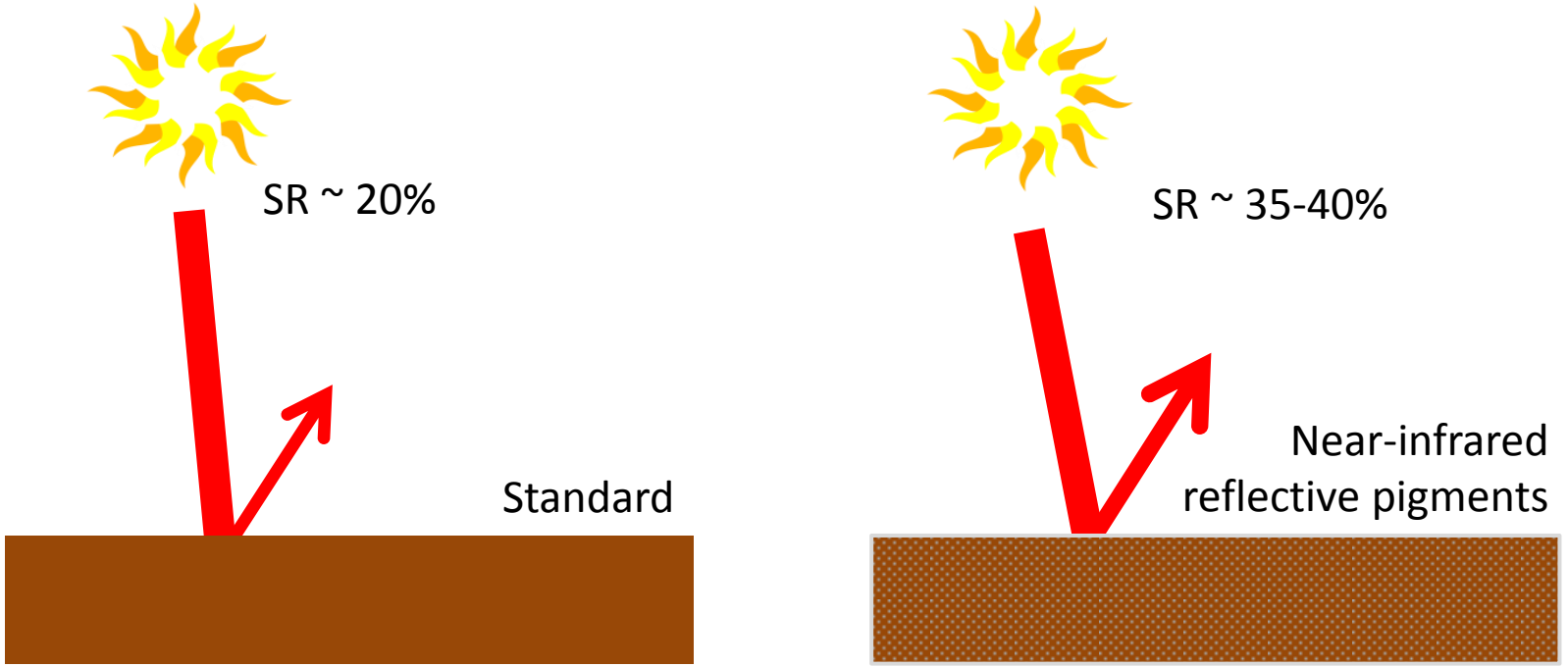
Building envelope technology: roof reflectance (visible colour)



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

Source: IEA Energy Efficiency Training Week

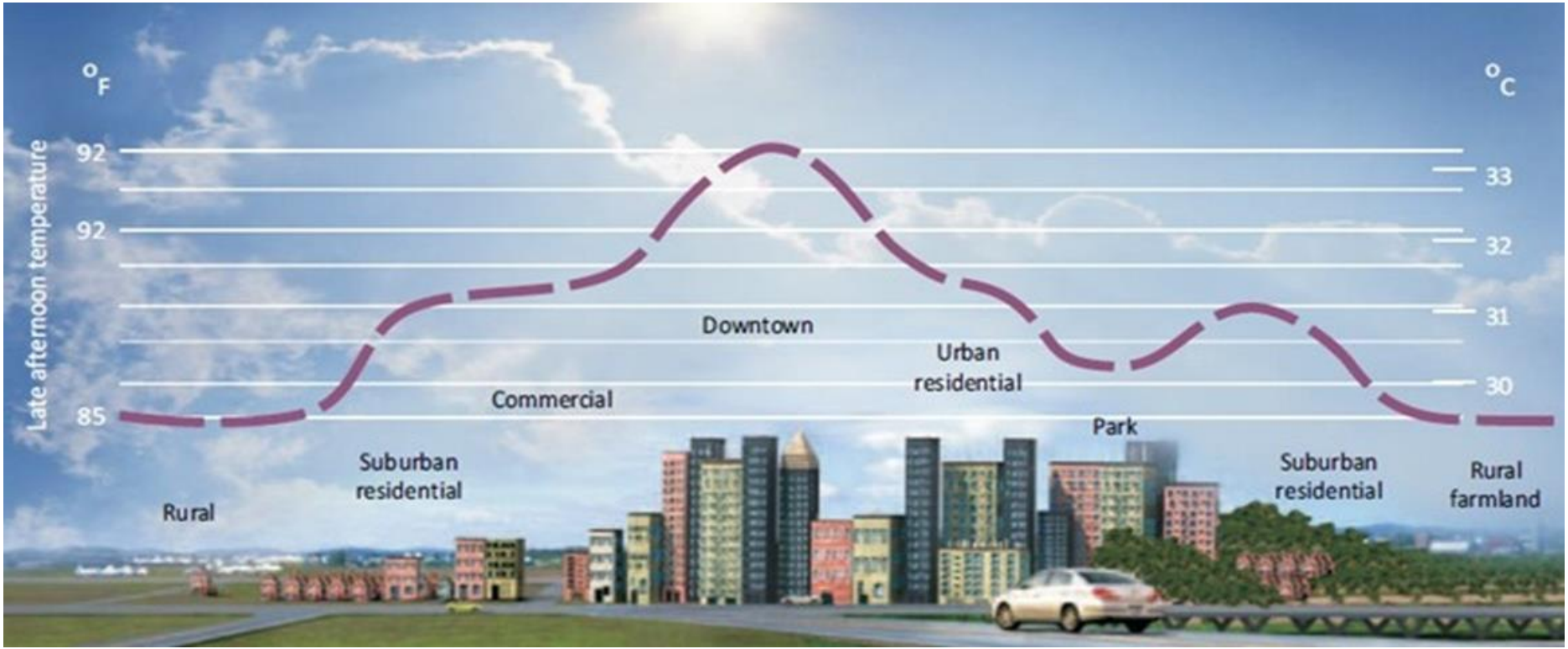
Building envelope technology: roof reflective pigments



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

Source: IEA Energy Efficiency Training Week and www.sciencedirect.com/science/article/pii/S1877705812014531

