Toolkit:
Energy efficient building technologies

Buildings: Session 4

Buildings energy efficiency sessions in partnership with:

BEEP

INDO-SWISS BUILDING ENERGY EFFICIENCY PROJECT

UCL ENERGY INSTITUTE

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Energy Efficiency Training Week: Buildings Program

1. **Where to start:** Understanding 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:** Enabling investment with energy efficiency policies
6. **What are the steps :** Building energy codes and standards

   Site Visit: Schneider Electric
7. **What are the steps:** Set targets and develop policies
8. **Did it work:** Evaluating the multiple benefits of energy efficiency
9. **Did it work:** Tracking progress with energy efficiency indicators

   Where do I get help? International and regional energy efficiency initiatives
10. **Energy Efficiency Quiz:** Understanding energy efficiency in buildings

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4. Toolkit: Energy efficient building technologies

Trainers: John Dulac and Brian Dean

Session: 1.5 hours

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?*

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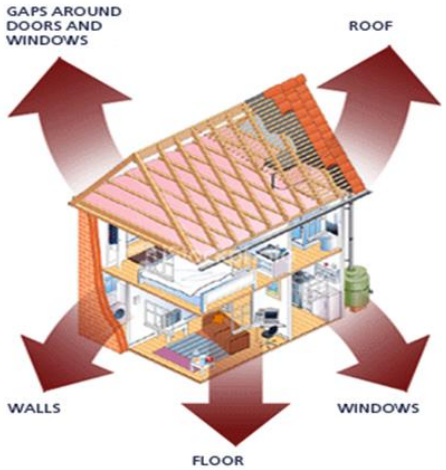
Building envelope technology

Insulation

Air sealing

Windows

Roof



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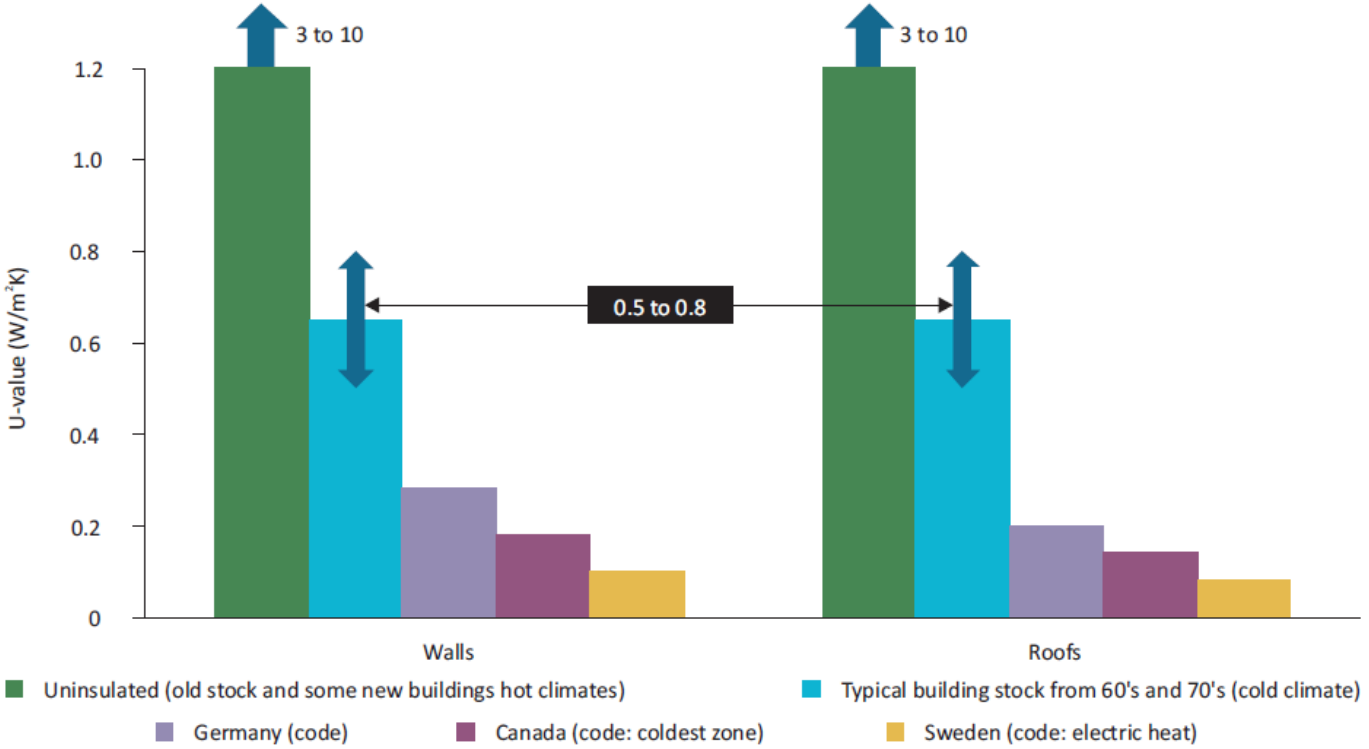
Building envelope technology: insulation

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

≤ 0.15 W/m²K cold climate

≤ 0.35 W/m²K 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

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Building envelope technology: insulation (exterior)

Before

After

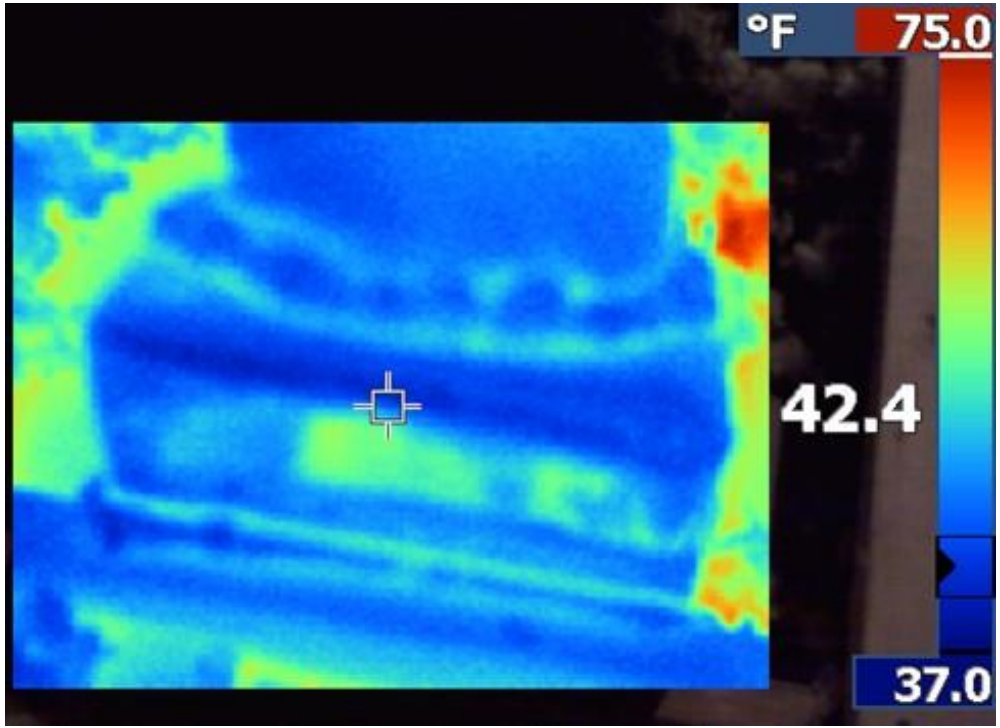
Exterior insulation is best approach to reduce thermal shorts/thermal bridges and can applied with external material. Applicable to all building types, but challenging for historic buildings.

