THERMAL INSULATION

PROPERTIES and APPLICATIONS in HOUSING

TECHNICAL MANUAL

Promoting community level job creation and income-generating activities through the development of cost-effective building materials production in Kyrgyzstan
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Every building material comes with some kind of environmental cost. For mitigating this cost, a number of principles can be used to provide help and guidance for selecting sustainable materials and construction systems. Careful analysis and reasoned selection of materials, including considering how the materials are being combined, can yield significant improvements in the comfort and cost effectiveness of homes, greatly reducing their life-cycle environmental impact.

In design and construction, it is also important to incorporate approaches that will make it easier to adapt, reuse, and eventually dismantle a building. By choosing durable, low-maintenance materials, the need for new materials and finishes can be minimized over the building’s lifetime. In addition to the choice of construction materials and other aspects of design, in countries with high seismic activity and cold climates like Kyrgyzstan, special attention must be paid to earthquake-resistant design and insulation. If houses are to be durable and energy efficient.

These days, a large number of synthetic and natural materials insulation options are available on the market. For the most part, the house-building industry chooses readily available and cost-effective insulation materials. However, there is a need to identify, distribute, and use environmentally-friendly and cost-effective insulation products that have been produced from locally-sourced materials. These materials, which are made from natural fibres, may appear more expensive initially, but their use can also benefit society through job creation. Natural, local products also offer significant long-term environmental benefits, compared with artificial insulation materials.

Sheep wool based insulation has been introduced under the UNIDO project in Kyrgyzstan. Sheep wool is a natural, sustainable, recyclable material, which is biodegradable and has low embodied energy. It does not endanger people’s health or the environment, and, unlike glass wool, does not require an installer to wear personal protective equipment. Wool is a highly-effective insulating material, which can perform better because it is able to absorb and release moisture.

This technical manual covers various aspects of insulation materials, including their properties, applications, worldwide marketing and patenting. Reference and bibliography is compilation of large numbers of research papers, articles and web links to share basic information about insulation materials among students and researchers. We sincerely hope that this technical manual will help in the dissemination of basic knowledge about the different kinds of insulation materials available to stakeholders in the building materials and construction industries.

Dr. Amit Rai
UNIDO International Expert
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INTRODUCTION

Insulation is one of the most efficient ways to save energy at home. It is estimated that a typical three-bedroom semi-detached house can see energy bills reduced by up to US $400 a year, as a result of installing loft and cavity wall insulation. Insulation helps keep a house at a desired temperature all year round, protecting it against cold in winter and excess heat in summer.

Whether we are considering central heating, water heating, heart pumps, or any other source of green energy for our home, the first step we should take is to improve our home’s insulation. This will ensure that the use of natural resources can be maximized without wasting energy. If we ignore this step, we may end up spending a lot of money on buying a very powerful system to meet the energy needs of a badly insulated house.

Insulation helps keep a house at a desired temperature all year round, protecting it against cold in winter and excess heat in summer.

In cold weather, heat can be lost from the house in all directions, and owners should consider integral insulation to ensure that heat is properly retained.

A wise choice is to insulate roofs, walls, windows and doors. The most important of these is walls, because in a typical house, they account for 30 to 40% of heat losses. Next come roofs, which account for approximately 25% of heat losses, than windows and doors, through which 10-20% is lost, and finally, floors.

Home insulation needs are met by a variety of natural or synthetic materials. The production process and applications differ depending on the specific design of houses and the particular structure involved. The energy requirements of the materials also vary in terms of the energy consumed in production, transportation, and application. Building insulation is a broad term and refers to any object in a building that is used to insulate for any purpose. While the majority of insulation in buildings is for thermal purposes, the term also applies to acoustic insulation, fire insulation and impact insulation (for example, where vibrations have to be damped in industrial applications). Often an insulation material is chosen for its ability to perform several of these functions at once.

Insulation requires intelligent planning. Not only does it make homes warmer in winter, it also helps keep them cooler in summer. The principle here is the same as a flask, which can keep drinks hot or cold by providing an insulating layer between the liquid and the outside air.