Building envelope technology: reflectance impact on heat island

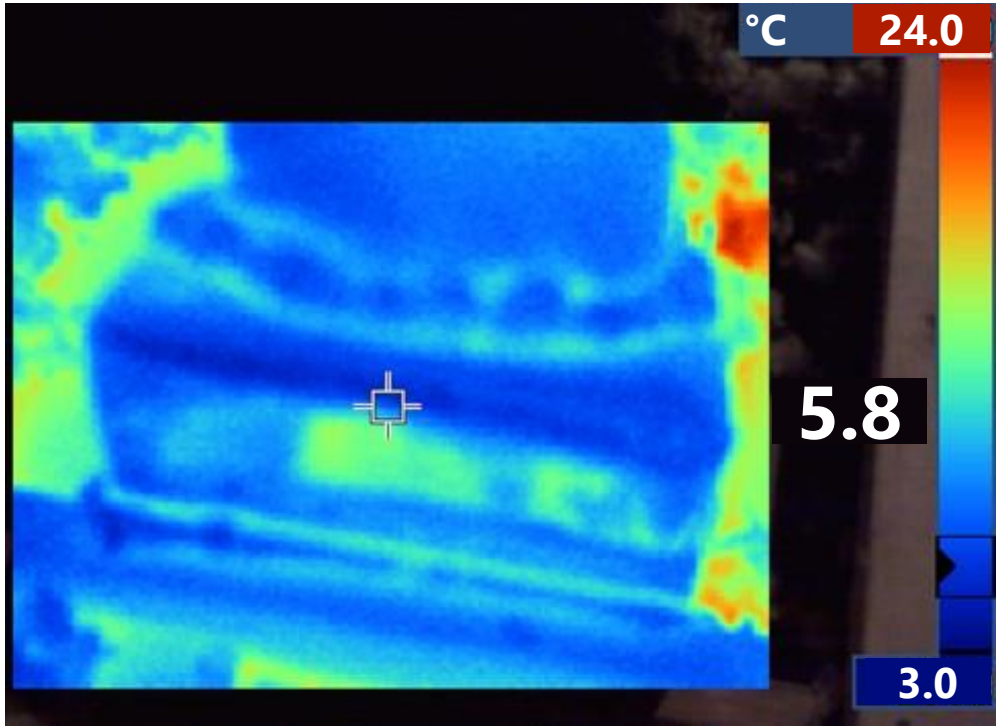


High density of low solar reflectance surfaces increases the heat absorption and heat islands in cities.

Source: LBNL

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.

Source: Marc LaFrance

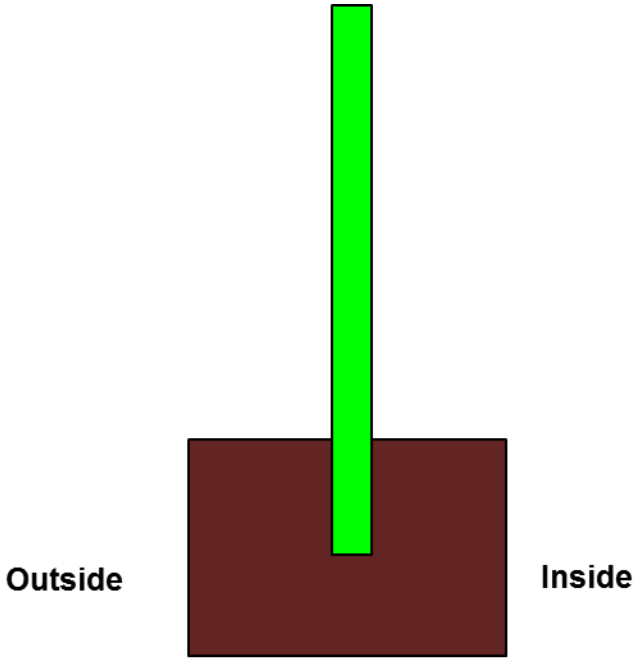
Building envelope technology: air sealing

- **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)

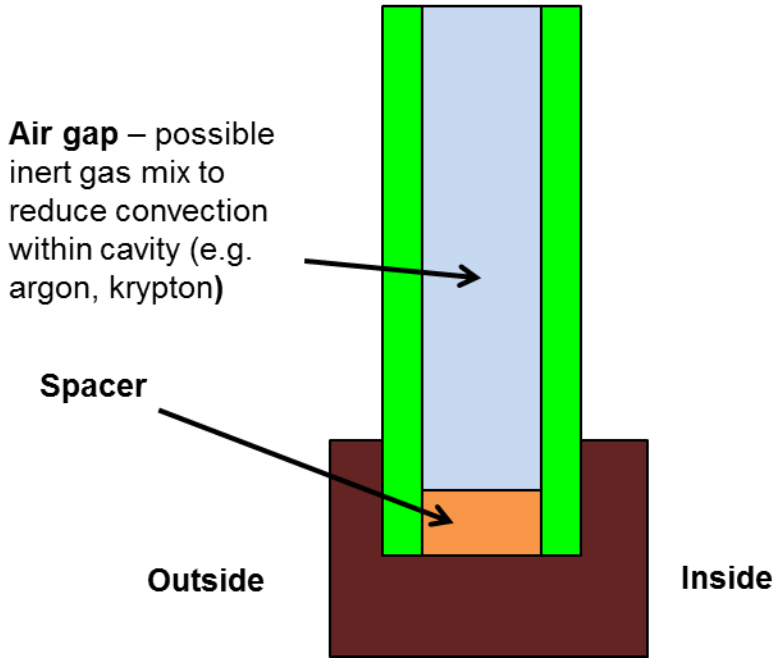
Source: Oak Ridge National Laboratory

Building envelope technology: windows

Single glazing



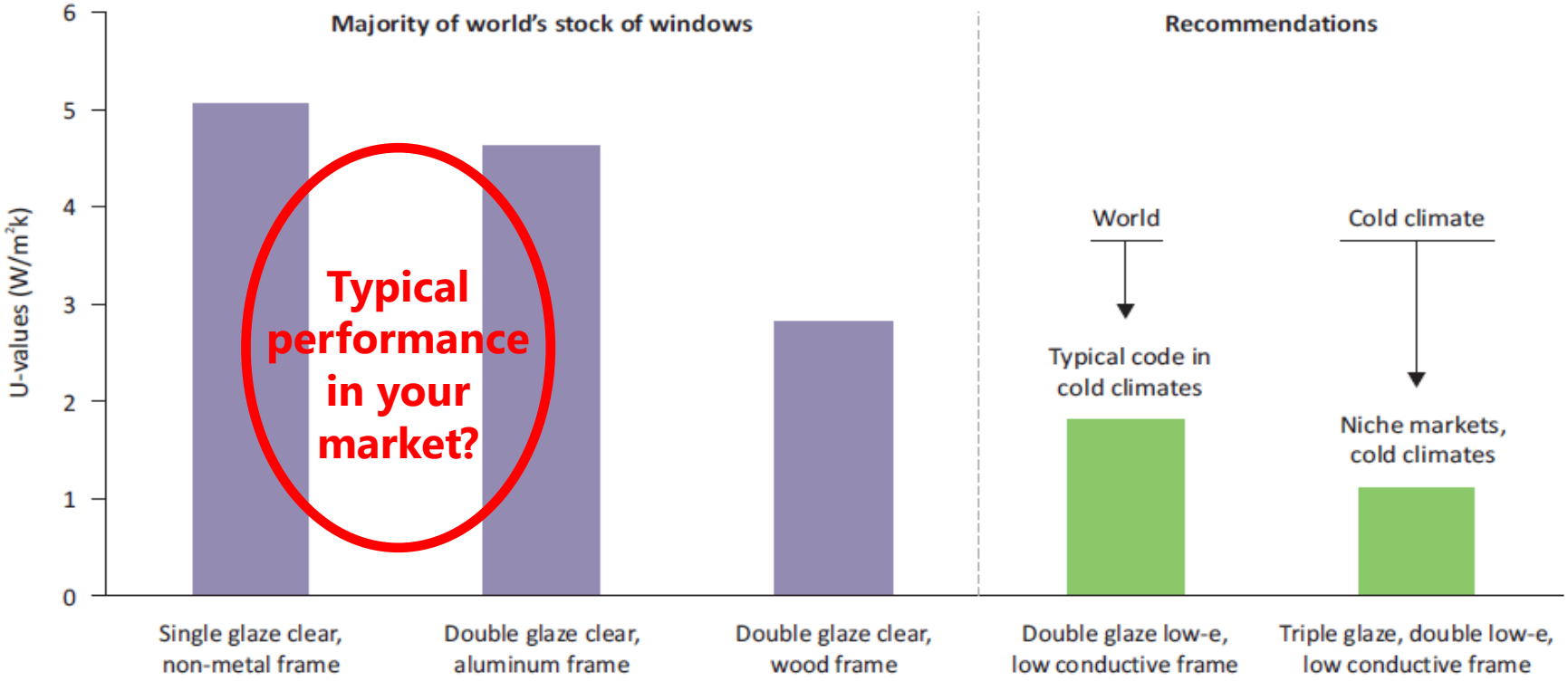
Double glazing



Single glazing windows are highly inefficient in all climate types.

