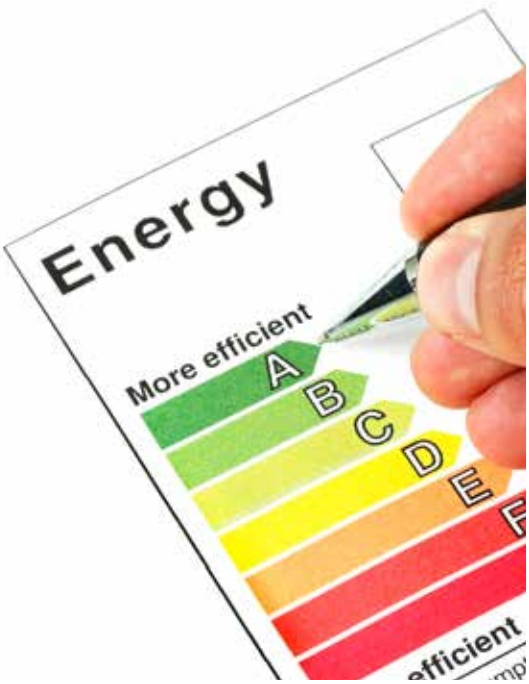
# KNOW-HOW

Quality characteristics of technical insulation materials:

# Insulation is the key to achieving higher energy efficiency


armacell®
MAKING A DIFFERENCE AROUND THE WORLD

Enormous energy-saving potential can be realized by insulating technical equipment. It is the most effective and least expensive way to reduce $CO_2$ emissions.

**Thermal conductivity is a central technical property, but it should not be the only one taken into account when selecting an insulation material. Standard-compliant fire behaviour, mechanical stability (ageing behaviour) and ease of installation are further obvious requirements that insulation materials must meet. But what about potential moisture ingress? Is there a risk of corrosion under insulation (CUI)? Can the insulation materials be installed quickly, reliably and cleanly?**

Armacell has investigated these and other properties of insulation materials in comprehensive tests. The key results will be presented in a series of articles. But first we will look at the increasing significance of technical insulation in view of climate change and other global trends.

## Development of insulation technology

The topic of thermal insulation is as old as humankind: Stone-Age man made clothing out of animal fur to protect himself against the cold in northerly regions. Humans have been using the principle of the low thermal conductivity of static air layers for thousands of years. The reed- or straw-thatched houses constructed in the Bronze Age provided good thermal insulation. Double-shell walls were also built at this time: by filling the space between two wattle and daub walls with dry grass, excellent insulation values were achieved. The principle of static air layers has been revisited again and again in the course of history.[1]

A crucial factor in the further development of insulation materials was the advancement in refrigeration techniques which led to the construction of the first cold stores at the beginning of the 20th century. Initially these were insulated with modified corkboard. Further impulses for the development and use of insulation materials came from the energy-saving regulations which were passed in many countries in reaction to the oil crises in the 1970s. Nowadays, numerous different insulation materials are available for a wide range of applications.

It was the oil crises that made the public aware of the economy's great dependence on oil and put this issue on the political agenda. The finite nature of fossil fuels and the search for alternative technologies, but also concerns about the impact on the environment and the climate, led to new social movements.

While early scientific studies on climate change were initially dismissed as being hysterical, today there is widespread agreement in the scientific community that climate change has anthropogenic (manmade) causes and dangerous consequences for the environment. It is now undisputed that we are living in an era of climate change. The shrinking Arctic sea ice, a series of climate records, more frequent heat waves and rising sea levels are undeniable indicators observed by scientists over the past 50 years.

## Building sector offers greatest energy-saving potential

The signing the global climate agreement in Paris by the international community of states marks the beginning of a global 'energy revolution'. For the first time, all 195 member states of the UN Framework Convention on Climate Change committed themselves to protecting the climate and unanimously agreed to restrict global warming to below 2 °C compared to the level before the beginning of industrialization. In order to build a low-carbon economy, by 2050 the European Union aims to progressively reduce its greenhouse gas emissions by 80 per cent compared to 1990. This ambitious target can only be achieved if the European directives on increasing energy efficiency are implemented more rigorously at a national level in future. The greatest potential for savings is to be found in the building sector: in the industrial nations a huge amount of energy is used in transport and industry, but the building sector accounts for the majority – around 40 % of European energy consumption! At the same time, the construction industry is one of the most resource-intensive business sectors and 30 – 40 % of the world's waste results from the demolition and disposal of buildings. The building sector is not only the largest single source of global raw material use and greatest producer of waste, buildings have the greatest environmental impact during their operation: some 40 % of greenhouse gases worldwide are produced in buildings.