Source: Sto Corporation

© OECD/IEA 2018

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

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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

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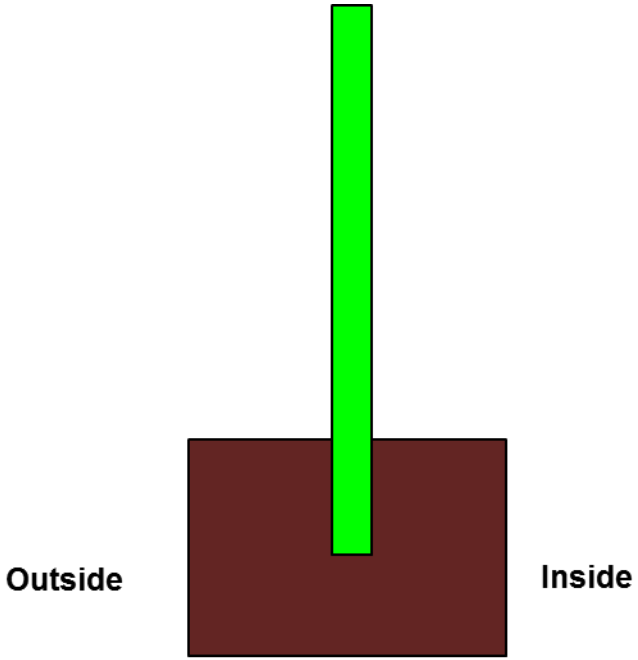
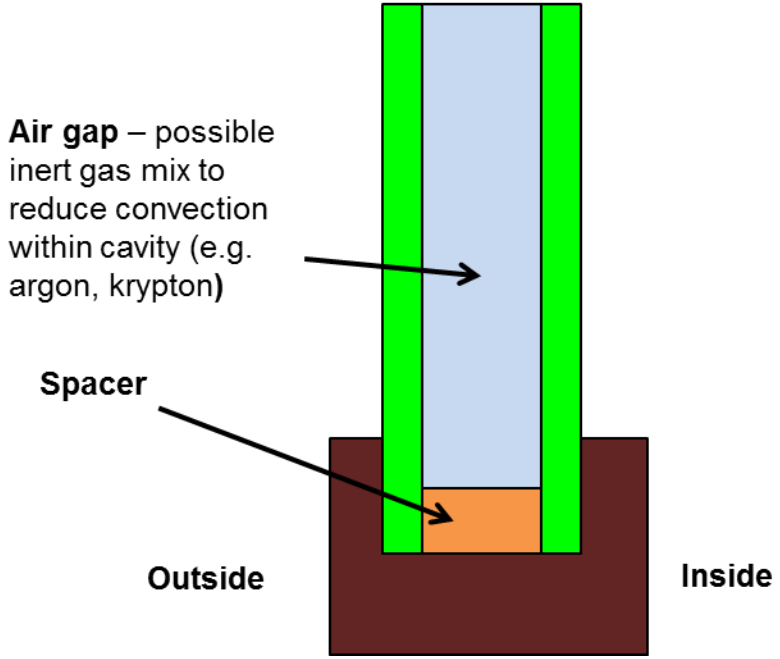
Building envelope technology: windows

Single glazing



Double glazing



Single glazing windows are highly inefficient in all climate types.

Source: IEA Energy Efficiency Training Week

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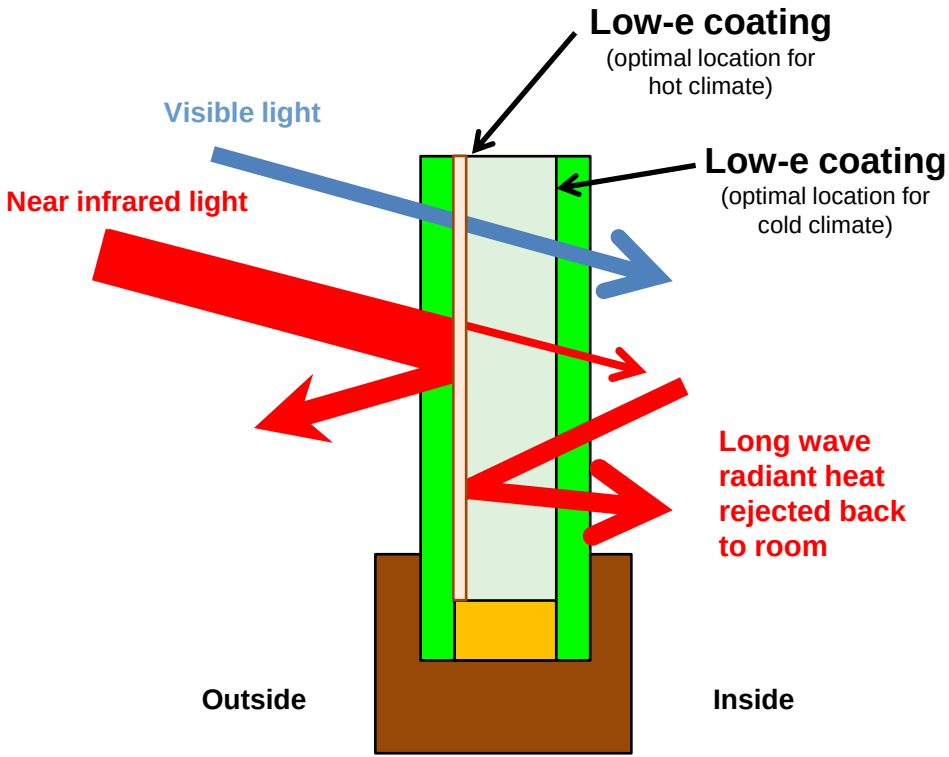
Building envelope technology: window coatings