Air is a poor conductor of heat and it is the tiny pockets of air trapped within the insulating material which minimize the amount of heat that can pass between the inside and outside of a house. This means that in winter, the heat stays inside a home; and in the summer it stays outside. Different types of insulation materials possess different properties, and as a result, are suited to different areas of buildings.

How much money can be saved by insulating a home depends on a number of different factors, like the type of insulation and the size of the house. Moreover, depending on the age of a building, planning permission may be required to fit insulation, yet most houses do not require such permission. In the long run, insulation will pay back any initial outlay, and is invariably considered a wise investment.

Modern houses are usually built to very good insulation standards, but older houses often require a lot of work in this respect. Fortunately, there are many options to improve the energy efficiency of older houses.
PROPERTIES OF INSULATION MATERIALS

Most common insulation materials work by slowing conductive heat flow and, to a lesser extent, convective heat flow. Radiant barriers, which are not classed as insulation products, and reflective insulation systems work by reducing radiant heat gain. To be effective, the reflective surface must face an air space.

How insulation works

To understand how insulation works, it helps to have some knowledge of heat flow which involves three basic mechanisms: conduction, convection and radiation. Conduction is the mechanism seen when heat passes through materials, such as when a spoon placed in a hot cup of coffee conducts heat through its handle to our hand. Convection is in evidence when heat circulates through liquids and gases, and is why lighter, warmer air rises, and cooler, denser air sinks in our houses. Radiant heat travels in a straight line and heats anything solid in its path that absorbs its energy.

Most common insulation materials work by slowing conductive heat flow and, to a lesser extent, convective heat flow. Radiant barriers, which are not classed as insulation products, and reflective insulation systems work by reducing radiant heat gain. To be effective, the reflective surface must face an air space.

Regardless of the mechanism, heat flows from warmer to cooler areas until there is no longer a temperature difference. In our homes, this means that, in winter, heat flows directly from all heated living spaces to adjacent, unheated attics, garages and basements and also to the outdoors. Heat flows can also occur indirectly through interior ceilings, walls and floors, wherever there is a difference in temperature. During the seasons when cooling is needed, heat flows from the outdoors to the interior of a house.

To maintain comfort, the heat lost in the winter must be replaced by the heating system, and the heat gained in the summer must be removed by the cooling system. Properly insulating a home will reduce these losses and gains by providing effective resistance to the heat flows.
R-Value

An insulating material’s resistance to conductive heat flow is measured, or rated, in terms of its thermal resistance or R-value, the higher the R-value, the greater its effectiveness as an insulator. The R-value of the individual layers must be added together. Installing more insulation in a home increases the R-value, and, therefore, the resistance to heat flow. Insulation experts can determine the degree of insulation that is appropriate for any given climate.

The effectiveness of an insulation material’s resistance to heat flow also depends on how, and where, the insulation is installed. For example, an insulation that is compressed will not provide its full, rated R-value. The overall R-value of a wall or ceiling will be somewhat different from the R-value of the insulation itself because heat flows more readily through studs, posts and other building materials, in a phenomenon known as thermal bridging. In addition, insulation that fills building cavities densely enough to reduce airflow can also reduce convective heat loss.

The amount of insulation, or R-value, needed depends on the climate, the type of heating and cooling system, and the part of the house that is to be insulated. Air sealing and moisture control are important to a home’s energy efficiency, health, and comfort.

Vapour permeability

Vapour permeability is the extent to which a material permits the passage of water through it. It is measured by the rate of vapour transmission through a unit area of flat material of unit thickness, induced by a unit of vapour pressure difference between two specific surfaces, under specified temperature and humidity conditions.

Thermal insulation is usually characterized as vapour permeable or non-vapour permeable. Often referred to, erroneously, as being of breathability construction, walls and roofs so treated are characterized by their capacity to transfer water vapour from the inside to the outside of the building – so reducing the risk of condensation.