Source: IEA Energy Efficiency Training Week

Building envelope technology: window market



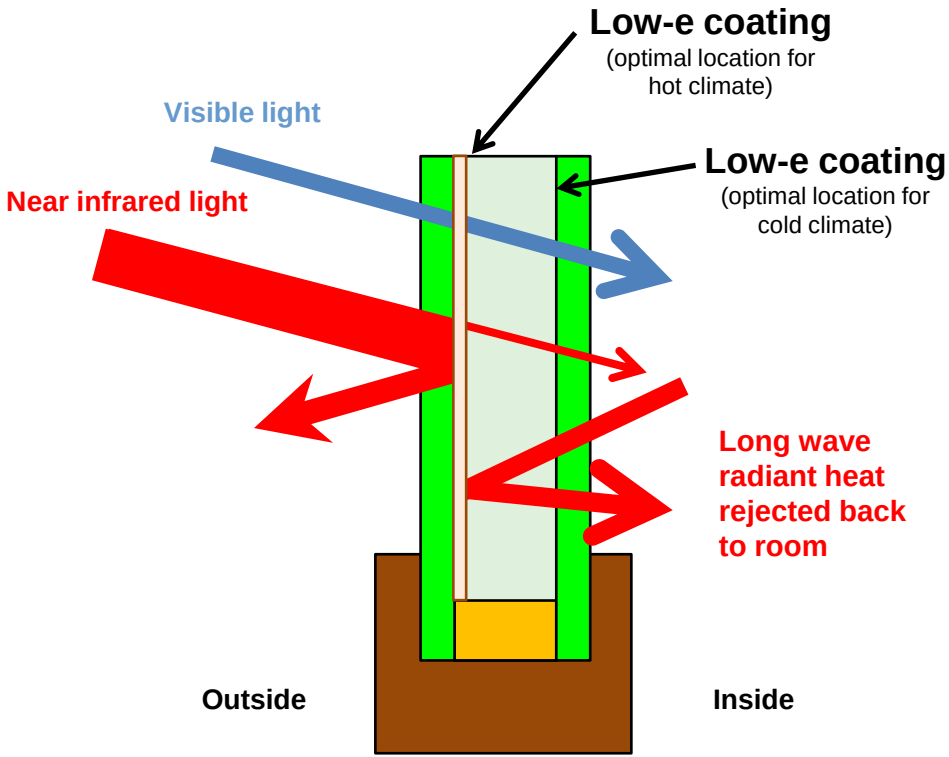
The majority of the world's installed windows can be significantly improved and more work is needed to ensure that new sales meet more stringent performance criteria.

Source: IEA

Building envelope technology: window coatings

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?

Source: IEA Energy Efficiency Training Week

Building envelope technology: window and building shading

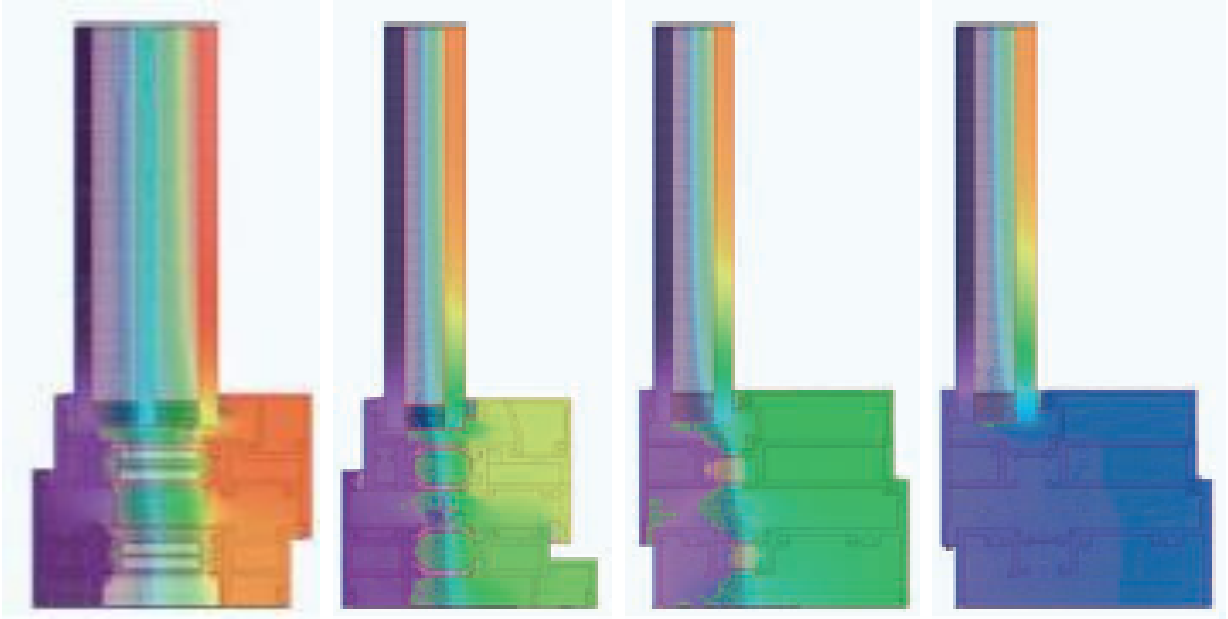
Ancient and modern shading can be a no or low cost demand efficiency measures.