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

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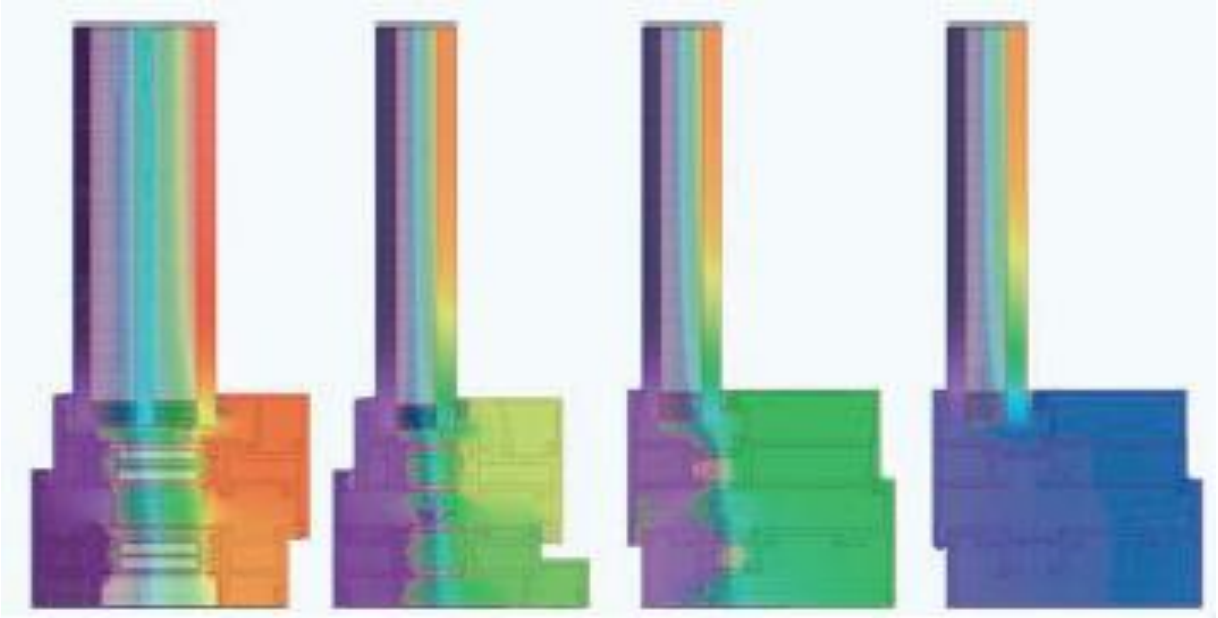
Building envelope technology: window frames

Window low conductive frames

Outside



Inside

Advanced, warm interior in winter

Improving performance

Old, no thermal break, cold interior in winter

Source: Alcoa/Kawneer

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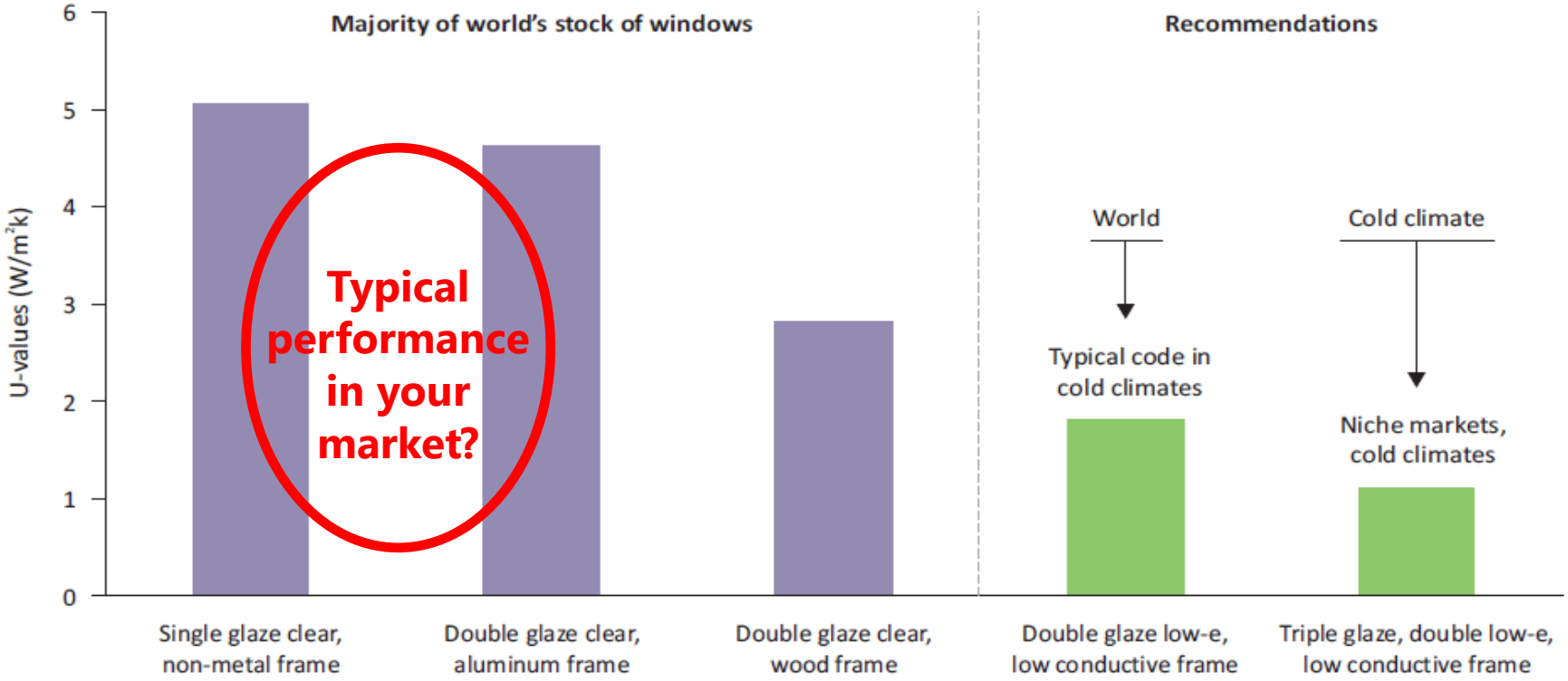
Building envelope technology: window market



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

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Building envelope technology: window and building shading