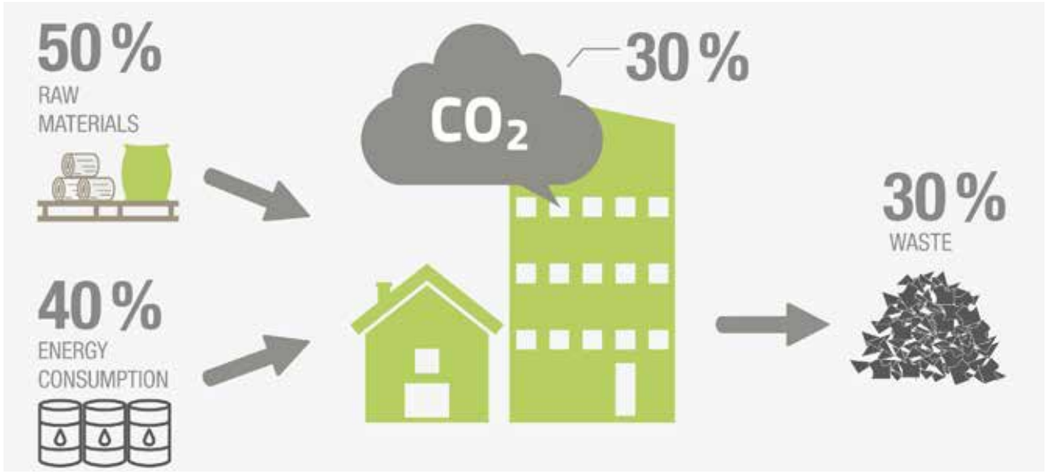



Figure 1: Buildings are the largest single source of raw material use, the greatest producer of waste, they account for 40 % of the world's energy consumption and are responsible for 30 % of $CO_2$ emissions worldwide

Over 30 per cent of the $CO_2$ emission in Europe originate in buildings.

Well over half of the energy demand is required for heating and cooling buildings. In EU households, heating and hot water alone account for 79 % of total final energy use (192.5 million toe). In Germany, figures are even higher with almost 90 % of the energy consumed by private households used to heat the building and provide hot water. With a share of around three quarters, space heating is by far the largest item. But climate control is also on the increase: cooling and air-conditioning account for around eight per cent of the total electricity demand in German private households; overall 14 % of electrically generated energy in Germany is used for cooling and air-conditioning.[2]

84 % of the energy required for heating and cooling is produced from fossil fuels, whilst only 16 % comes from renewable energies.[3] In order to do justice to the EU's climate objectives, the energy consumption for heating and cooling buildings must be drastically reduced and the use of fossil fuels minimized.

The problem is exacerbated not only by the relatively long lifespan of buildings and the outdated building service equipment found in existing buildings, but also by a global construction boom. The United Nations Environment Programme (UNEP) estimates that greenhouse gas emissions from the construction sector will double over the next 20 years unless countermeasures are taken.[4] No insulation or inadequate insulation, old boilers and over-sized, inefficient circulation pumps cause gas, oil and electricity consumption in buildings to soar. Existing buildings need to be better insulated and inefficient heating must be replaced by modern systems. While in individual cases the energy requirement in existing buildings can be reduced by up to 90 %, on average a reduction of around 50 % is achieved.[5]

## Increased energy efficiency is crucial

Up to 80 % of the energy required in buildings could be saved just by using existing, tried-and-tested technologies. From an economic point of view, programmes to increase energy efficiency are the most practical way to reduce greenhouse gases. Experts expect that in the short term at least twice as much can be achieved through energy-saving measures as through the greater use of renewable energies. This is confirmed by a study on the size and cost of measures to reduce greenhouse gas emissions conducted by McKinsey & Company. The extensive study investigated more than 200 technologies from 10 different areas and all relevant sources of emission (not only energy-related ones) in 21 different regions around the globe (see Figure 2).

