ISC3
International Sustainable Chemistry Collaborative Centre (ISC_3)

Sustainable Building and Living, Focus on Plastics

Workstream Report: Summary and Highlights

Sustainable Building and Living, Focus on Plastics

How can sustainable chemistry assist in building – considering global megatrends?

Facts:

- The world will have to build over two billion homes by the end of the century in order to meet the 40% increase in global population.
- The world's legacies in the construction sector are decades of linear, toxic and wasteful production of building materials.
- Additives in plastic materials emit volatile compounds that can have serious health consequences of an endocrine, reproductive, carcinogenic, cognitive and immune nature.
- Burning, flame-retarded polymers release toxic fumes and residues. Smoke emissions are mostly not regulated.

Recommendations:

- Life cycle assessment (LCA) should already be considered in the design and planning phase.
- Natural materials represent the most environmentally friendly type of production and low pollution rates in the disposal phase, provided that they are made from residual biomass or secondary raw materials.
- The preferred solution for substituting substances of high concern (SHC) is non-hazardous additives. Hazardous additives must be restricted and substituted.
- The informal sector (self-builders) should be supported by regulations, financial incentives, social programmes, training and capacity building.
- Deconstruction should be used for buildings instead of demolition.

In the past decades, the importance of plastic building materials has increased enormously in comparison to conventional ones. Plastics have become very attractive thanks to their specific properties, easy handling, availability and low price. Both new and recycled from waste, they can play a major role in sustainable development if managed well. The International Sustainable Chemistry Collaborative Centre – ISC_3 – has coordinated a study in which experts from science, public authorities, NGOs and industry address various questions concerning the sustainability of plastics as building materials.

The report is a final document in the workstream led by ISC_3 during 2019/20. This consisted of a preliminary study on polymers, a multi-stakeholder dialogue, international thematic workshops and conferences as well as interviews, online surveys and contributions by experts in the field. The report takes regional perspectives into account. Expert authors from China, Germany, Kenya, the UK and the USA have contributed. The reader is introduced to the main aspects of plastics in buildings **(Chapter 1)**. Three major topics are then highlighted in the report: the global megatrends urbanisation, resilience and affordable housing **(Chapter 2),** protection of human health and the environment **(Chapter 3)** and resource demand and recycling **(Chapter 4)**. In the last chapter, **Chapter 5**, ISC_3 has derived and compiled specific recommendations for decision makers.

Plastics in buildings

Plastic building materials are a 'rising star' in the building materials industry worldwide. With the rapid growth of the global real estate sector and increasing investments in infrastructure, it has become the second pillar in the plastics industry after packaging. The current status quo of plastics production and its share in building materials is around 20 % of the estimated world production of plastics.