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

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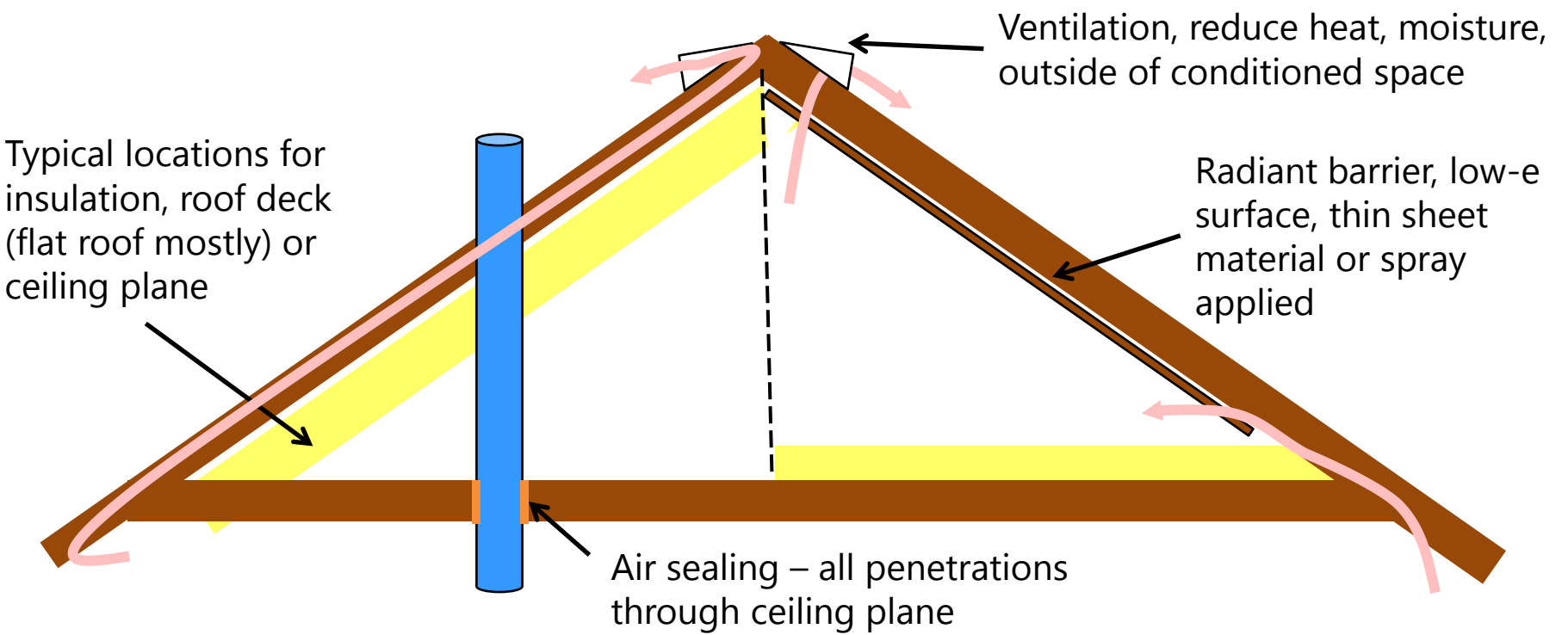
Building envelope technology: roof as a system



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

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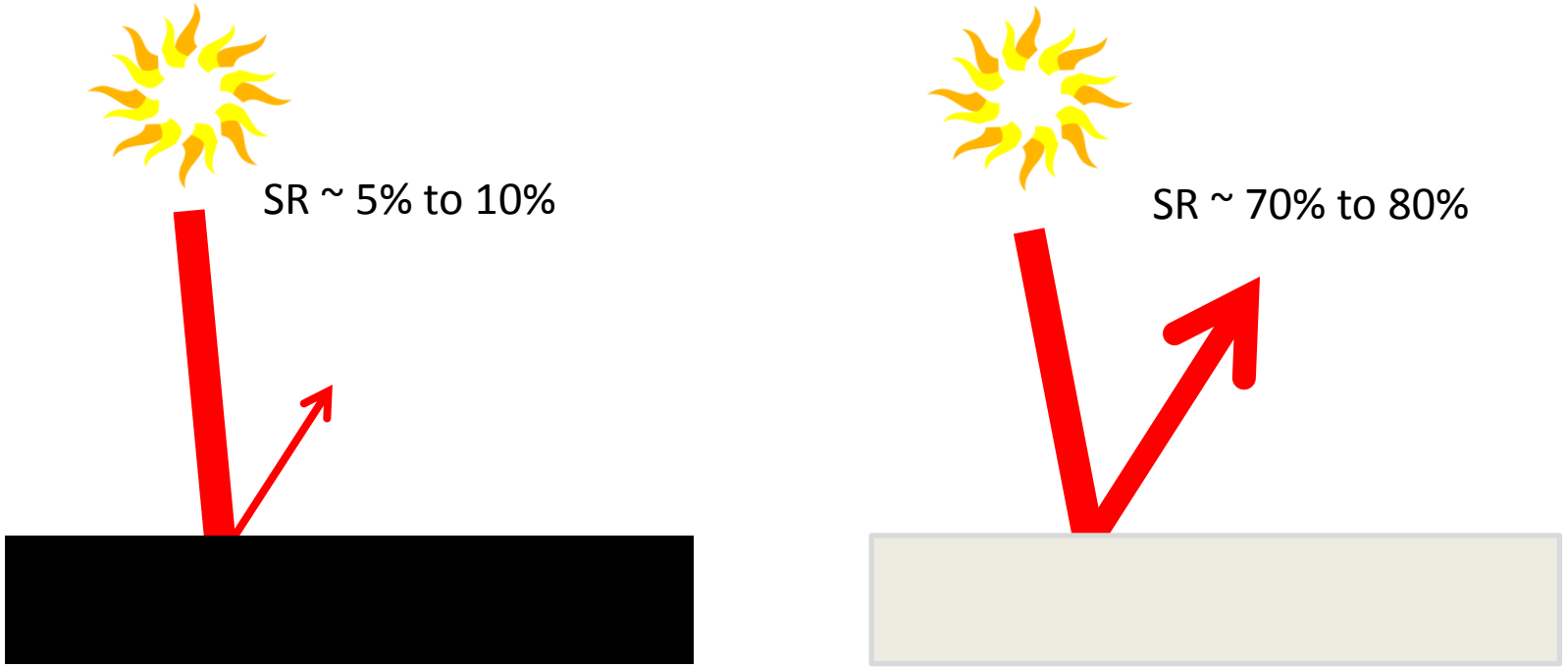
Building envelope technology: roof reflectance (visible colour)



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

Source: IEA Energy Efficiency Training Week

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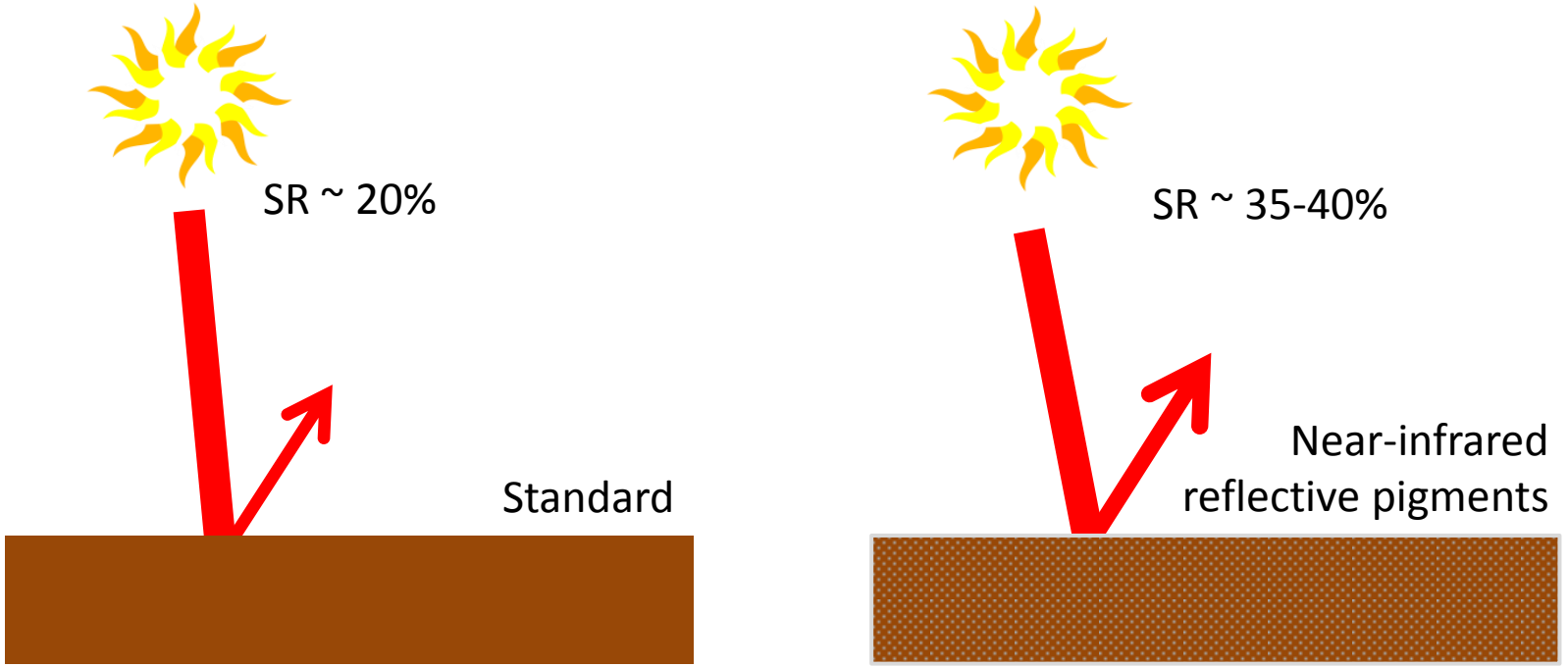
Building envelope technology: roof reflective pigments



