IEA Technology Roadmap for energy efficient building envelopes

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The latest International Energy Agency (IEA) Technology Roadmap concerning energy efficiency in buildings was released on 18 December 2013 and focuses on Energy Efficient Building Envelopes[1][1]. The publication consists of definition and analysis of available technology, development vision for R&D and technology deployment and assessments of policy, financial and related needs.[2]

Keywords: building envelope, thermal insulation, energy efficient building, IEA.

The IEA is an autonomous organisation which works to ensure reliable, affordable and clean energy for its 28 member countries and beyond. The IEA's four main areas of focus are: energy security, economic development, environmental awareness, and engagement worldwide.

In most of the world, the energy performance of building envelopes has been significantly neglected. While there has been substantial success in improving the energy efficiency of new appliances, lighting and heating and cooling equipment, many buildings are still being constructed that are leaky, have no insulation or exterior shade control, and have single-glazed clear glass windows and solarabsorbing roofs in hot climates. Given that heating and cooling account for over a third of global energy consumption in the buildings sector, optimising building envelope design should be a key part of any long-term energy reduction strategy.

Key findings and actions

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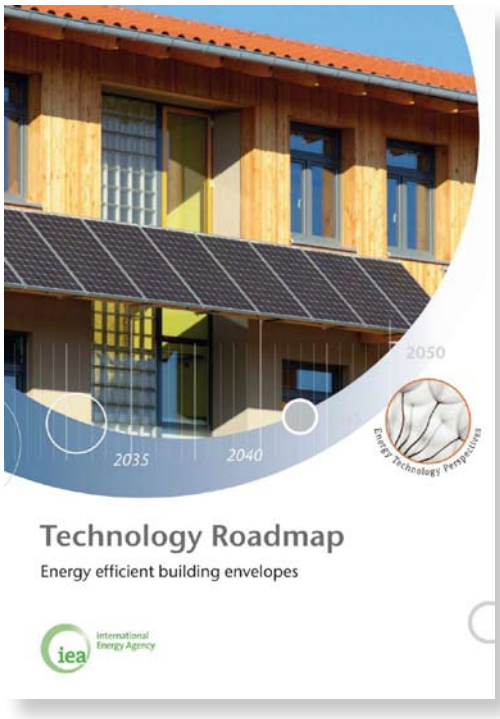
- The building envelope – the parts of a building that form the primary thermal barrier between interior and exterior – plays a key role in determining levels of comfort, natural lighting and ventilations, and how much energy is required to heat and cool a building.
- The construction of new buildings offers the best opportunity to deploy passive heating and cooling designs, which make use of energy efficient building materials to minimise energy required for heating and cooling.
- Transforming typical building renovation to make way for deep reductions in energy consumption – known as deep renovation – should be a high priority.[3]



[1] This publication was prepared by the Energy Technology Policy Division of the International Energy Agency (IEA). Marc LaFrance was the lead author and coordinator for this roadmap. The IEA worked with several key organisations to host workshops including the Russian Energy Agency, Tsinghua University and the United States Department of Energy.

[2] In addition the roadmap also includes 2 annexes [2] which go into more depth on building envelope technologies and life-cycle cost analysis for energy efficient envelopes and integrated systems.

[3] Deep renovation is considered here to mean refurbishment that reduces energy consumption by 75% and limits energy consumption for heating, cooling, ventilation, hot water and lighting to 60 kWh/m/yr (GBPN, 2013). Several organisations, including EuroAce, are calling for a tripling of the current rate of renovation.