Building envelope technology: window frames

Window low conductive frames

Cold climate outside

Hot climate inside



Cold climate inside

Hot climate outside

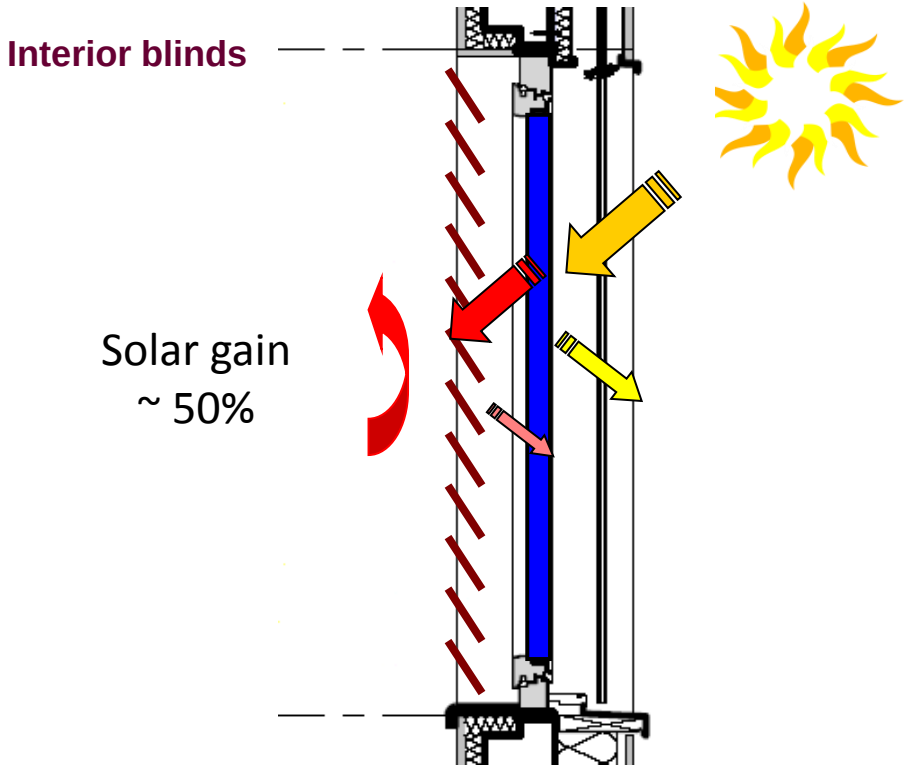
Advanced frame

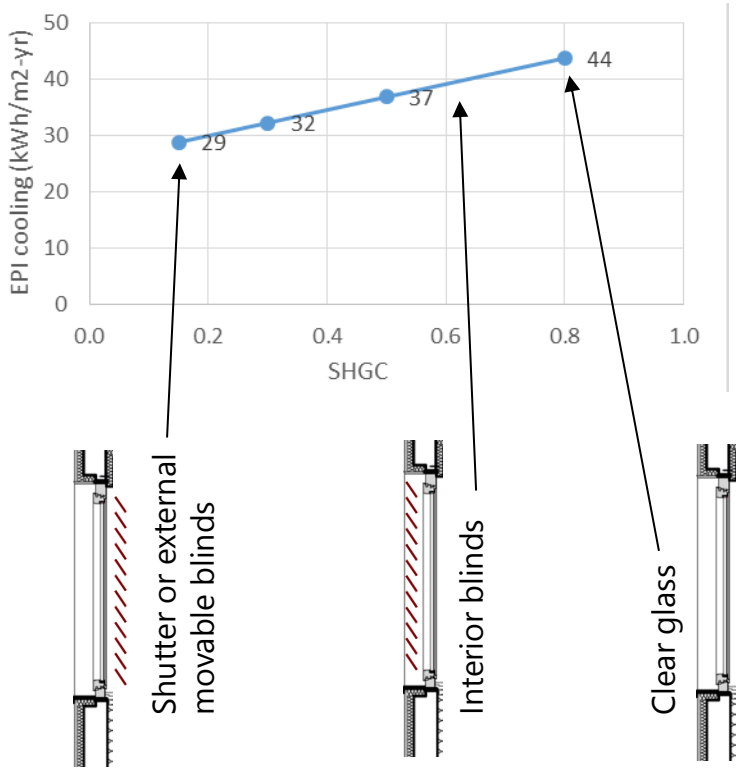
Improving performance

Old, no thermal break

Source: Alcoa/Kawneer

Building envelope technology: internal vs. external shading

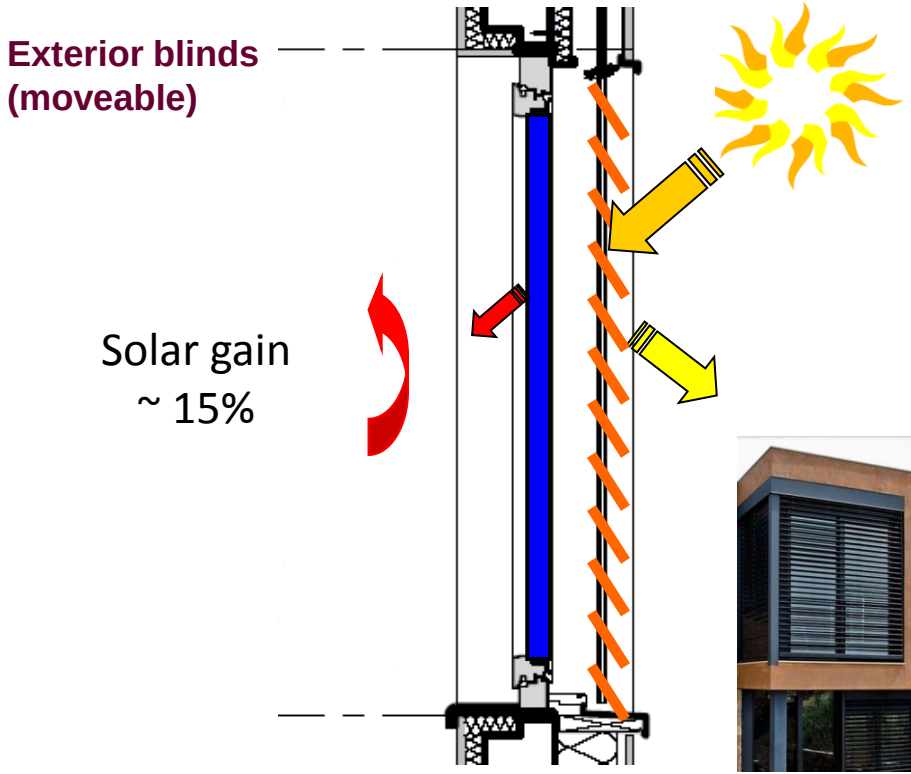


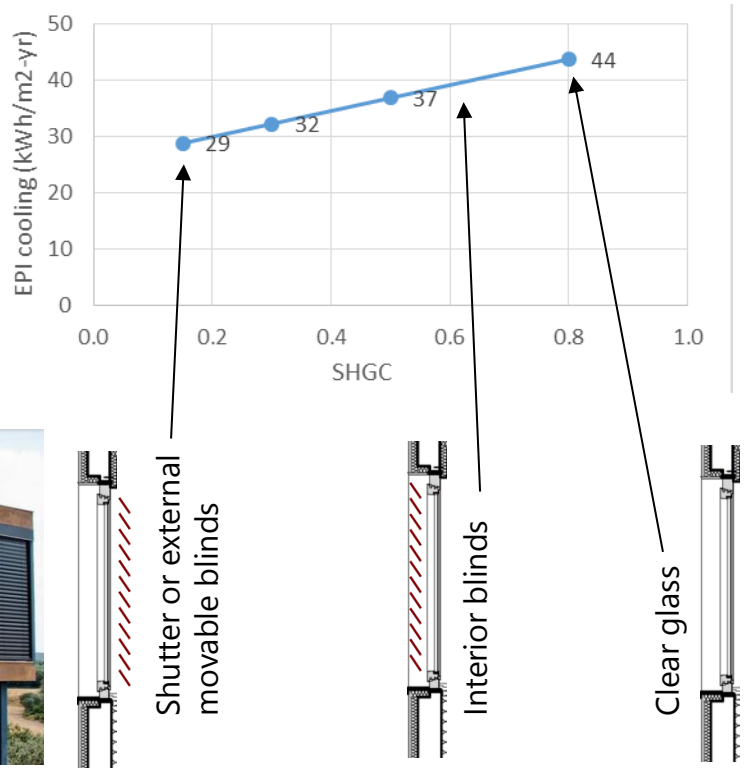


Internal shades still allow the solar heat gain to enter the building.

Source: BEEP India

Building envelope technology: internal vs. external shading





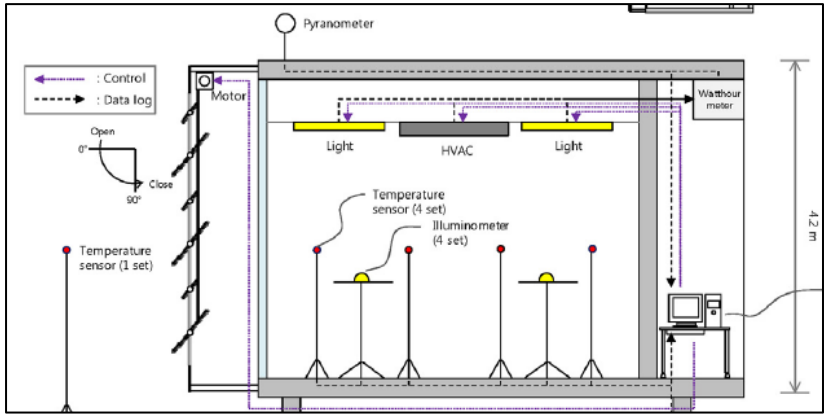
External shades keep out much more heat than internal shades.

Source: BEEP India

Glass vs. glass + external louvered blinds

No shading	Movable shading
Extruded polystyrene (50 mm)	Extruded polystyrene (50 mm)
Gypsum board (12.5 mm)	Gypsum board (12.5 mm)
Rigid urethane foam (125 mm)	Rigid urethane foam (125 mm)
Low-E double glazing(40 mm)	Low-E double glazing(40 mm)
None	Slat rotating (0°–90°)
	Fabric (50% solar transmittance)

Lighting and cooling energy assessment of multi-purpose control strategies for external movable shading devices by using shaded fraction Su-Ji Choi, Dong-Seok Lee, Jae-Hun Jo, Department of Architectural Engineering, Inha University, South Korea, Energy and Buildings 150 (2017), 328–338



The movable shading device in Modes 1–3 decreased the total amount of energy consumption by 48% compared to the mock-up with no shading.