Thermal conductivity

Thermal conductivity measures the ease with which heat can travel through a material by conduction, which is the main way that heat is transferred through insulation. Thermal conductivity is often termed the Λ (lambda) value, or k value; and the lower the figure, the better the performance.

In simple terms, this value is a measure of the capacity of a material to conduct heat, or its capacity to store heat. All materials, have specific thermal conductivity values that can be used to determine their effectiveness. Insulators, Thermal conductivity can be defined as the amount of heat/energy (expressed in kcal, Btu, or J) to measure their effectiveness as insulators. Thermal conductivity can be expressed in kcal/m²°C/W/m°C and, in the SI system, in watts (W) m-1°C-1.

Thermal diffusivity

Specific heat capacity

The specific heat capacity of a material is the amount of heat needed to raise the temperature of 1kg of the material by 1°C. A good insulator has a higher specific heat capacity, meaning it takes time and heats the material, and more heat before actually heating up (showing a better performance) as the material stores the heat it has absorbed. High specific heat capacity is a feature of materials providing thermal mass or thermal buffering.

Density

The density refers to the mass per unit volume of a material and is measured in kg/m³. A high-density material maximizes the overall weight and is a feature of high thermal diffusivity and high thermal mass materials.

Embodied energy

Though not a factor in the thermal performance of an insulation material, embodied carbon is a key concept when it comes to balancing the greenhouse gas emissions generated when producing a material with the emissions saved by the insulation over its lifetime. Embodied carbon is usually considered as the amount of carbon released as gas from the fossil fuels used to produce the energy needed for the extraction of raw material and its manufacture into a finished product, to the point where it leaves the factory gate. In reality, of course, the extent of embodied carbon goes much further than this. It includes transportation to the site where the product will be used, and the energy used in installation, through to that required for demolition and disposal. The science related to embodied carbon is still evolving, consequently, firm and reliable data is difficult to obtain.

Vapour Permeability (building materials)
Fibreglass is the most commonly used insulation material of recent times. As a result of the way it is being produced, by weaving fine strands of glass into an insulating material, fibreglass is able to minimize heat transfer. It is commonly used to produce two different types of insulation: blankets (batts and rolls) and loose fill, and it can also be found in the form of rigid boards and duct insulation. Manufacturers now produce medium and high-density fibreglass batt insulation products that have slightly higher R-values than the standard batts. The denser products are intended for insulating areas with limited cavity space, such as cathedral ceilings.

Fibreglass is a nonflammable insulation material, with R-values ranging from 2.9 to 3.8 per inch. Moreover, it is a cheap form of insulation and is therefore the recommended option. However, installing it requires safety precautions. It is important to use eye protection, masks and gloves when handling fibreglass.

Cellulose insulation is arguably one of the most eco-friendly forms of insulation. It is produced from recycled cardboard, paper and other similar materials, and is supplied in a loose form. Cellulose has an R-value between 3.1 and 3.7 per inch. Some recent studies on cellulose have shown that it may be an excellent product to prevent fire damage. As a result of its dense nature, cellulose contains virtually no oxygen. This lack of oxygen retards combustion, and, therefore, helps to minimize the amount of damage that a fire could cause. Manufacturers tend to add the mineral borate, sometimes blended with less costly ammonium sulphate, to cellulose insulation to ensure fire and insect resistance. Cellulose insulation typically requires no moisture barrier and, when installed at the appropriate densities, does not settle in building cavities.
Some natural fibres, including cotton, sheep wool, straw and hemp are used as insulation materials. 

COTTON INSULATION MATERIALS 
Cotton insulation consists of 85% recycled cotton, and 15% plastic fibre treated with borate. The insulation is treated with a fire retardant to ensure it is not readily exposed to flames. The R-value of cotton fibre treated with borate is about 3.0 per inch, which is similar to other fibrous types of insulation. 