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

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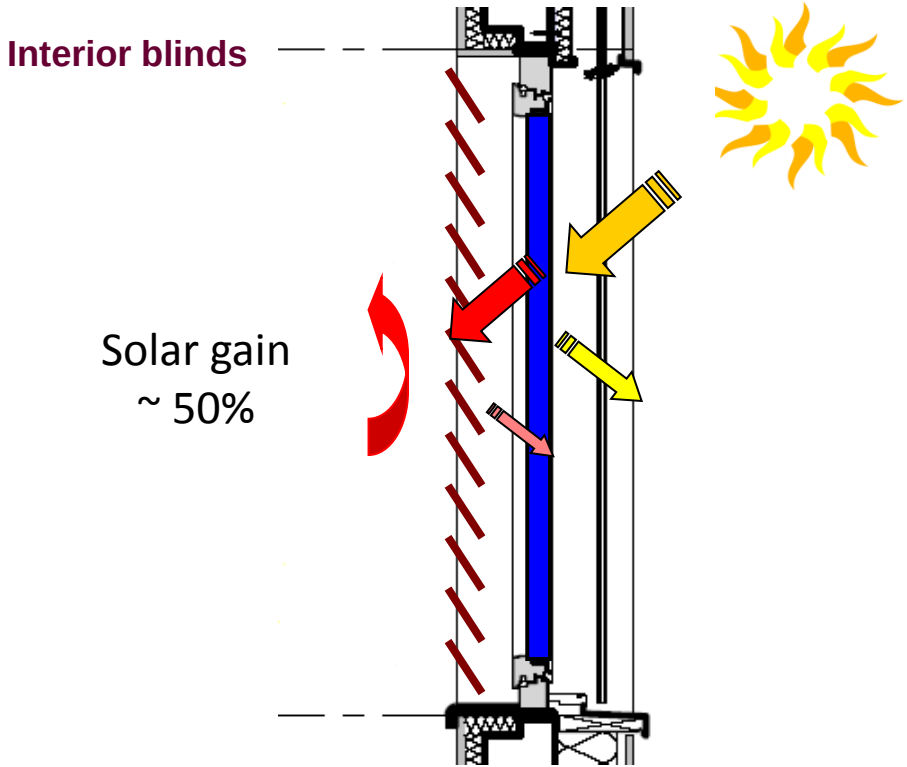
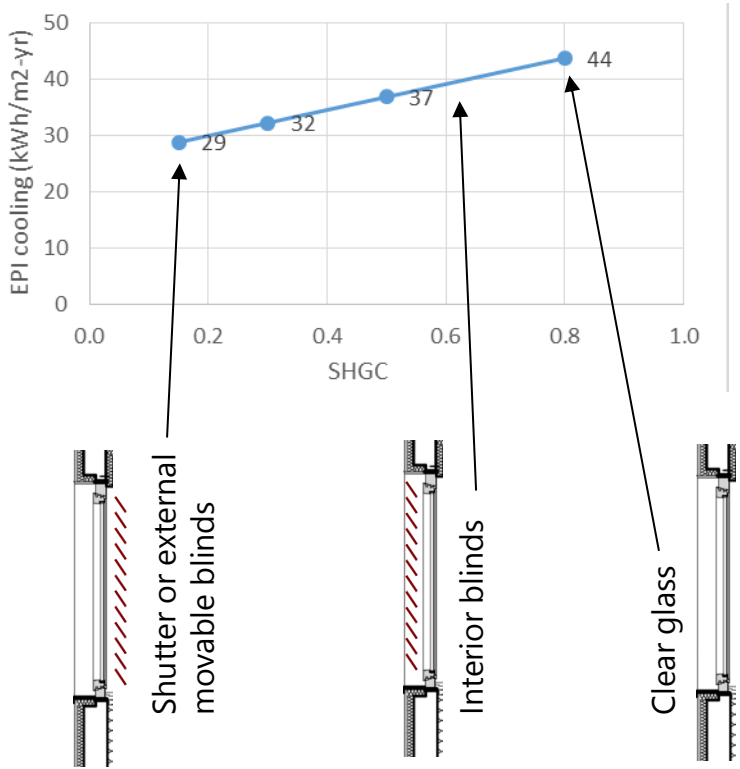
Building envelope technology: internal vs. external shading