Source: BEEP India

Glass vs. glass + external louvered blinds: daily impacts

Movable shading

Extruded polystyrene (50 mm)
Gypsum board (12.5 mm)
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Low-E double glazing(40 mm)
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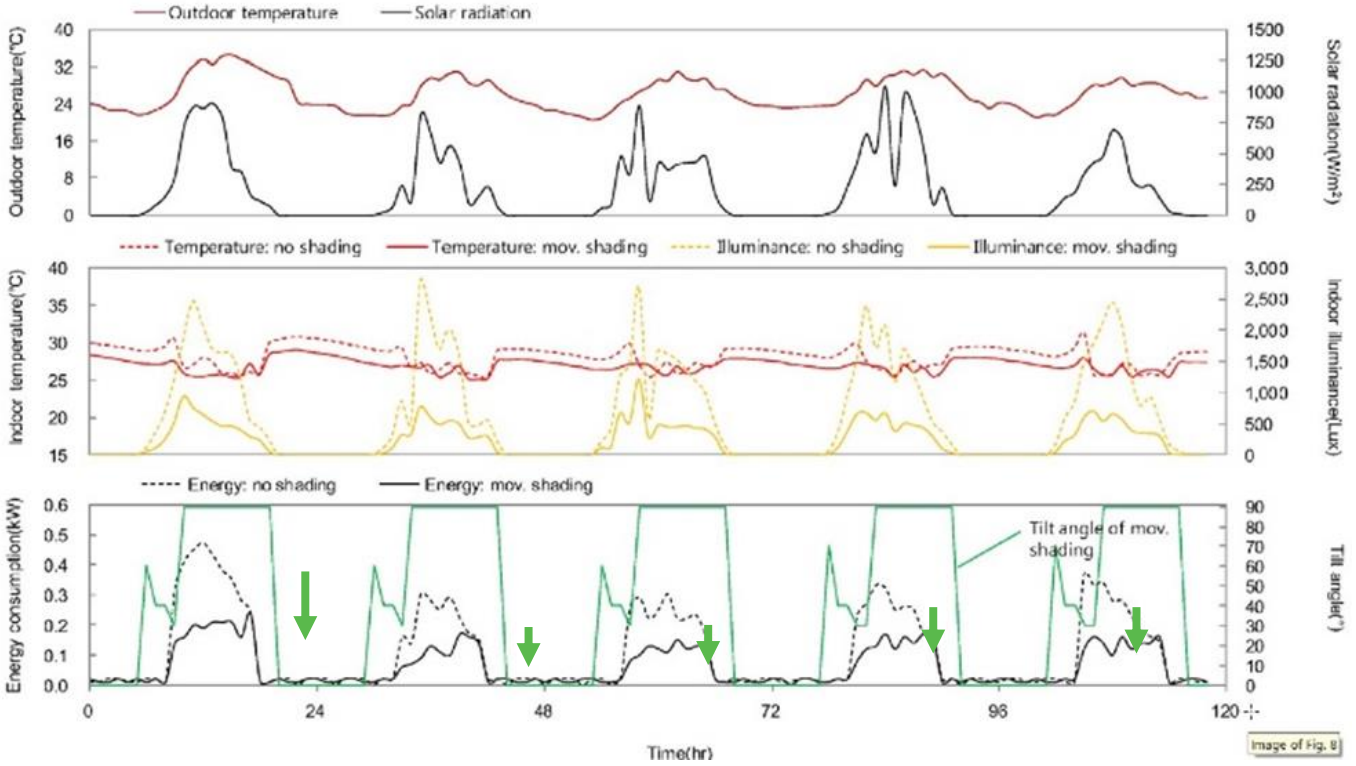


The movable shading device in Modes 1–3 decreased the total amount of energy consumption by 48% compared to the mock-up with no shading.

Source: Actual comparative measurement performed by the Department of Architectural Engineering, Inha University, South Korea

Building envelope technology: integrated solutions

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

Source: Sage Electrochromics

Advanced technologies: building envelope and modelling

Examples of some of the newest technologies

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

Building equipment and systems

- Space heating
- Water heating
- Space cooling
- Ventilation
- Lighting
- Controls
- Innovative technologies

Building equipment and systems: space and water heating

Shifting to more efficient and renewable integrated technologies.

Sources: wood-furnaces.net, asapburnerservice.com, altal.eu, redinfratech.com

Building equipment and systems: space and water heating

Heat pump R&D

- Improve performance in cold climates

Standards

- Ban electric resistance heaters
- Require condensing gas boilers

Promote solar thermal systems

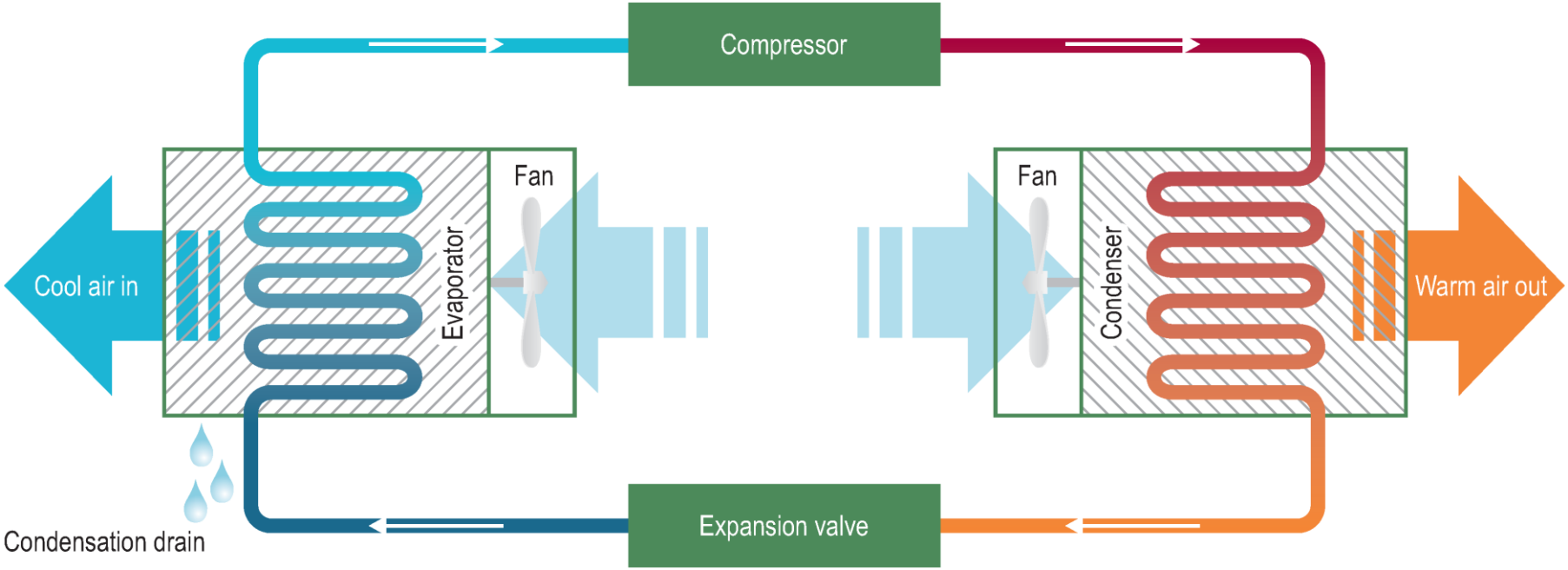
- Develop lower costs systems
- Invest R&D for cooling applications

Integrated district heating

- Focus on greater participation of renewables, waste heat & co-generation
- Develop model advanced district heating systems with efficient building envelopes

