Case Study

The Impact of Building Insulation on Greenhouse Gas Emissions

Source: McKinsey & Company - Innovations for Greenhouse Gas Reductions - A life cycle quantification of carbon abatement solutions enabled by the chemical industry

Introduction

Building insulation is a critical component in the effort to reduce greenhouse gas (GHG) emissions. According to a study by McKinsey & Company, insulation of buildings accounts for 2.4 gigatons of CO_2 equivalent ($GtCO_2e$) in net emissions savings, making it the largest contributor to net emissions reductions. This case study explores how insulation significantly decreases the energy needed for heating and highlights the environmental benefits of using expanded polystyrene (EPS), extruded polystyrene (XPS), and polyurethane (PU) as insulation materials.

Global Consumption and Regional Analysis

The study assessed the annual global consumption of key chemical insulation materials across different regions:

Asia: 1,121 kilotons (kt)

Europe: 850 kt

North America: 882 kt

Methodology

The study analysed 60 cases across three regions (Asia, Europe, and North America), considering various factors such as climate zones, building standards, and building parts (roof, wall, or floor). Savings were calculated using a heat flux model that considered:

U-value difference: Indicates improved thermal characteristics.

Temperature difference over 50 years: Expressed in Heating Degree Days.

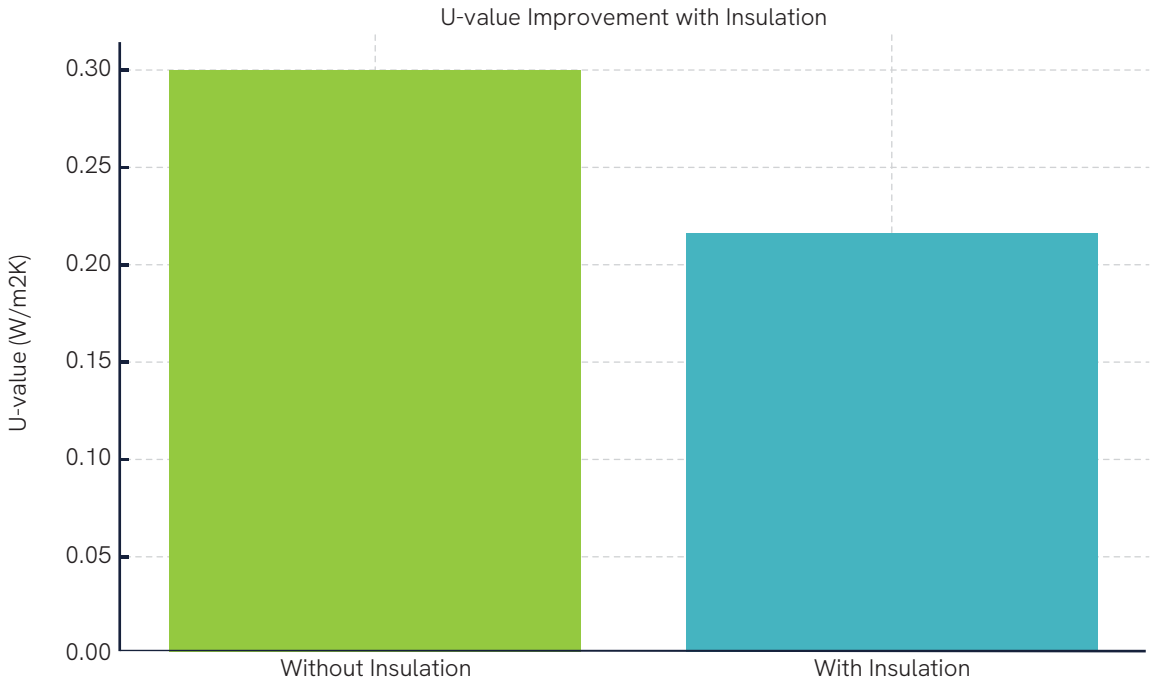
Surface treated by insulation: Calculated from annual production volume and thickness based on U-values.

