Building Shell and Thermal Insulation

HIGHLIGHTS

■ **PROCESS AND TECHNOLOGY STATUS –** The building shell and thermal insulation have a significant effect on heating and cooling loads. Incorporating high levels of thermal insulation and increasing air tightness in buildings can reduce energy demand in both cold and warm climates. In almost all OECD countries, Building Codes require new buildings to include some level of thermal insulation; in general, colder climates have stricter requirements although the standards vary significantly between countries and regions. Older building stock typically has lower levels of insulation, as Building Codes have become stricter over time and many properties are specified to meet the minimum standards in force at the time of construction. Many developing countries also have Building Codes; however, ensuring compliance has been a problem in the past. The most popular building thermal insulation materials include expanded polystyrene, extruded polystyrene, polyisocyanurates, polyurethane, mineral wool, cellulose (recycled newspapers) and fibreglass. The traditional market leader in the US is fibreglass and in Europe it is mineral wool. Both types are used primarily in the residential market. Demand for foamed plastic insulation (used mainly in non-residential market) is increasing due to the higher performance levels required by stricter Building Codes. Penetration of double-glazed windows is high in most European countries, and triple-glazed units are common in Scandinavian countries. Heat losses due to air infiltration may be reduced by using air tight construction and sheltering exposed walls. Some Building Codes have provisions for air tightness, but this is less common than for thermal insulation. Improvements to air tightness can be achieved by a variety of means including caulking, weatherstripping, use of certain insulation materials and installing impermeable barriers.

■ **PERFORMANCE AND COSTS –** In general it is far more cost-effective to integrate insulation and air tightness into new buildings than to retrofit an existing building. Improvements to the building shell can reduce heating requirements by a factor of two to four compared to standard practice at an additional cost of the order of a few percent of the total cost of residential buildings. There is little to no incremental cost in commercial buildings when downsizing of heating and cooling systems is accounted for. Using materials with higher thermal conductivity (resulting in higher k-values and poorer performance as an insulation material) means that a greater thickness is required to achieve the same performance. Mineral wool and natural fibre insulation materials typically have a range of thermal conductivities measured in k-values from 0.03 to 0.04 W/mK. Mineral wool costs around €4.40-7.80 per square metre (€/m^2) and cellulose costs around 10 €/m^2. For 50 mm thick flax, sheep's wool, hemp or cotton the cost is around 5.50 €/m^2 and for 100 mm thickness the cost is approximately doubled. Foam boards typically have a higher thermal performance compared to natural fibres, and have k-values of 0.025-0.035 W/mK. Foil-faced versions have improved values of 0.02-0.0235 W/mK. A 50 mm thick expanded polystyrene board costs around 3.14 €/m^2. Foamed-in-place insulation is more expensive compared to traditional forms of insulation, but is much more effective, with k-values of 0.023-0.028 W/mK. Use of foamed-in-place insulation can reduce other construction costs such as labour (as it requires less time to install) and improve air tightness measures (as it conforms to surfaces to create an airtight seal). Prices for window replacement in residential buildings vary from around 140 €/m^2 to 430 €/m^2 depending on the thermal performance (with better-performing windows costing substantially more). If installed as part of a general renovation or in a new building, the same performance windows would cost from 60€/m^2 to 130€/m^2. In domestic properties, use of products to improve air tightness can reduce air leakage rates by a factor of five to ten compared to standard practice in regions such as North America, Europe and Asia. Some types of thermal insulation can provide high levels of air tightness, such as spray-applied cellulose and foamed-in-place polymers. Other techniques include the use of caulking and weatherstripping. The addition of caulking strips to reduce air ventilation is expected to cost between 3 €/m^2 and 10 €/m^2 of living area.

■ **POTENTIAL AND BARRIERS –** Improvements in building shell and thermal insulation are largely driven by Building Codes, which regulate the design and construction of new buildings. For new buildings, the IEA envisages that Building Codes in cold climates will reach standards that reduce energy demand to between 15 and 30 kWh/m^2/year of useful energy for heating and cooling by 2020 or 2030. Achieving these standards for new buildings is expected to increase construction costs by between 2 % and 7 %. These costs are expected to decline over time as high-performance building shell materials achieve mass market penetration. In developing countries, new construction accounts for a large share of buildings, so energy efficiency measures for new-builds offer a major energy saving opportunity. In OECD countries, retrofitting existing stock is important, as many of the buildings in existence today will still be in use in 2050. Despite its cost-effectiveness, there are many barriers to energy efficiency in buildings, including access to finance, insufficient information, split incentives, users' lifestyle choices and multiple decision makers. In developing countries, access to finance is the most important barrier.

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