Source: IEA

Building equipment and systems: cooling



ACs use a refrigerant and a vapour compression cycle to move heat from one space to another, providing comfort and the sensation of fresh, cool air

Source: IEA The Future of Cooling 2018

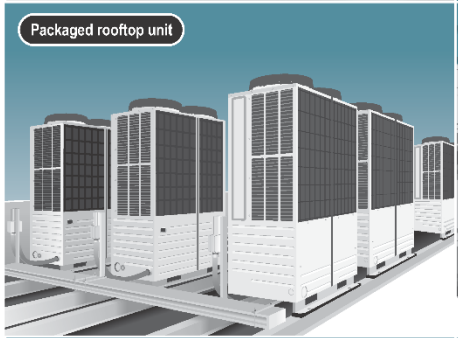
Building equipment and systems: cooling equipment types

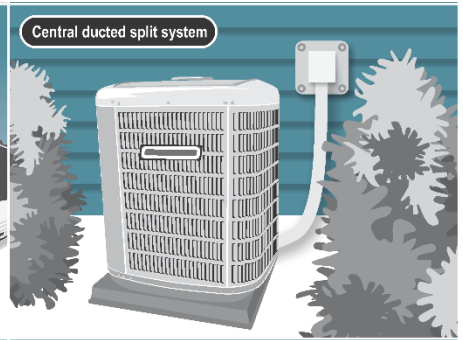
Packaged ACs	• Window air conditioners • Portable units • Packaged rooftop units
Split System ACs	• Chilled water systems • Rooftop and air handling units • Variable Refrigerant Flow (VRF)
Chillers	• Water cooled chillers • Air cooled chillers
Other systems	• Evaporative coolers • Absorption chillers • Ground source or geothermal

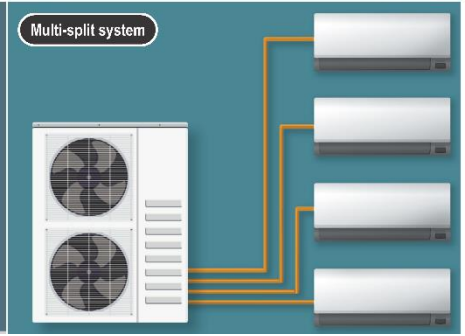
What makes an energy efficient system?

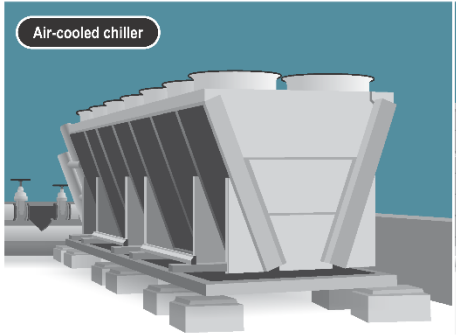
- ✓ Reduced energy used for same output of cooling
  - ✓ High COP or EER
  - ✓ High CSPF or SEER
- ✓ Correctly sized
- ✓ Ability to reduce output according to load
- ✓ Ability to integrate smart controls

Building equipment and systems: cooling equipment









Building equipment and systems: cooling equipment features

Flexibility	• Variable speed compressors, “inverter”, variable speed fans, variable flow refrigerant.
Storage	• Ice or chilled water • For peak demand control
Thermal recovery	• Heat and/or enthalpy exchangers
Smart controls	• Pre-cooling, free-cooling • Set point adjustment and demand-side management • Integration with other building systems

Building equipment and systems: cooling considerations

- Refrigerant fluids used in air conditioning equipment are harmful to the environment, either because of their damage to the **ozone layer**, or for **the Global Warming Potential** of their emissions.

- Transitions to cleaner, alternative fluids are underway, as well as a gradual phase down of the most harmful fluids under the **Kigali Amendment to the Montreal Protocol.**

- This is an opportunity to also transition to more efficient compressor technologies.

- The K-CEP programme is available to support economies in this phase down.

KIGALI COOLING EFFICIENCY PROGRAM

Find out more:

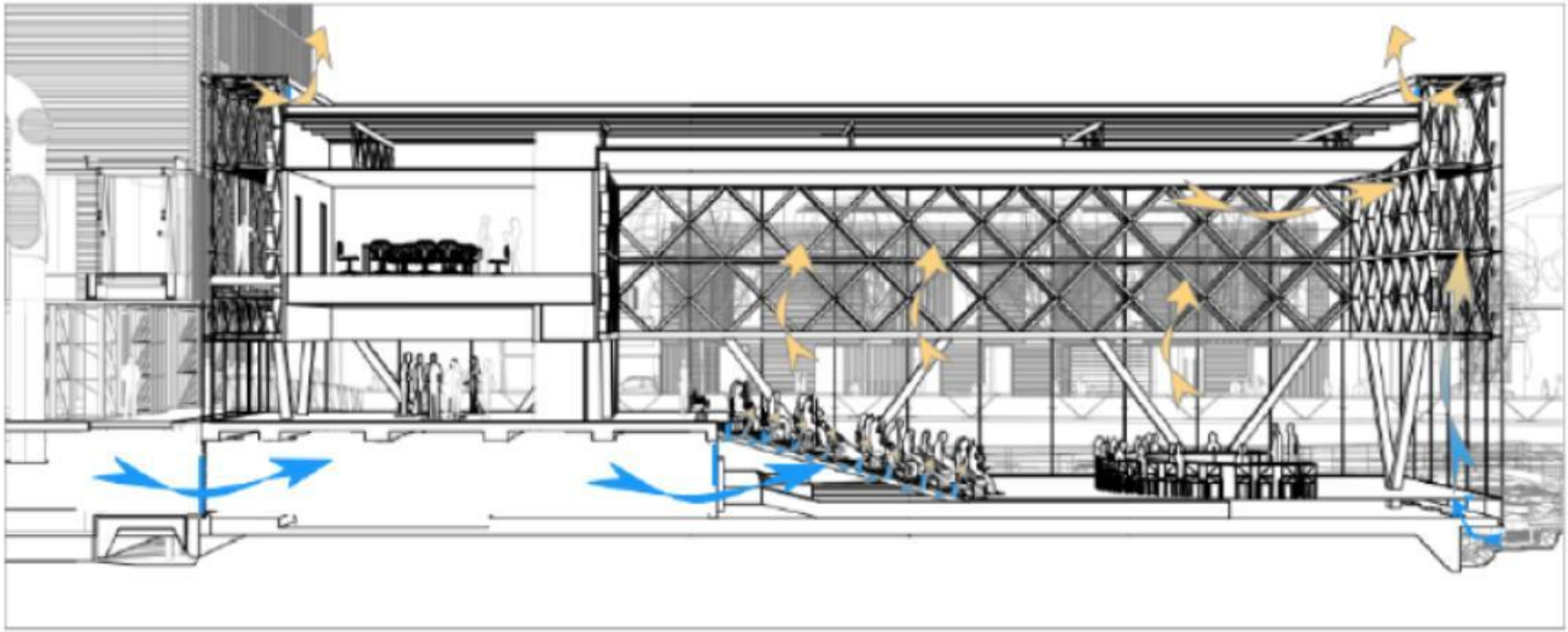
https://www.k-cep.org/
https://ozone.unep.org/