At the low end of the curve are measures for improving energy efficiency. These measures reduce greenhouse gas emissions by decreasing the demand for energy. At the top end of the cost curve are technologies that abate greenhouse gas emissions (such as wind power and carbon capture and storage). The curve also shows ways to reduce emissions by replanting tropical forests and switching to agricultural practices with greater greenhouse gas efficiency. On the left are the most profitable measures for abating emissions, i.e. measures with the greatest savings potential and the lowest investment costs.[6] The cost curve for greenhouse gas abatement provides a quantitative basis for judging which measures are the most cost-effective for reducing emissions.

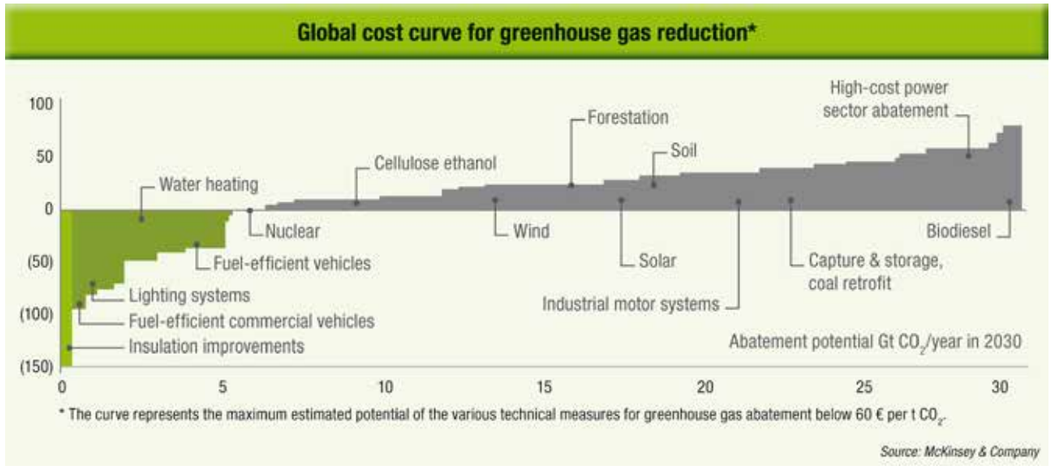



Figure 2

# INSULATION IS THE KEY TECHNOLOGY

Of the many technologies investigated in the study, insulation is the most effective and least expensive method to reduce $CO_2$ emissions. This is due to the enormous saving potential. Insulation decreases the thermal losses of the biggest 'energy guzzlers', thus leading to a reduction in the amount of energy required for heating and cooling buildings. Insulation is the key technology for increasing energy efficiency. Wherever energy is produced, transported or stored, part of the valuable resource is lost if equipment is poorly insulated. This is equally true for building service equipment and industrial plant. Technical insulation is one of the simplest, most cost-effective measures for energy-efficient building renovations and it can be realized very quickly. No other investment in climate protection has comparable potential and such a short payback period. Accounting for an average of just 1 % of the total cost of the technical equipment, insulation ensures higher performance, longer service-life and greater efficiency of equipment in both buildings and industry.

The annual heat loss due to uninsulated distribution pipes and fittings in the cellar can account for up to a quarter of the yearly heating energy consumption

**>>** Wherever energy is produced, transported or stored, part of the valuable resource is lost if equipment is poorly insulated. **<<**

As a study by Ecofys, a leading international consultancy in the field of renewable energies and energy efficiency, shows, insulation of industrial plant is not usually economically designed. By installing optimized insulation systems, it is possible to achieve energy savings of up to 45 %. The investments have often paid off after just a few months. Unlike for the building or transport sector, there are as yet no corresponding legal regulations or energy-saving programmes for industry.

# GLOBAL MEGATRENDS DRIVE THE DEMAND FOR TECHNICAL INSULATION

Nowadays business and society change much more rapidly than at the time of the industrial revolution. The development of the internet, social networks and digital devices is a powerful illustration of the incredible pace of technological change. New technologies have always changed the world, but today that happens at much greater speed. While it took around 50 years for half of the US American population to own a telephone, Facebook had six million users after just one year and a few years later the figure stood at one billion. Digitization is one of the megatrends which will transform companies, the economy, politics and society. Megatrends are complex change processes which alter our social and economic structures over the course of decades. Apart from digitization, globalization and the demographic shift, urbanization, energy efficiency / climate change and growing wealth are among the most important megatrends which will shape overall economic development over the coming years and reinforce current trends in refrigeration and air-conditioning technology.