When it is to be used as an insulating material, sheep wool is also treated with borate for past, fire and mold resistance. It can hold large quantities of water, which may be an advantage in some walls, but repeated wetting and drying can result in borate being leached from the material. The R-value of sheep wool batts is about 3.5 per inch, which is similar to other fibrous types of insulation. 

Sheep wool is a proven material when it comes to absorbing and neutralizing harmful substances. It is a natural protein made up of 18 different types of amino acid chain, 60% of which have a reactive side chain. These reactive areas allow the wool to absorb harmful and odorous substances including nitrogen dioxide, sulphur dioxide and formaldehyde, which are then neutralized through a process known as chemisorption. Therefore, using sheep wool as insulation can offer benefits in terms of wellbeing, and help create a healthy indoor climate. 

Several sheep wool batts, similar to those manufactured from sheep wool to absorb harmful and odorous substances, including nitrogen dioxide, sulphur dioxide and formaldehyde, which are then neutralized through a process known as chemisorption. Therefore, using sheep wool as insulation can offer benefits in terms of wellbeing, and help create a healthy indoor climate. 

Polystyrene, a colourless, transparent thermoset plastic, is commonly used to make foam or bead board insulation, concrete block insulation, and a type of loose fill insulation consisting of small beads of polystyrene. 

Moulded expanded polystyrene (MEPS), commonly used in foam board insulation, is also available as small foam beads. These beads can be used as a pouring insulation for concrete blocks or other hollow wall cavities, but, because they are extremely lightweight and hold a static electric charge very easily, they are notoriously difficult to control. 

Hemp is one of the oldest cultivated plants on earth and is an excellent insulating material, as well as being widely used for clothing, paper, oil, fuel, food and other construction materials. 

Hemp can grow to a height of nearly four metres in a period of 100-120 days. Because the plants naturally shade the soil, no chemicals, or potentially toxic compounds, are required in hemp cultivation. As well as having low embodied energy during manufacture, hemp insulation is carbon negative because the plant absorbs carbon from the atmosphere, "locking it in" as it grows. 

Hemp insulation is a little-known insulating material that is not commonly used. It has an R-value of about 3.5 per inch, which is similar to other fibrous types of insulation.
Polyisocyanurate, also known simply as polyiso, is a thermosetting type of plastic closed-cell foam that contains a low-conductivity, hydrochlorofluorocarbon-free gas in its cells. The high thermal resistance of the gas gives polyisocyanurate insulation materials an R-value ranging from 5.6 to 8 per inch. Polyisocyanurate insulation is available as a liquid, as a sprayed foam, and as a rigid foam board. It can also be produced as laminated insulation panels with a variety of facings. Over time, the R-value of polyisocyanurate insulation may fall as the low-conductivity gas in its voids escapes and is replaced by air, a phenomenon known as thermal drift. Reflective foil, if installed correctly and facing an open-air space, can also act as a barrier to radiated heat transfer. Depending on the size and orientation of the air space, this can add another 2 per inch to the overall R-value. Panels with foil facings have stabilized R-values of about 8.5 per inch. Polyisocyanurate insulation is available in liquid sprayed foam and rigid foam board forms.

Polyurethane is a foam insulation material that contains a low-conductivity gas in its cells. The high thermal resistance of the gas gives polyurethane insulation materials R-values ranging from 5.6 to 8.5 per inch. Polyurethane foam insulation is available in closed-cell and open-cell forms. In closed-cell foam, the high-density cells are closed and filled with a gas that helps the foam expand to fill the spaces around it. Open-cell foam cells are not as dense and are filled with air, giving this form of insulation a spongy texture and a lower R-value. Foil and plastic facings on rigid polyurethane foam panels can help stabilize the R-value. Panels with foil facings have stabilized R-values of 7.1 to 8.7 per inch. Some manufacturers use polyisocyanurate as the insulating material in structural insulated panels (SIPs), which can be manufactured from both foam board and liquid foam.