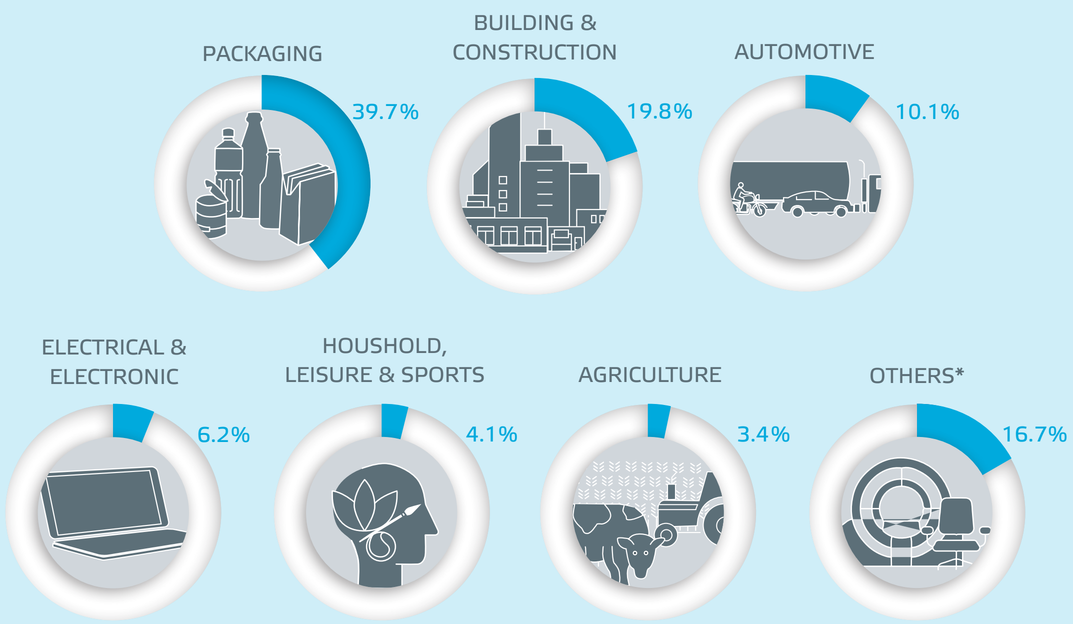


FIGURE 1
Distribution of European (EU28+NO/CH) plastic converter by segment in 2017 (in Mt)

Total converter demand 51.2 Mt

Use of plastics in different areas and percentage of plastic waste from these applications.

* medical equipement, plastic furniture and furniture equipement, technical parts used for mechanical engineering or machine-building, etc.

Source: Graphics compiled from PlasticsEurope, 2018

Urbanisation, affordable housing and resilience

In 2050, almost ten billion people are expected to inhabit the globe.

The world will have to build over two billion homes by the end of the century in order to meet the 40 % increase in global population.

More than two thirds of people will live in urban areas. This surge in URBANISATION is taking place almost exclusively in two world regions: Africa and Asia. Rapid, uncontrolled development leaves developing countries grappling with two problems: First, providing more affordable, quality housing and infrastructure for citizens, and second, battling environmental degradation. The rapid urbanisation in developing and emerging economies adds the informal sector (self-builders) to the problems connected with affordable housing: The demand for cheap construction materials, which brings plastic (waste) into play. For vulnerable social groups, a bottom-up approach is needed:

The informal sector should be supported by regulations, financial incentives, social programmes, training and capacity building.

AFFORDABLE HOUSING is not only a matter of the upfront costs for the construction phase but also includes the costs of what is referred to as the 'sick building syndrome' and other mismanagement throughout the whole life cycle. This syndrome is often caused by volatile compounds stemming from polymeric building materials – and could be exacerbated by using recycled plastics of an uncontrolled quality. In this respect and among other steps, the new restrictions of the Basel Convention for mixed plastic waste should be enforced in industrialised as well as in developing and emerging economies in order to stop the practice of exporting waste.

One of the major issues leading to an urgent need for **RESILIENT** buildings is climate change. Changing climate conditions result in a reduction in the service life of building materials, components and structures. For example, polymer-based joint sealants, originally developed for a service life of 20–25 years, fail after only 7–10 years. There is therefore a need to improve the durability of climate-adapted materials. Today, this is only possible by using additives in polymers.

Protection of health and the environment

Plastic building materials can contribute to reaching important Sustainable Development Goals (SDGs) and their derivatives, such as reduction of the energy consumption of buildings, yet at the same time they can conflict with other sustainable development goals, such as good health. The main impacts on **HUMAN**