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

Source: BEEP India

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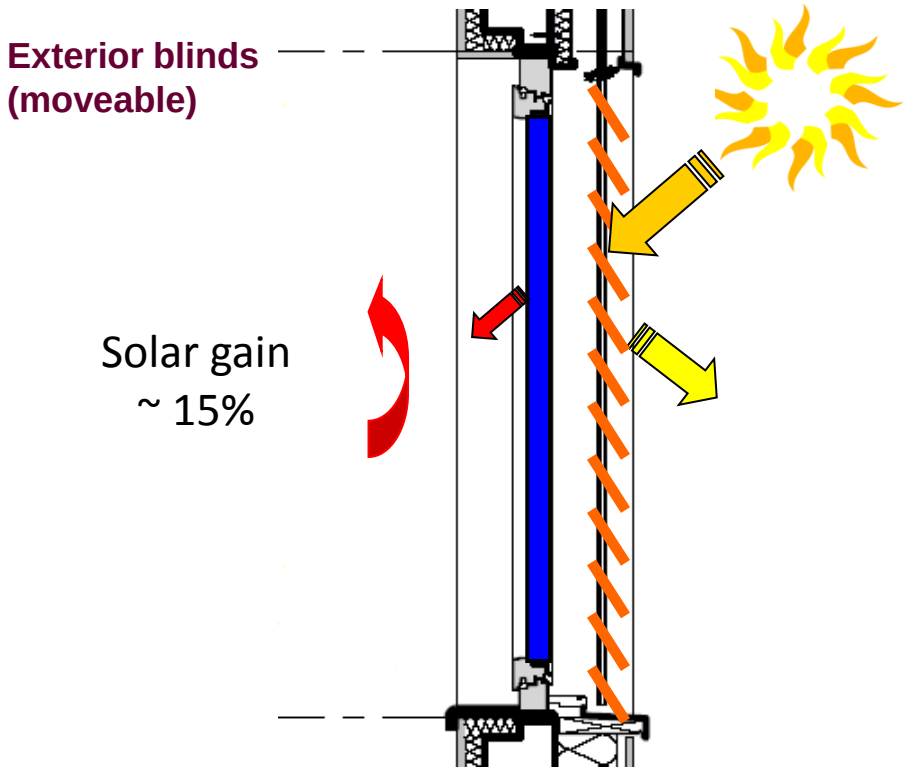
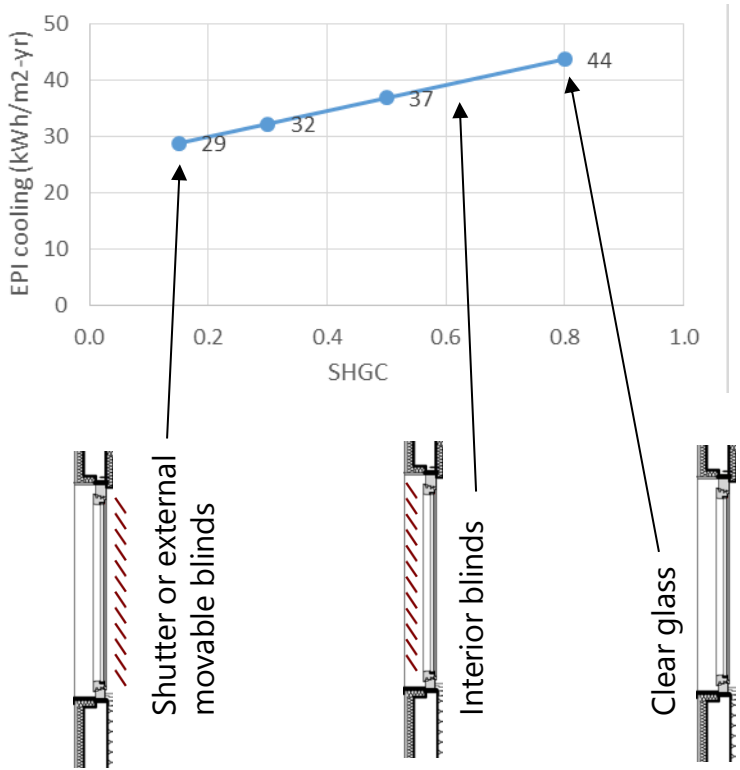
Building envelope technology: internal vs. external shading





External shades keep out much more heat than internal shades.

Source: BEEP India

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Building envelope technology: integrated solutions

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

Source: Sage Electrochromics

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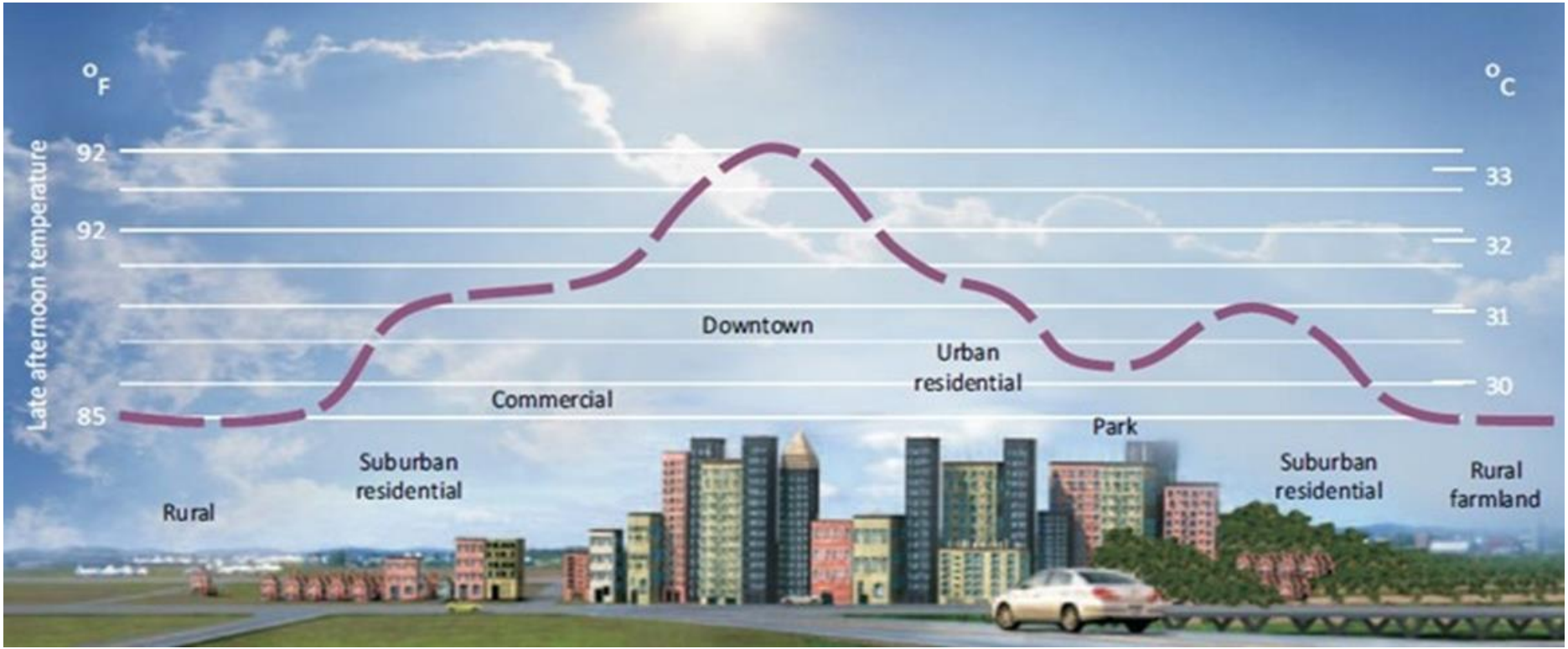
Building envelope technology: reflectance impact on heat island



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

Source: LBNL

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Advanced technologies: building envelope and modeling

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

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Building equipment and systems

Heating (space and water)

Cooling

Ventilation

Lighting

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Building equipment and systems: heating

Shifting to more efficient and renewable integrated technologies.