Vermiculite and perlite insulation materials are commonly found as attic insulation in homes built before 1950. Vermiculite insulation materials are not widely used today because of the risk of their containing asbestos. Having said that, only a few sources of vermiculite have been found to contain more than trace amounts of asbestos. Vermiculite and perlite consist of very small, lightweight pellets, which are made by heating rock pellets such that they expand and pop. This creates a type of loose fill insulation that contains a low-conductivity, thermosetting plastic, closed-cell foam. They are made by heating rock pellets very small, lightweight pellets, which are made by heating rock pellets such that they expand and pop. This creates a type of loose fill insulation that contains a low-conductivity gas in its cells. The high conductivity gas helps the foam expand to fill the spaces around it. Open-cell foam cells are not as dense and are filled with air, giving this form of insulation a spongy texture and a lower R-value. Foil and plastic facings on rigid polyurethane foam panels can help stabilize the R-value. Panels with foil facings have stabilized R-values of 7.1 to 8.7 per inch. Some manufacturers use polyisocyanurate as the insulating material in structural insulated panels (SIPs), which can be manufactured from both foam board and liquid foam.

Urea-formaldehyde (UF) foam was used in homes during the 1970s and early 1980s. However, as a result of numerous health-related court cases caused by improper installations, UF foam is no longer available for residential use and has been discredited due to its tendency to emit formaldehyde and shrink. It is now used primarily to insulate walls in commercial and industrial buildings. UF foam insulation has an R-value of about 4.6 per inch and uses compressed air as the foaming agent. Nitrogen-based UF foam may take several weeks to cure completely, and, unlike polyiso, it cannot be sanded or milled. UF foam does not expand as it cures. Water vapour can easily pass through it and it breaks down when exposed to temperatures above (90°F (88°C) for prolonged periods of time. Moreover, UF foam contains no fire retardants.

Cementitious insulation materials are a cement-based foam used as sprayed foam or foam-in-place insulation. One type of cementitious spray-foam insulation contains magnesium silicate and has an R-value of about 3.9 per inch. With an initial consistency similar to cream, it is pumped into closed cavities. The cost of cementitious foam is similar to that of polyurethane foam, and it is nontoxic, non-flammable and made from minerals extracted from seawater, such as magnesium oxide.

Phenolic (phenol-formaldehyde) foam was quite popular in the past, in the form of rigid foam board insulation, but in these days it is available only as a foamed-in-place insulation. Phenolic foamed-in-place insulation has an R-value of 4.8 per inch and uses air as the foaming agent. One major disadvantage of phenolic foam is that it can shrink by up to 2% after curing, a property that contributes to its lack of popularity today.

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Insulation commonly works through a combination of two characteristics:

- The insulating material’s natural capacity to inhibit the transmission of heat; and
- The use of pockets of trapped gas which act as natural insulators.

Gases possess poor thermal conduction properties, compared with liquids and solids; therefore, if they can be trapped, they make good insulation materials. Dispersing the gas into small cells, that cannot transfer heat effectively by natural convection, will further enhance a gas’s insulating effectiveness. Convection involves larger, bulk flows of gas, driven by buoyancy and temperature differences; it does not take place effectively in small cells where there is little density difference to drive it. In foam materials, small gas cells or bubbles are present in the structure. In fabric insulation, such as wool, small variable pockets of air occur naturally.

General concepts for insulation of residential housing

Insulation acts as a barrier to heat flow and is essential for keeping homes warm in winter and cool in summer. A well-insulated and well-designed home can provide year-round comfort, potentially cutting cooling and heating bills in half. This, in turn, reduces greenhouse gas emissions.