Building equipment and systems: ventilation

- 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, or mixed-mode

Source: IEA

Building equipment and systems: hybrid ventilation



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

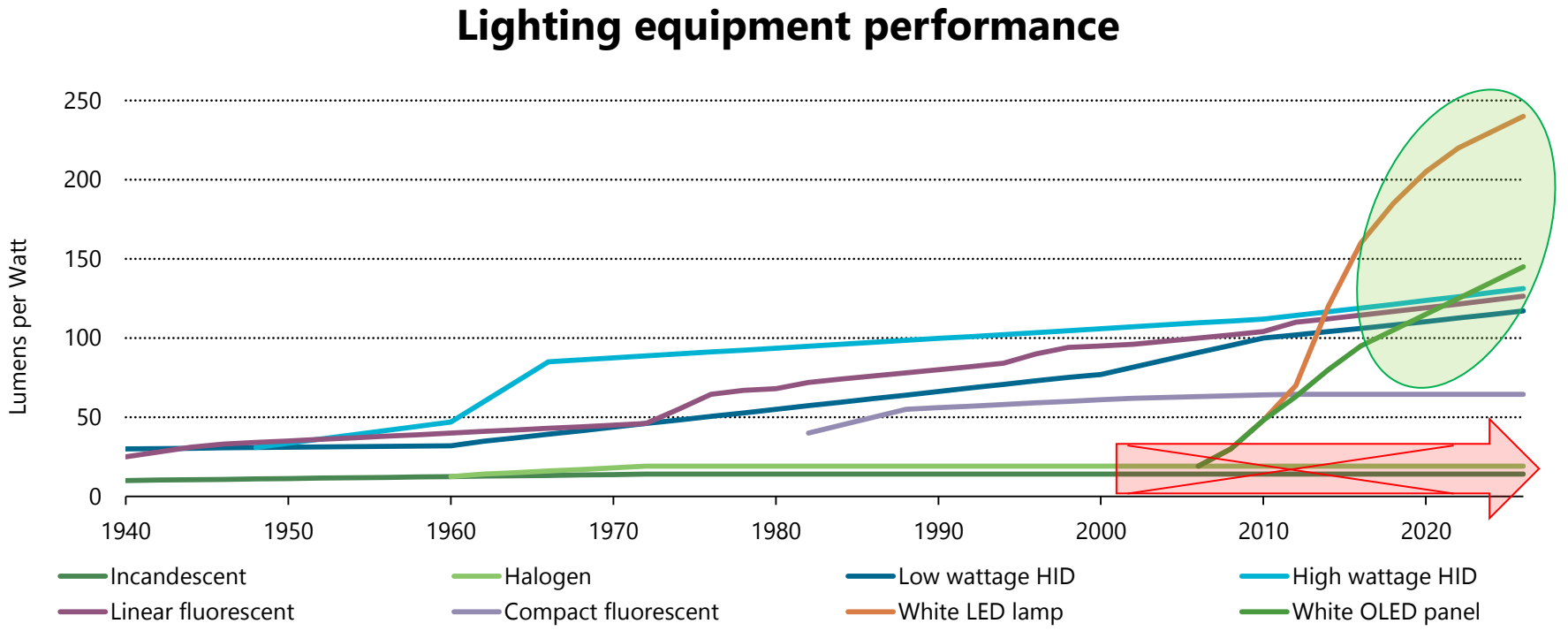
Source: IEA EBC Annex 62 – Ventilative Cooling

Building equipment and systems: lighting

Shifting to high performance technologies

Source: premierlightbulbs.com

Building equipment and systems: lighting

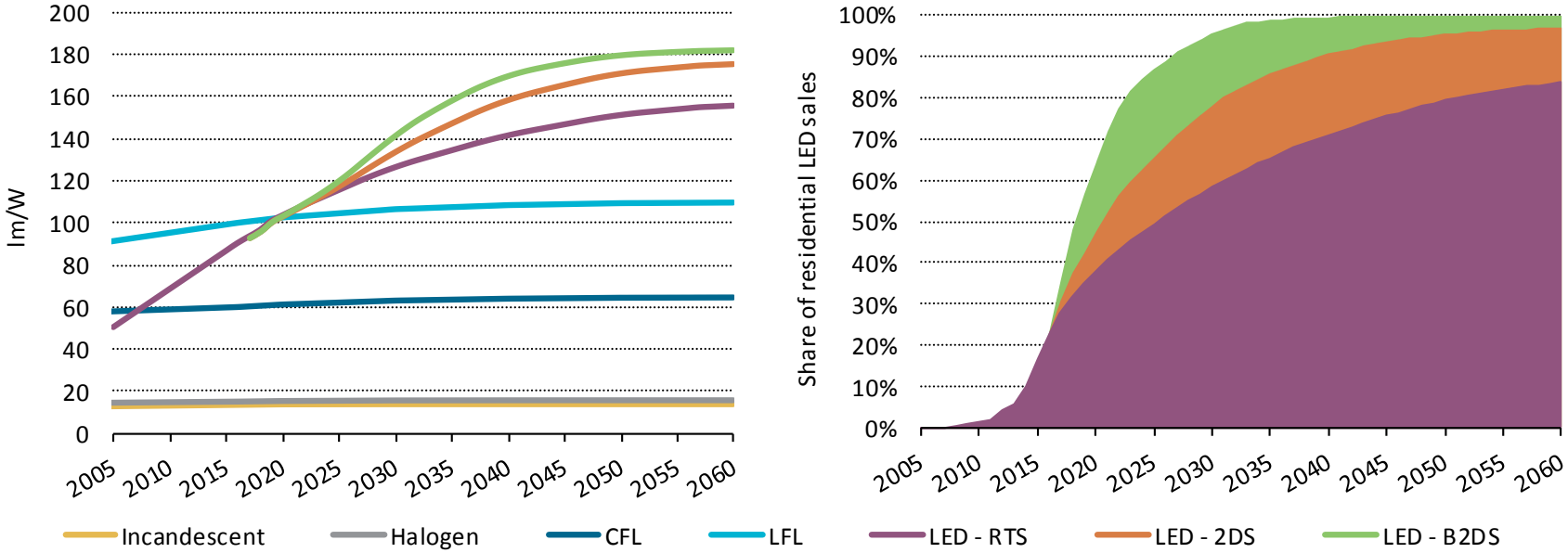


Technology performance improvements continue to drive energy efficiency, but energy policy needs to keep up with the technology…

Source: IEA Transition to Sustainable Buildings (2013) and IEA Energy Technology Perspectives

Building equipment and systems: lighting

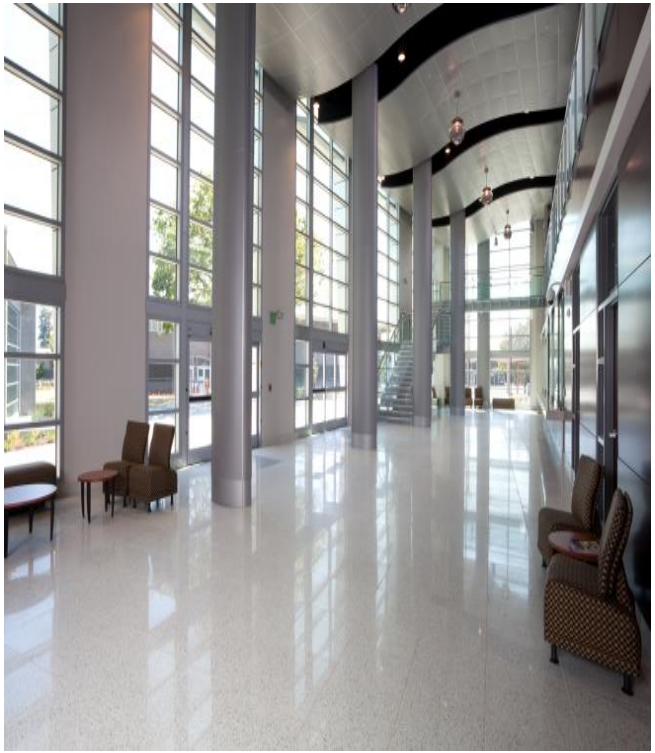
Lighting equipment performance and residential LED sales share to 2060



Rapid deployment of energy-efficient technologies will create critical mass in the market, helping to lower technology costs and drive R&D for greater energy performance.