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

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Building equipment and systems: heating and cooling

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

Source: IEA

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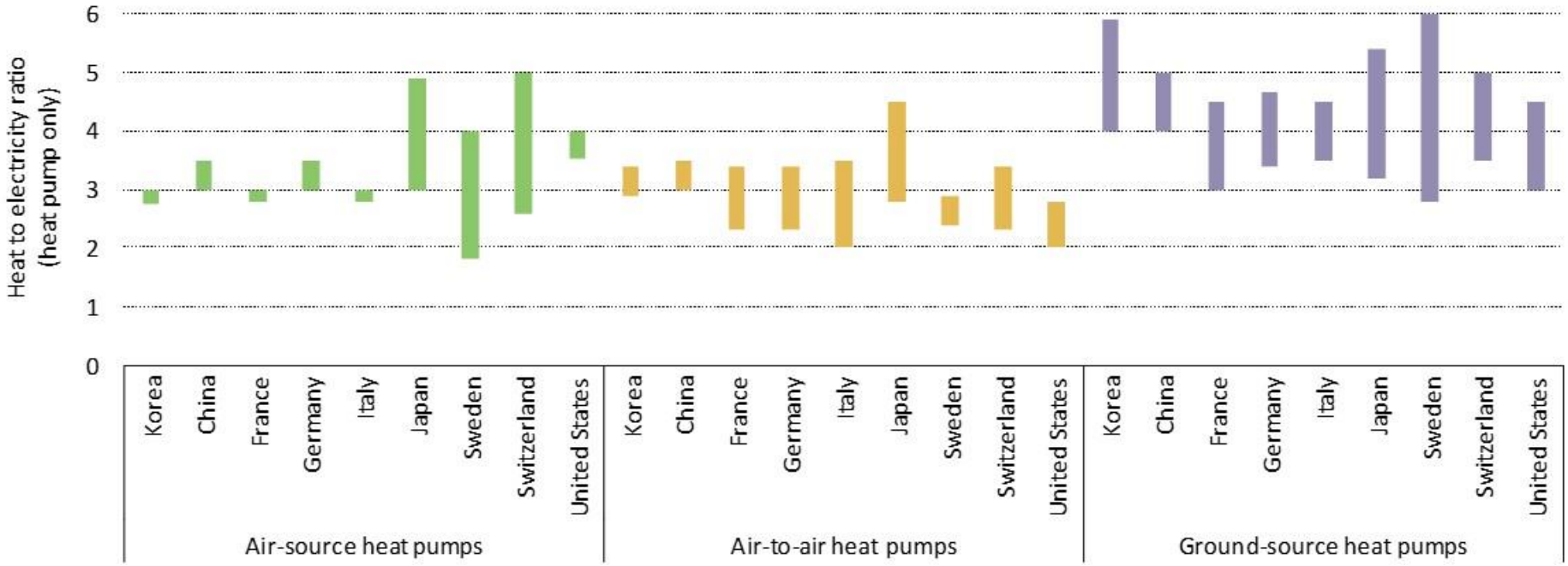
Building equipment and systems: water & space heating/cooling



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

Source: IEA

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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

Source: IEA

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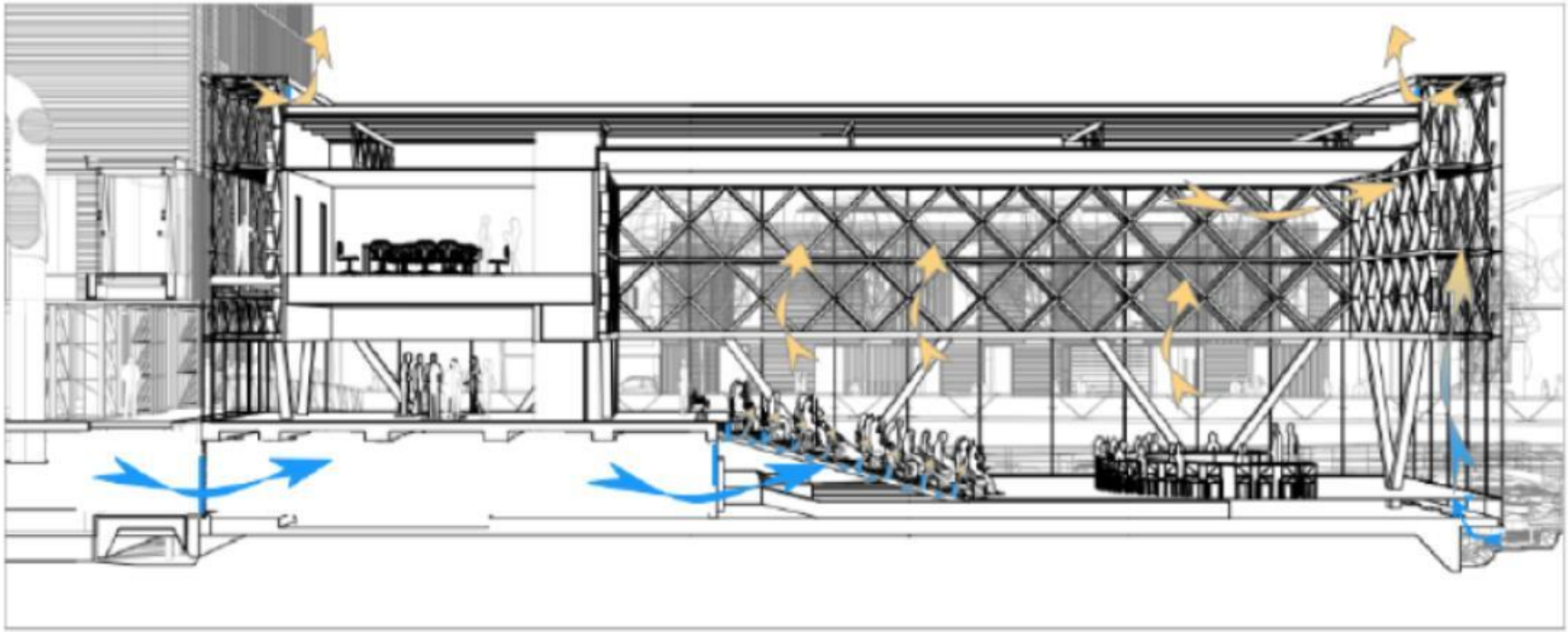
Building equipment and systems: hybrid ventilation



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

Source: IEA EBC Annex 62 – Ventilative Cooling

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Building equipment and systems: lighting