Figure 5: Thermal heat losses and gains without insulation in a temperate climate

<table>
<thead>
<tr>
<th>Insulation Category</th>
<th>Winter Heat Losses</th>
<th>Summer Heat Gains</th>
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<td>Ceiling</td>
<td>25% to 35%</td>
<td>25% to 35%</td>
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<tr>
<td>Windows</td>
<td>10% to 20%</td>
<td>25% to 35%</td>
</tr>
<tr>
<td>Walls</td>
<td>15% to 25%</td>
<td>15% to 25%</td>
</tr>
<tr>
<td>Floor</td>
<td>10% to 20%</td>
<td>15% to 25%</td>
</tr>
<tr>
<td>Air leakage</td>
<td>15% to 25%</td>
<td>15% to 25%</td>
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The two general types of insulation

Insulation products come in two main categories – bulk and reflective – which are sometimes combined as a composite material. Bulk insulation is mainly provided in walls and roofing areas of houses, in order to resist the transfer of direct heat inside the house. The trapped air in the insulation materials restricts heat transfer by providing thermal resistance. For the most part, the thermal resistance remains the same, regardless of the direction of heat falling on the outside surface of the house.

Bulk insulation could be provided using a large number of natural, as well as artificial materials, such as glass wool, wool, cellulose fibre, polyester and polystyrene. Most bulk insulation products have a defined R-value for a given thickness.

Reflective insulation mainly resists radiant heat flows as a result of its high reflectivity and low emissivity (ability to re-radiate heat). As this insulation works by reflecting heat, air flow and the angle at which the sun rays fall on the surface of the house also play an important role in overall insulation where reflective insulators are used. The thermal resistance of reflective insulation varies according to the direction of heat flows through it.

Reflective insulation usually consists of shiny aluminium foil laminated onto paper or plastic, and is available as sheets (sarking), concertina-type batts, and multi-cell batts. Together these products are known as reflective foil laminates, or RFLs. To achieve the best results from this kind of reflective insulation the outer surface must be clean.

Composite bulk and reflective materials are available, which combine some of the features of both of the above types of insulation. Examples include reflective foil-faced blankets, foil-backed batts and foil-faced boards.
The total R-values for reflective insulation are supplied as ‘up’ and ‘down’ values. Total values depend on where and how the reflective insulation is installed. You must ensure that any system values provided by the manufacturer relate to your particular installation.

**Worldwide patterns in the use of housing insulation**

Rural-to-urban migration in developing countries in the Asia/Pacific and Africa/Middle East regions will stimulate building activity in urban areas. As urban buildings are usually more insulation intensive than those in rural areas, this will, in turn, stimulate demand for insulation. Additionally, rising per capita incomes will encourage the use of modern building techniques and materials, including insulation. In some countries in the Africa/Middle East and Asia/Pacific regions, the adoption of minimum insulation requirements will also contribute to demand.

**Foamed-plastic insulation to grow the most rapidly**

Of the major insulation types, foamed-plastic segments will see the most rapid rise in demand. Foamed plastic insulation will be used more frequently in construction applications as a result of its high insulation value, which will allow it to capture market share from fibreglass and mineral wool insulation. Demand for fibreglass insulation will benefit from strong growth in residential construction activity in North America, as it is a product that is used extensively in the United States of America and Canada. Mineral wools are expected to show the slowest growth among major insulation materials, though gains will still be considerable, since requests from China, where fire safety is a major concern, will boost demand for this product.

**Building insulation for cost-effective energy consumption**

A well-insulated building, whether commercial or residential, is both an energy-efficient and cost-efficient choice because it reduces the cost incurred by a heating or cooling system. Insulation relates to the prevention of the passing of thermal energy between two objects from a region of higher heat concentration to one of lower heat concentration and thereby maintaining the heat in a given area. A properly insulated building saves unnecessary wastage or gain of heat energy. More specifically, building insulation means the use of specific materials in a building in order to lower the heat loss that occurs in it.