Source: IEA Energy Technology Perspectives 2017

Building equipment and systems: lighting (passive)

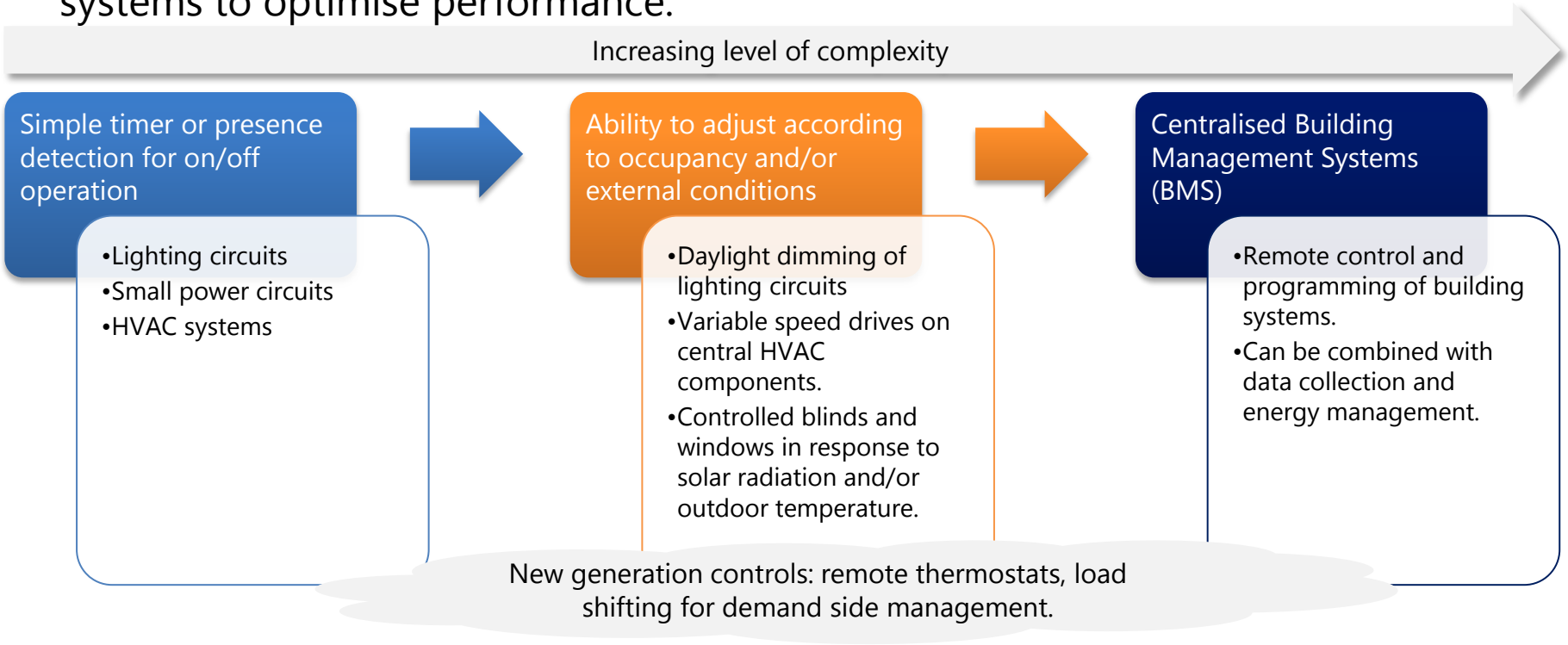


Passive solar lighting can reduce lighting energy use.
But shading can increase lighting energy use.

Source: Sage Electrochromics

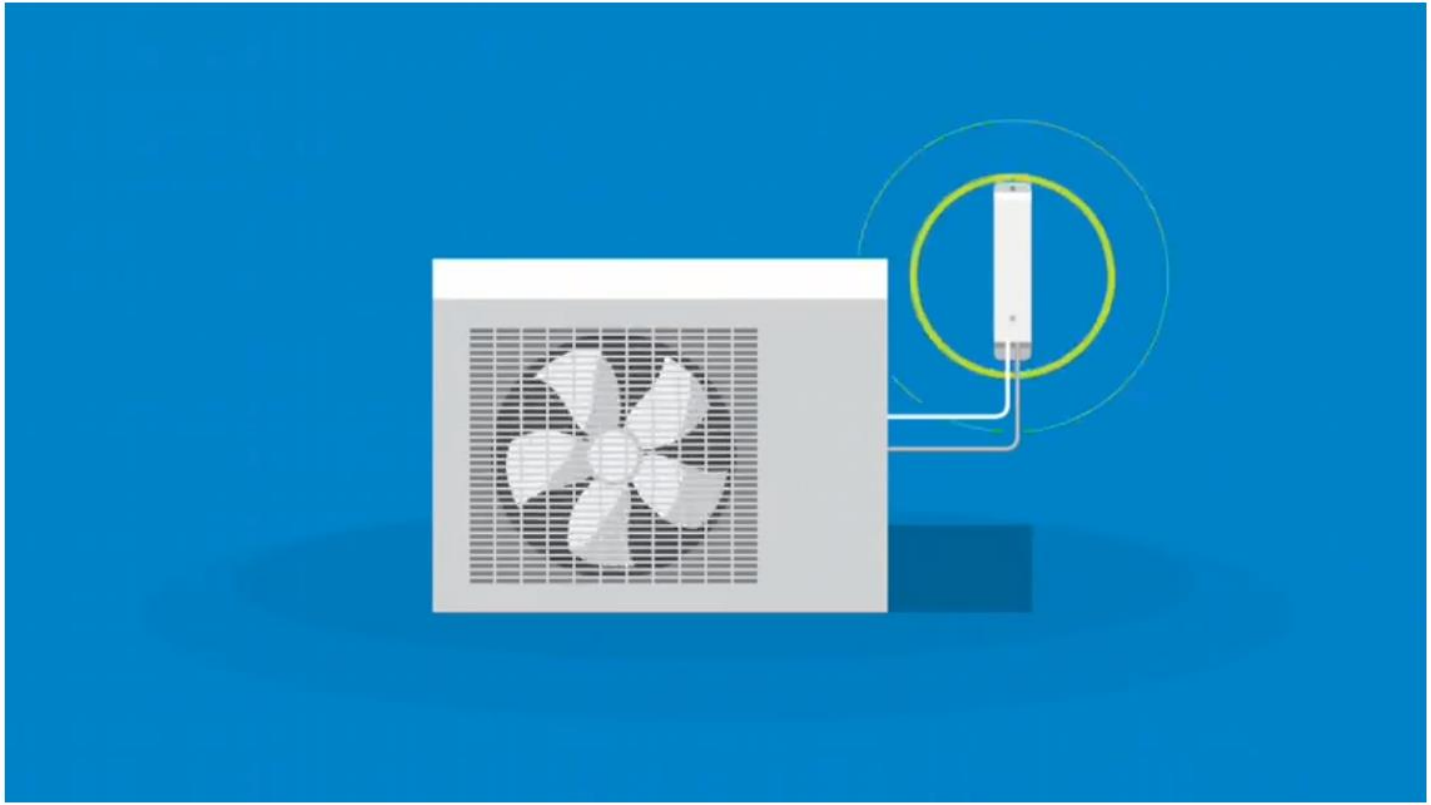
Building equipment and systems: controls

- Controls can be used to regulate and/or automate the operation of building systems to optimise performance.



Building equipment and systems: controls

- PeakSmart, in Australia: https://www.youtube.com/watch?v=fQQYNMofG5w



Advanced technologies: equipment and systems

Examples of some of the newest technologies

- ***Heating:***
  - Natural gas heat pumps
  - Cold climate heat pumps
  - Seasonal thermal storage with heat pumps
- ***Cooling:***
  - Modulating refrigerant to optimize EER/COP of HVAC systems
  - Cooling combined with hot water or refrigeration
- ***Control and automation:***
  - Building control optimization
  - Fault detection automation
- ***Lighting:***
  - Advanced LED lighting with sensors and controls
- ***Data centers:***
  - Immersion cooling
  - Liquid cooling direct to computer chip

Technology strategies for sustainable buildings

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

Source: IEA Energy Technology Perspectives 2017

Summary

Technology roadmaps

What can change your market?

Technology demonstration

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

https://webstore.iea.org/technology-roadmaps

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

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?

Energy Efficiency Training Week: Buildings

Special session: Technology demonstration

Trainers: Daikin

Purpose: To see how technology works and what it takes to make technology more energy efficient.

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