In 2050, two thirds of the population will live in town and cities - sustainable building services will be more important than ever

## Megatrend 'energy efficiency'

A future-compliant, sustainable energy supply is one of the greatest societal challenges of our times. Global energy consumption will continue to rise: according to British energy group BP, in 2035 one third more energy will be needed on Earth than today (see Figure 3).
An energy revolution can only be achieved if energy efficiency is increased in all areas. In industry it is first necessary to raise awareness for the fact that the optimized insulation of process equipment has an unrivalled return on investment. But in the building sector – with 40 % the world's biggest energy consumer – this has been common knowledge in Europe since the introduction of the Energy Performance of Buildings Directive (EBPD). In the industrial nations, the requirements regarding the energy efficiency of buildings are increasing and higher insulation standards for building service equipment are defined in energy-saving laws – both for the construction of new buildings and the renovation of existing ones. Rising energy prices, threats to the security of supply as fossil fuels become scarcer and more expensive, soaring energy consumption in emerging countries and not least the consequences of climate change, will all inevitably lead to the introduction of stricter energy-saving laws.

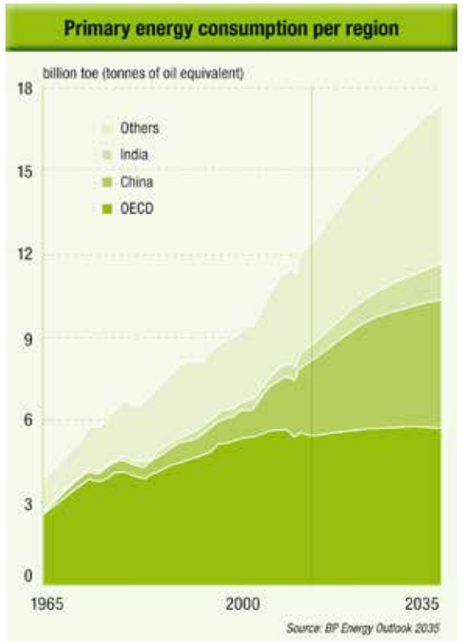



Figure 3

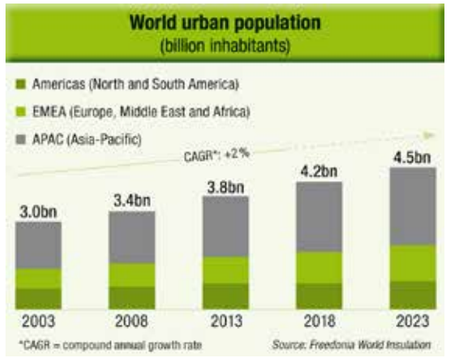



Figure 4

## Megatrend 'urbanization'

Today, over half of the world's population lives in towns or cities – more than ever before. And the trend is set to continue: in future more and more people will move from rural to urban areas. This migration to the cities is particularly pronounced in the emerging countries, but the trend is also unbroken in highly developed countries with low population density. In fast growing countries such as India and China, the demand for technical insulation materials is rising due to the growing construction sector. In the industrial nations, the trend has led to a higher demand for property in towns and cities. Land is becoming scarce, a factor that is reflected in the construction of ever taller buildings. To ensure that the infrastructure can keep pace with the growing cities, a political framework has to be defined for the construction of new buildings and energy-efficient modernization of existing ones. Retrofitting insulation to accessible pipes is one of the simplest and most cost-effective energy-saving measures in existing buildings.

To confront advancing climate change and meet the growing energy demand it is imperative that resources are saved in buildings. Buildings equipped with modern environmental and HVAC equipment will increasingly serve as a model for a new generation of buildings. Green building stands for future-compliant buildings and the responsible use of resources.