- Building envelope improvements can improve occupant comfort and the quality of life to millions of citizens, while offering significant non energy benefits such as reduced health care costs and reduced mortality of "at risk" populations.
- Air sealing – restricting the passage of air through the building envelope – is a key way of increasing energy efficiency during new construction and deep renovation.
- New office buildings should be fitted with integrated facade systems that optimise daylight while minimising energy requirements for heating, cooling, artificial lighting and peak electricity use.
- It is vital to increase global collaboration on developing more affordable zero-energy buildings, especially in cold climates.
- R&D on the following technologies will lead to greater returns on investment:
  - Highly insulated windows;
  - Advanced, high-performance, "thin" insulation;
  - Less labour-intensive air sealing, and lower-cost;
  - Validation testing;
  - Lower-cost automated dynamic shading and;
  - Glazing;

Table 1. An assessment of market saturation for high-priority building envelope components (reproduced from Technology Roadmap: Energy efficient building envelopes © OECD/IEA 2013, Table 4, p. 18, modified by author).

Market maturity/ saturation	ASEAN*	Brazil	China	European Union	India	Japa/ Korea	Mexico	Middle East	Australian / New	Russia	South Africa	United States/
Double-glazed low-e glass	O	⅄	⅄	■	⅄	O	O	⅄	O	O	O	■
Windows films	⅄	⅄	⅄	O	⅄	O	⅄	⅄	O	⅄	⅄	O
Window attachments (e.g. shutters, shades, storm panel)	O	⅄	O	■	⅄	O	⅄	O	O	⅄	O	O
Highly insulating windows (e.g. triple-glazed)		⅄	⅄	O		⅄		⅄	⅄	⅄	⅄	⅄
Typical insulation	■	O	■	■	O	■	O	■	■	■	O	■
Exterior insulation	O	⅄	O	■	O	O	⅄	O		⅄	⅄	■
Advanced insulation (e.g. aerogel, VIPs)				⅄		⅄				⅄	⅄	⅄
Air sealing	O	⅄	⅄	■	⅄	O		⅄	⅄	⅄		O
Cool roofs	⅄	⅄	⅄	O	⅄	⅄	⅄	⅄	⅄			■
BIPV/ advanced roofs	⅄	⅄		⅄	⅄	⅄			⅄	⅄	⅄	⅄

■ Mature market O Established market ⅄ Initial market

* ASEAN = Association of Southeast Asian Nations. Blank cells indicate that there is currently not any market presence or it is so low that it is not known to domestic experts. Some technologies may not be recommended for all climates, such as cool roofs in Russia or highly insulated windows in hot climates. Typical insulation refers to widely available products such as fibreglass and various foams with thermal conductivities higher than 0.02 watts per meter Kelvin (W/mK). VIP = vacuum-insulated panel.

- ➔ More durable and lower-cost reflective roof ;
- ➔ Materials and reflective coatings.

- To provide policy makers with the information they need, key energy efficiency indicators and benchmarks should be established for the energy consumption of multiple building types, and the market share of advanced building envelope technologies and products should be tracked.

Table 2. Cost and performance goals for building envelope technologies, 2020-30* (reproduced from Technology Roadmap: Energy efficient building envelopes © OECD/IEA 2013, Table 6, p. 25, modified by author).