Shifting to high performance technologies

Source: premierlightbulbs.com

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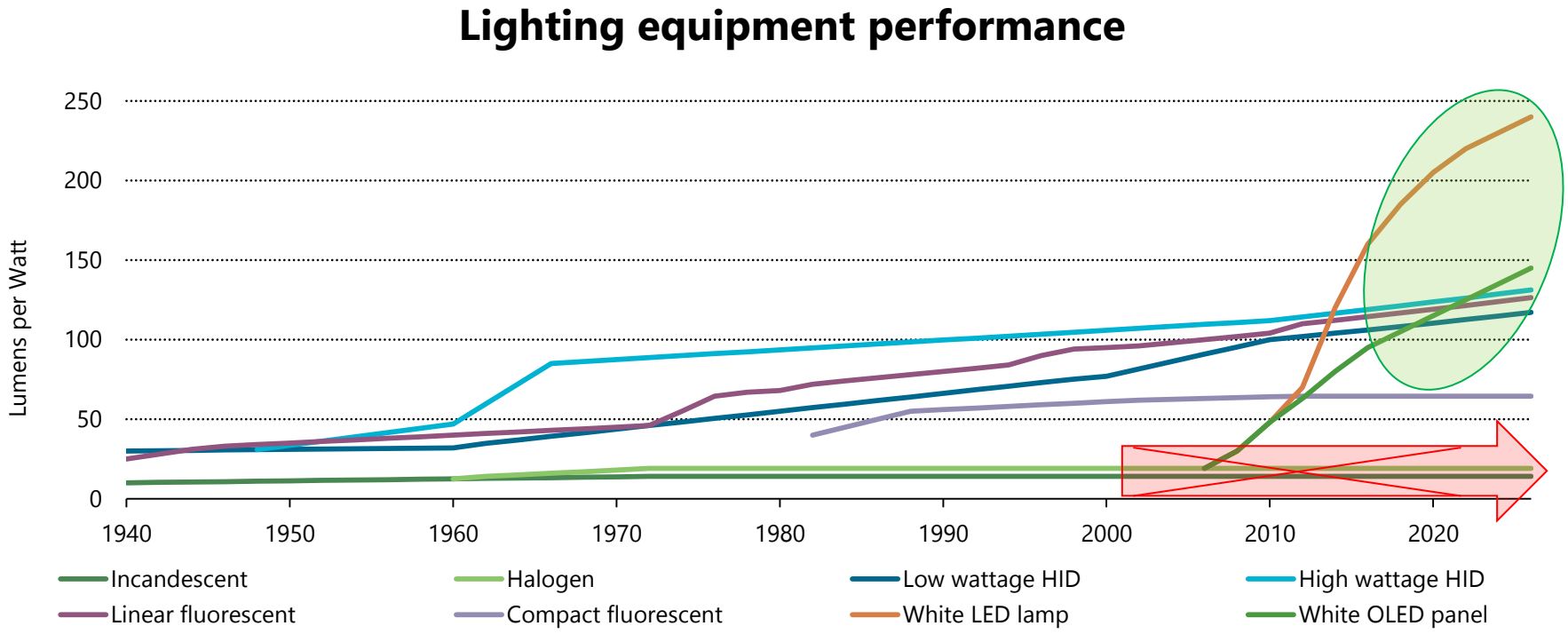
Building equipment and systems: lighting



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

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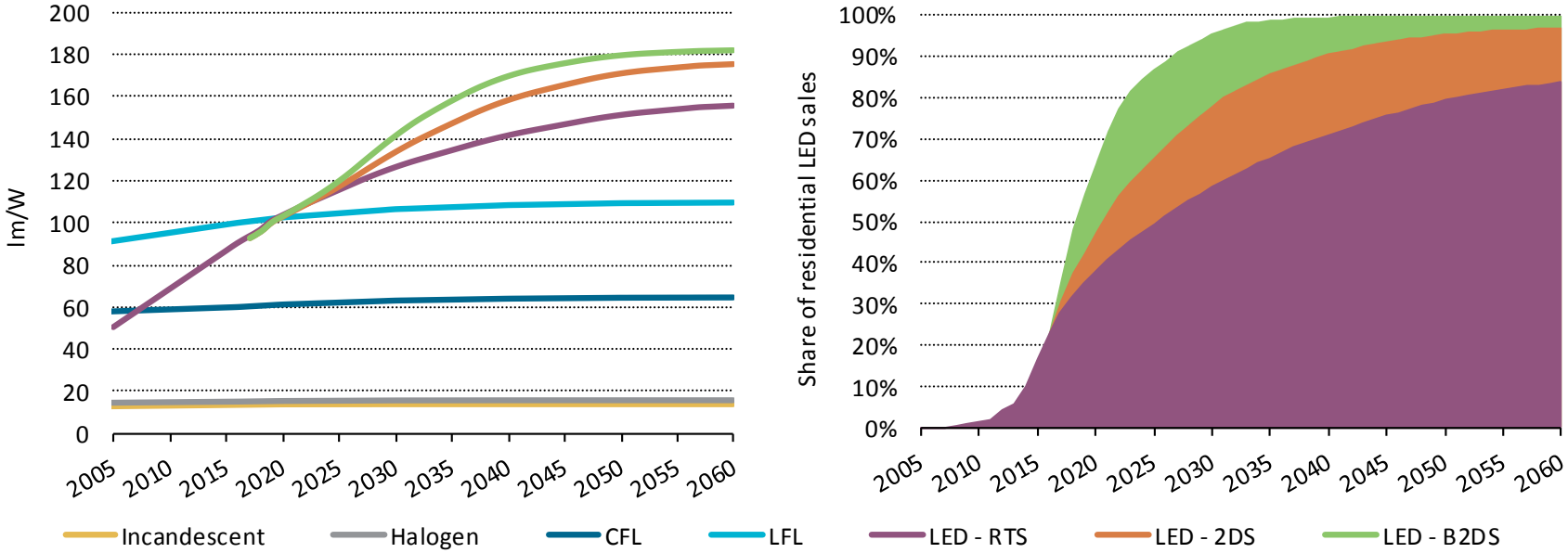
Building equipment and systems: lighting

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

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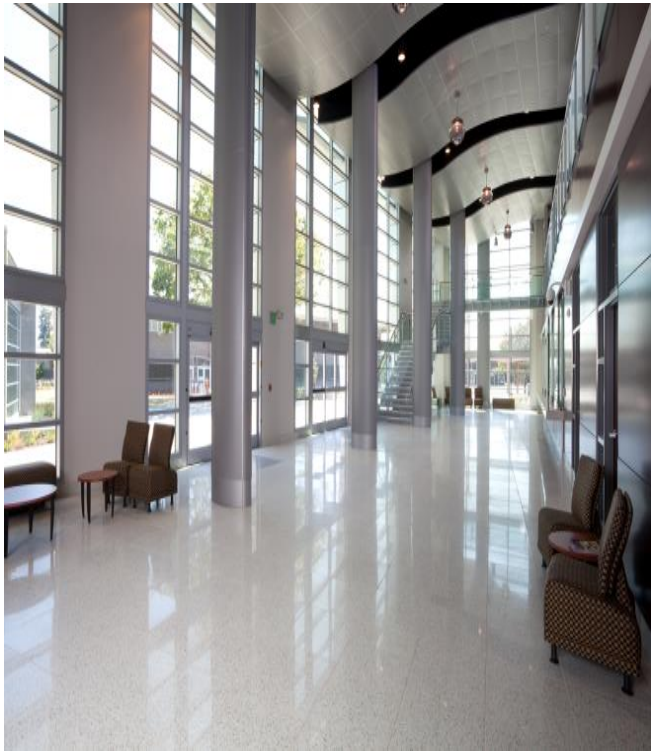
Building equipment and systems: lighting (passive)



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

Source: Sage Electrochromics

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Advanced technologies: equipment and systems

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

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Summary

Technology roadmaps

Advanced technologies

What can change your market?

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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

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

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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

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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 energy efficient.*

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