**Important considerations in house insulation**

The level of insulation required for a home or office depends on the design of the building, climate, personal preferences, available budget and energy costs. Selecting the strategy for the insulation of a building is based on considerations such as the modes of energy transfer that occur within it and the intensity and direction of energy flows. These may vary over the day and from one season to another. Therefore, to maximize the benefits that can be derived from insulation, the right design, combination of materials and building techniques must also be selected. Where a requirement has been identified to add insulation, the levels of existing insulation in the building should be determined before taking additional measures.
I n 2016, an international market research company published a new report titled Insulation (Plastic Foam, Mineral Wool, Fibreglass and Others) Market for Residential Buildings, Non-Residential Construction, Analysis, Size, Share, Growth, Segment Trends and Forecast: 2014–2020. According to this report, the global insulation market is expected to reach approximately US $65.0 billion by 2020, growing at a compound annual growth rate (CAGR) of about 8.0% between 2015 and 2020. The insulation market is segmented on the basis of its key products, including plastic foam, mineral wool, fibreglass and others. Fibreglass is the largest product segment and accounted for over 40% of the total revenue generated in 2014. The growth of this segment, which accounted for over 50% of the share of the total revenue generated in 2014, is dominated by the residential-buildings segment and other sectors. The insulation market is expected to exhibit strong growth as a result of rising government support and dramatic increase in the use of green building materials. Such regulations and initiatives have been identified as the underlying driving factors in the market. However, there are challenges facing the thermal insulation sector, such as low awareness of its materials in emerging countries, and the high capital cost of installing thermal insulation in buildings. The Asia/Pacific market is the largest regional market for insulation, accounting in 2014 for over 40% of the total revenue generated in the sector. The market for insulation in the Asia/Pacific region is expected to exhibit strong growth as a result of rising government support and dramatic increase in the use of green building materials. Insulating materials are widely applied in the residential-building non-residential-construction, industrial, heating ventilation and air conditioning (HVAC), Original Equipment Manufacturer (OEM) and other sectors. The insulation market is dominated by the residential-buildings segment, which accounted for over 50% of the share of the total revenue generated in 2014. The growth of this segment can mainly be attributed to increasing urbanization combined with high disposable income. Construction sector output, manufacturing industry output, construction industry spending and the trend towards urbanization, are some of the macro-economic drivers in the insulation market. Developed economies, such as North America and Europe, have introduced regulations concerning energy-efficient buildings, and according to the Concerted Action Energy Performance of Buildings Programme (a joint initiative between the Member States of the European Union and the European Commission), all new buildings constructed in the Member States by 2020 should comply with zero-energy standards. Even governments in emerging countries are actively promoting the use of thermal-insulation materials. For example, in 2014, Andhra Pradesh (a state in South-East India) adopted the Energy Conservation Building Code (ECBC), under which commercial and public buildings in the state are expected to cut costs and dramatically reduce energy usage by 40% to 60%, through the use of green building materials. Such regulations and initiatives have been identified as the underlying driving factors in the market. However, there are challenges facing the thermal insulation sector, such as low awareness of its materials in emerging economies, and the high capital cost of installing thermal insulation in buildings. The favourable regulatory environment that can be found in most parts of the world, for example, building codes in the European Union which require increased use of insulation to reduce energy consumption, is expected to have a positive influence on demand growth. In addition, increased spending on infrastructure in the emerging markets of the Asia/Pacific region, such as India, China, Indonesia and Thailand, is also expected to spur growth in the period to 2024. Volatile prices of key raw materials are expected to remain a considerable challenge for players in the industry. Raw materials, such as styrene, which is used to manufacture plastic foams, are facing volatility on account of varying crude oil prices. Such issues are expected to present challenges to industry players in terms of production costs and profitability. However, the current period of lower crude oil prices is expected to benefit demand for plastic foams. High levels of integration exist in the foamed-plastic market as the raw material suppliers are forward integrated and also manufacture insulation products. The major players in the industry are likely to pursue a first-mover advantage in order to achieve a large market share and product portfolio. Increasing expenditure on research by key players is also likely to positively impact the market. Moreover, leading players have been focusing on mergers and acquisitions to expand their presence in emerging regions.
High
Fair
Moderate

Regional insights
The Asia/Pacific insulation market led the global industry and accounted for over 40% of global revenue in 2015. The market in this region is characterized by high insulation demand for residential and commercial buildings. High industrialization rates and increased construction spending in the emerging economies of China, India, Indonesia, Thailand, Malaysia and the Philippines have driven the need for better infrastructure.