Technology	Market perspectives	Performance goals	Cost targets
Typical insulation (widely available, thermal conductivity of > 0.02 W/mK)	Highly competitive market with uniform performance metrics in all regions for existing stock and new construction.	Average U-value walls and roof, cold climate ≤ 0.15 W/m²K; hot climate ≤ 0.35 W/m²K.	LCC neutral or lower at moderate energy prices.
Advanced insulation (e.g. aerogel, VIPs)	Used for very high-performance buildings in cold climates and space-constrained applications.	Thermal conductivity of ≤ 0.015 W/mk.	Material cost less 50%, installed cost competitive with typical insulation.
Air sealing	Widely applied to over 95% of world structures with heating and cooling loads.	Retrofit ≤ 3.0 ACH or 50% reduction; New ≤ 0.5 ACH with mechanical ventilation.	Validation testing reduced by 30% to 60%; 50% lower ACH in existing buildings reduced from USD 24/m² to ≤ USD 10/m².
Reflective surfaces	Applied to new roofing materials and after-market coatings for hot climates and dense urban areas.	Long-lasting SR of ≥ 0.75 for white surfaces, and SR ≥ 0.40 for coloured surfaces.	Additional installed price premiums ≤ USD 10/m².
Windows (double low-e galzing, low-conductive frames)	Minimum for global market.	Whole-window performance, U-value ≤ 1.8 W/m²K.	Price premiums from single-glazed (≤ USD 40/m²), from double clear (≤ USD 5/m²).
Highly insulating windows (e.g. tripleglazed, low-e, and lowconductive frames)	Needed for cold climates for all buildings, and mixed climates for residential.	U-value ≤ 1.1 W/m²K.	Price premiums from double low-e (≤ USD 40/m²)
Energy-plus windows in cold climates (highly insulating and dynamic solar)	Dynamic solar control for most service buildings that have glass to optimise daylight; and highly insulating and dynamic solar control for mixed and cold climates residential.	Whole-window performance, highly insulating U-value ≤ 0.6 W/mK and variable SHGC 0.08 – 0.65.	Highly insulating dynamic SHGC price premium from double low-e (≤ USD 120/m²).
Window attachments* (automatic solar control, e.g. exterior solar shades and blinds)	Priority for existing windows but also for alternative option to dynamic glass.	Ability to reduce solar heat gain almost to zero, but preferred options would have daylight features (e.g. SHGC 0.05 to 0.5) to prevent increased lighting energy.	USD 70/m²(not including control systems that can be expensive if not used for other building systems)
Window attachments (highly insulating, e.g. cellular shades, low-e films)	Predominately retrofit market but also applicable to new zeroenergy buildings.	Installed with existing windows, total performance, U-values ≤ 1.1 W/m²K.	USD 40/m².

* VIP = vacuum-insulated panel. This table is based on IEA analysis, with data taken predominantly from envelope roadmap workshop presentations. Targets have not been vetted by all regions and will vary considerably. These targets are provided as a reference or starting points so regions and countries can develop implementation plans tailored to local markets, climates and conditions. The U-values are calculated according to ISO standard. (decrease with 10% for calculating the EN standard value).

Key actions in the next ten years

To enable advanced building envelopes to be used in a wider range of climates and regions, all interested parties must make greater effort to support mechanisms that favour R&D and deployment of energy-efficient building materials.

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- Policy makers must take responsibility for establishing goals for the energy efficiency of building envelopes, when new buildings are constructed and during deep renovation.
- National and local government authorities should urgently establish and enforce stringent energy codes for new buildings that identify affordable technological solutions, particularly in urban areas of developing countries with tropical or arid climates.
- It is vital to accelerate deployment of proven technologies such as insulation, air sealing, low-emissivity (low-e) windows, exterior shading or other attachments, through innovative financing mechanisms such as utility programmes, revolving funds and energy-performance contracts.
- Building energy codes should require that roof/attic insulation that meets the latest standards – including proper air and duct sealing if applicable – is installed when roofs are replaced.
- The economic, comfort and health benefits of low energy buildings need to be better communicated to the public and financial communities.

Market assessment of energy efficient building materials

Data on current market share are difficult or expensive to obtain in developed countries and are often not available in emerging markets, so the IEA has used assessment and inputs from experts worldwide to estimate three levels of market saturation: mature market (greater than 50%), established market (approximately 5% to 50%), and initial market presence (available but less than 5%) (see **Table 1**).

Cost reduction and performance goals

Establishing specific cost and performance criteria for the entire world is almost impossible because factors such as climate, occupant behaviour, construction practice and availability of resources vary widely. Key improvement metrics and goals can be established, however, that provide benchmarks for policy makers (see **Table 2**). For most regions, these criteria will be seen as aggressive, but for several advanced programmes in cold climates where energy prices are high, they may be seen as not stringent enough. Based on local conditions, more stringent criteria can easily be pursued.

Conclusions

The nature of the building envelope determines the amount of energy needed to heat and cool a building and hence needs to be optimised to keep heating and cooling loads to a minimum in accordance with LCC analysis. Lower heating and cooling requirements will also help offset envelope investments since avoided capital cost for equipment can be used to fund envelope efficiency measures. ■

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