## Megatrend 'increasing wealth'

Between 1970 and 2014, the real value of the global gross domestic product rose from 12,138 to 77,451 billion US dollars. In Germany, the GDP per capita increased by an average of 6.8 % annually, in Japan by 7.8 %. According to estimates by the World Bank, the per capita income in low-income countries will rise twice as much by 2050 as in the OECD states. From 1999 to 2009, the disposable per capita income in Asia grew by 90 %. Thanks to the internationalization of markets, emerging countries are now also participating in world trade, wealth and economic growth. Higher private incomes have been boosting the economy for years in Asia, but they have also led to a dramatic rise in $CO_2$ emissions per capita – and it has not yet been possible to offset this development by using energy-efficient technologies.

## Cold chain market is booming

Greater wealth in emerging and developing countries is leading to changes in consumer behaviour. Especially in China the demand for meat and dairy products is growing rapidly. The food supply is more varied than ever before. Thanks to modern refrigeration technology, food can now be transported around the world without any difficulty. As a result of globalization, the cold chain – continuous refrigeration during transportation from manufacturer to wholesaler to retailer to consumer – is more and more important, not only for the food industry but increasingly also for pharmaceutical and chemical products. The unbroken growth in population and rising life expectancy are additional factors which will continue to boost the global cold chain market for decades to come. Figure 5 shows the forecast development of this sector. Refrigeration and insulation technology will benefit equally from this trend. Optimal insulation of the refrigeration technology is essential to reduce the high energy costs and greenhouse gas emissions in this segment.

Efficiently insulated cold chains will become even more important for the food and pharmaceutical industry in the future


Figure 5


Figure 6

Professional acoustic insulation is also becoming more and more important in one's own four walls

## Acoustic insulation is on the increase

In industrial nations greater wealth has led to enhanced living comfort. Purely functional bathrooms have given way to home spas and, even in moderate temperature zones, air-conditioning is no longer seen as a luxury, but as an amenity which many would not like to be without. In cars it has been standard equipment for years.

Occupants' expectations of acoustic insulation in buildings are also on the rise: sounds that were not perceived as annoying, but simply accepted in multi-family houses twenty or thirty years ago, are today regarded as 'unacceptable disturbance' and lead to problems amongst the residents. The significance of acoustic insulation for people's well-being and the quality of a building is shown by the results of representative surveys: 82 % of respondents are not prepared to accept cost savings at the expense of acoustic insulation and 94 % consider good sound and noise control to be important, 57 % even for particularly important.[7] Acoustic insulation in buildings means peace and relaxation, but also privacy, intimacy and a sense of security.

In the workplace, noise disturbance is not just annoying, it can also be a health hazard. The risk of cardiovascular disease, high blood pressure and migraines rises significantly. Noisy environments often lead to a drop in levels of concentration and individual performance and a rise in the number of mistakes made. In industry, the risk of accidents in the workplace increases as a result of exposure to excessive noise levels from unprotected or inadequately insulated equipment. Occupational exposure to noise causes 16 % of adult disabling hearing loss worldwide. Noise-induced hearing loss has long ranked among the most common occupational illnesses in industrialized countries and comes at a huge cost to the economy.

In future it will become more and more important to acoustically insulate equipment. Specifiers and plumbers must satisfy occupants' higher expectations and continue to optimize their noise control solutions. Leading insulation manufacturers offer innovative products which minimize noise at the source and increase living comfort in buildings. For applications requiring high-performance noise absorption, such as enclosures for heat pumps and combined heat and power plants (CHPs) or casings for fans, there are new acoustic foams with excellent sound absorption properties.

## Conclusion

The trends presented above often reinforce each other. For example, migration to the cities means that people will be more likely to be exposed to noise. The high rate of urbanization in Asia will further boost economic growth, but will also have consequences for the environment. Considerable resources are required for the huge building projects planned and soil sealing and the emergence of 'heat islands' will accelerate global warming and climate change. This is where there is a need for innovative concepts for reducing energy requirements and emissions (e.g. through energy-efficient heating, hot-water supply and air-conditioning).

According to the UN, a third of the food produced throughout the world is lost on the way from plantation to plate. Effectively insulated cold chains not only prevent the wastage of food, they also raise energy efficiency and conserve precious resources.

The key technology for increasing energy efficiency is insulation. Because wherever energy is produced, transported or stored, part of the valuable resource is lost if equipment is poorly insulated. As we will show in the next articles in this series, there are significant differences in the performance of the various materials used for technical insulation.

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