Example: Wall Insulation in North America

To illustrate the calculation of savings, let's consider a wall in North America exposed to a moderate climate:

1. **Initial U-value:** Without insulation, the U-value (thermal conductivity measure) is 0.30 W/m^2K.
2. **Post-insulation U-value:** After adding 1.5 inches of XPS insulation foam, the U-value reduces to 0.215 W/m^2K, resulting in a U-value difference of 0.085 W/m^2K.
3. **Heating Degree Days:** The moderate climate zone corresponds to 3,500 Heating Degree Days.
4. **Surface Area:** The volume of 17.4 kt and a thickness of 1.5 inches result in a treated surface of 16.7 million square meters.

By multiplying these factors, the saved heating energy for one year is 430,000 gigajoules (GJ). Over the insulation's 50-year lifetime, and considering the carbon intensity of heating (0.107 kgCO2e per megajoule), the total savings amount to 2.3 million metric tons of CO2 equivalent (MtCO2e). The production emissions of the insulation material, with a footprint of 2.8 kgCO2e/kg, amount to only 49 kilotons of CO2 equivalent (ktCO2e).



This chart illustrates the improvement in U-value (thermal conductivity) for a wall in North America, comparing the values without insulation and with 1.5 inches of XPS insulation.

Overall Impact

Chemical-based insulation materials (EPS, XPS, PU) have an impressive efficiency ratio of 233:1. For every unit of energy used in production, 233 units of energy are saved through reduced heating needs. This results in a total net savings of 2,400 MtCO2e globally. The savings derived from Asia, Europe, and North America are roughly equal, underscoring the widespread benefits of building insulation.

The Role of EPS in Energy Efficiency

EPS manufacturing uses less than 0.1% of the global oil supply as a feedstock. Despite this small usage, EPS can save up to 200 times the amount of energy it took to produce it through thermal energy savings over its lifespan. This highlights the significant energy efficiency benefits of using EPS for insulation purposes.

Benefits of EPS and XPS for Building Insulation

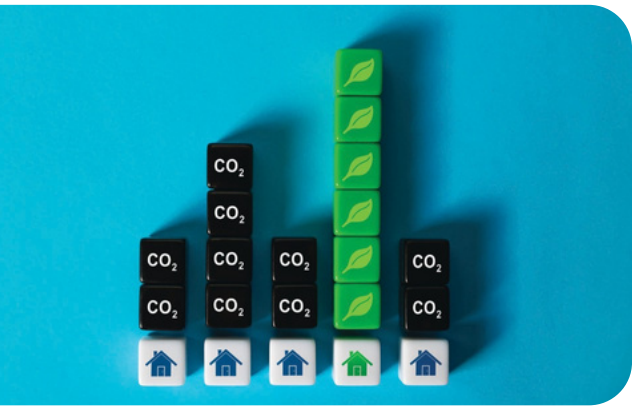
1. **Energy Efficiency:** EPS and XPS provide excellent thermal insulation, significantly reducing heating and cooling energy requirements. This leads to substantial energy savings and lower utility bills.

2. **Environmental Impact:** Both EPS and XPS contribute to significant GHG emissions reductions. Their high energy efficiency ratio means that they save much more energy over their lifetime than is used in their production.

3. **Durability and Longevity:** EPS and XPS are durable materials that maintain their insulating properties over time, ensuring long-term energy savings and environmental benefits.

4. **Lightweight and Easy to Install:** EPS and XPS are lightweight, making them easy to handle and install. This can reduce labour costs and construction time.

5. **Recyclability:** EPS and XPS are recyclable materials, further contributing to their environmental benefits. Recycling initiatives like StyroCycle help divert polystyrene from landfills and turn it into sustainable building products.



Conclusion

Building insulation is a highly effective strategy for reducing greenhouse gas emissions. The use of chemical insulation materials like EPS, XPS, and PU significantly cuts down energy consumption for heating, providing substantial environmental benefits. This case study demonstrates the importance of insulation in mitigating climate change and highlights the potential for further GHG abatement by including cooling savings in future analyses.

Key Takeaways

- Building insulation contributes 2.4 GtCO2e in net emissions savings.
- EPS, XPS, and PU insulation materials are highly efficient, with an energy savings ratio of 233:1.
- EPS manufacturing uses less than 0.1% of the global oil supply but can save up to 200 times its production energy in thermal savings.
- Significant emissions savings are observed across Asia, Europe, and North America.
- Insulation reduces heating energy needs and has the potential to further reduce GHG emissions if cooling savings are considered.
- This case study underscores the critical role of building insulation in achieving global emissions reduction targets and enhancing energy efficiency in buildings.