Growing demand for thermal insulation in residential and commercial buildings is expected to be a major driver of demand in North America. High awareness among consumers regarding energy conservation and regulatory policies to reduce greenhouse gas emissions are expected to have a positive impact on regional growth in this area.

Growth in the North American insulation market will be influenced by government initiatives such as the Weatherization Assistance Program, which promotes thermal insulation, especially in low-income households. Regional demand growth can also be attributed to the demand for insulation materials that is generated by building refurbishment.

Competitiveness insights
The global insulation market is characterized by the presence of multinational conglomerates. Production of insulation materials is capital-intensive and, as a result, entry barriers are high. Achieving economies of scale remains the major focus for players in the industry participants in terms of competitiveness.

The industry is dominated by a small number of major companies with very small differences in their product offerings. Key players include Saint-Gobain, Rockwool, Johns Manville, Knauf, and the Huntsman Corporation.

As a result, the rapid development of infrastructure in emerging regions, the major players are now focusing on achieving a first-mover advantage in the lucrative markets that this has generated. Competition in the industry is greatly affected by environmental regulations.

The winning market-share strategy
Leading players in the global insulation materials market have adopted various strategies to gain additional market share. The main strategies employed have been generated by analysis of press releases, annual reports of players operating in the market and direct discussions with industry experts. The market players profited in this manual are insulation materials producers and distributors serving industries such as construction, oil and gas, HVAC and OEM, automotive, wires and cables.

The key strategies adopted by these players include new product launches, joint ventures, acquisitions, partnerships, expansion and investment.

Patent analysis
From January 2011 to January 2016, a total of 4,184 patents related to insulation materials were consumed in 2015, accounting for over 40% of global revenue in 2015. The main strategies employed by these players include new product launches, joint ventures, acquisitions, partnerships, expansion and investment.

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Figure 10: Global thermal insulation material market value split, by region (2016 and 2020)

Figure 12: Patent analysis by geographic region (2011-2016, %)

Figure 13: Important areas and segments for the insulation market
The UNIDO low-cost housing project entitled “Promoting community level job creation and income-generating activities through the development of cost-effective building materials production in Kyrgyzstan” was conceived with the objectives of using locally available materials for the development of new and alternative building materials and employment generation. The project is funded by the Russian Federation and is fully consistent with the needs and the priorities set out by the country’s government.

The technical and administrative implementation of the UNIDO project in Kyrgyzstan has generated a large number of new ideas, which have been shared and discussed among large numbers of stakeholders to help ensure their appropriate and effective adoption as part of the project.

A procurement process was initiated for the adoption of new materials and technologies covering roofing, walling, flooring, paving, insulation materials and thermal modifying of wood. During the technical discussions among team members and the advisory board, various ideas for technology adoption using local materials were analysed. It was decided that a sheep wool insulation product/technology should be introduced working jointly with a private company. This technology is considered an excellent choice for Kyrgyzstan. The advantages of sheep wool insulation, listed below, also lent weight to the adoption of this environmentally friendly technology as one of the elements of this project.

### ADVANTAGES OF SHEEP WOOL INSULATION
- MANAGES MOISTURE
  - Sheep wool can absorb 33% of its weight in moisture without compromising its insulating ability. The core of the sheep wool fibre is hygroscopic, meaning that it will absorb water vapour – making it perfect in the loft space where you tend to encounter more condensation.
- NON-FLAMMABLE
  - A great thing about sheep wool is that it doesn’t burn, it is just about the only thing that naturally resists flaming and as soon as the flame is removed it will actually self-extinguish. As a result of the wool’s high nitrogen content, it will simply smoulder and singe away instead of burning. In fact you will need to heat the wool to a temperature in excess of 560°C before it burns.
- SHEEP WOOL DOES NOT ITCH
- AIR QUALITY
  - Not only does it not give off formaldehyde, nitrogen dioxide and sulphur dioxide, sheep’s wool absorbs and breaks them down.
- RAPID ENVIRONMENTAL PAYBACK
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