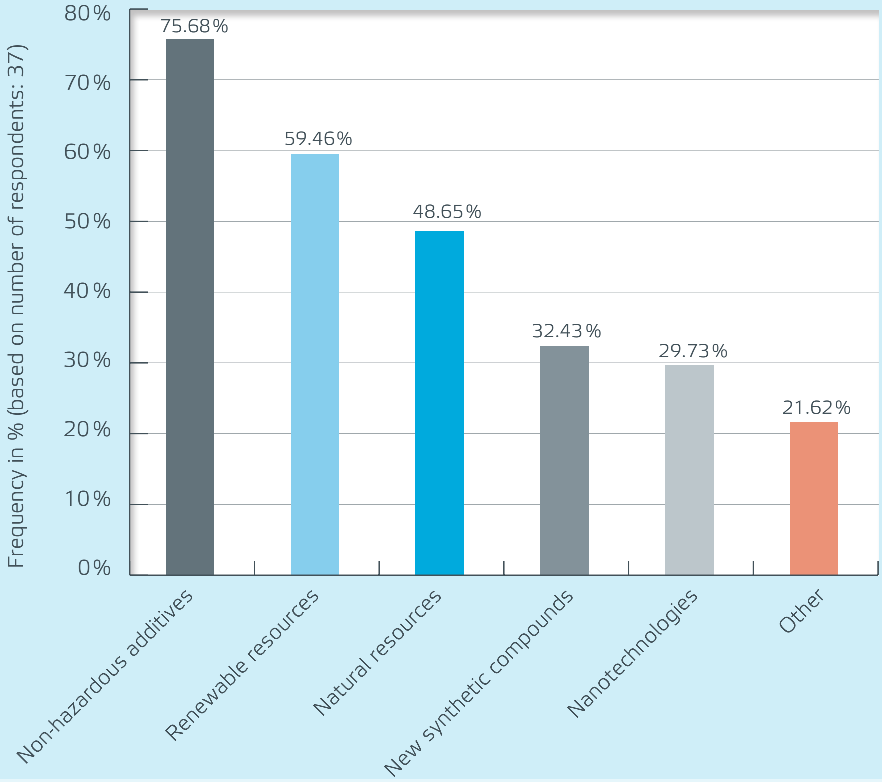


FIGURE 2
How to substitute SHC?

Which trends and technologies can substitute substances of high concern connected to polymers in buildings?

Source: ISC₃ Online Survey, 2019

HEALTH are not necessarily connected to polymers as such, but to chemical additives which are in most cases indispensable components for specific functionalities. Indoor air is one of the most problematic issues, since it is influenced by chemicals in walls, ventilation, insulation, sealants and furniture.

Additives in plastic materials emit volatile compounds that can have serious health consequences of an endocrine, reproductive, carcinogenic, cognitive and immune nature.

Some of these substances have been banned from the market for decades, but they can still be found in old constructions and are still harmful. Besides the impacts of chemicals such as phosphates and amines on indoor air during the use phase, another problem of plastics in buildings arises in the event of fire.

Burning, flame-retarded polymers release toxic fumes and residues.

In much of the world, the content of building materials and specifically smoke toxicity is largely unregulated.

The world's legacies are decades of linear, toxic and wasteful production of building materials.

The current life cycle impacts from making, using and disposing of plastic building materials undermine the 2030 Agenda and thus endanger the ENVIRONMENT and human health. Careless practices pollute the air, water and soil and can harm living organisms. Impacts begin at wellheads where oil and gas – the key resources for plastic building materials – are extracted. Impacts reach as far as the Earth's stratosphere, where blowing agents released from plastic foam insulation damage the ozone layer.

In the survey, two thirds of experts suggested non-hazardous additives as the preferred solution for substituting substances of high concern (SHC).

Renewable and natural resources followed, with only about 60 % and 49 % of answers **(see figure 2).**

Resource demand and recycling

While the experts estimated the potential for ENERGY SAVING IN PLASTIC INSULATION as very high, they recognised that energy demand during production, recycling and general resource demand for disposal is very high as well **(see figure 3)**.

Life cycle assessment (LCA) of materials is a more holistic approach.

To measure a broader range of the impacts generated by building materials, life cycle assessment (LCA) is gaining more importance for building and construction products too. It helps to estimate the impacts of a product in its early stages, such as resource extraction, production and transportation, as well as during and after its use phase. For example, a comparison of different insulation types shows that for recycling as it stands today natural materials, such as wood-fibre blown-in insulation, hemp and jute mats, are often best suited:

Natural materials represent the most environmentally friendly type of production and low pollution rates in the disposal phase, provided that they are made from residual biomass or secondary raw materials.

Renewable raw materials made from residues or primary products cultivated in an environmentally friendly way can be recycled or disposed of after the use phase without causing environmental damage. In future, plastic materials from fossil sources such as HBCD[1]-free EPS[2] will also achieve very good LCA values in the case of a much more advanced circular economy. However, current practices for recycling and recovery are today not technically mature and widespread enough.

Considerations based on LCA are extremely important, and they should include various aspects. To be complete, they should also take into account factors such as toxic additives, microplastic pollution or specific properties of materials, such as flammability or moisture resistance. In the case of building products made from renewables, LCA should be combined with possibly competing goals such as food security.

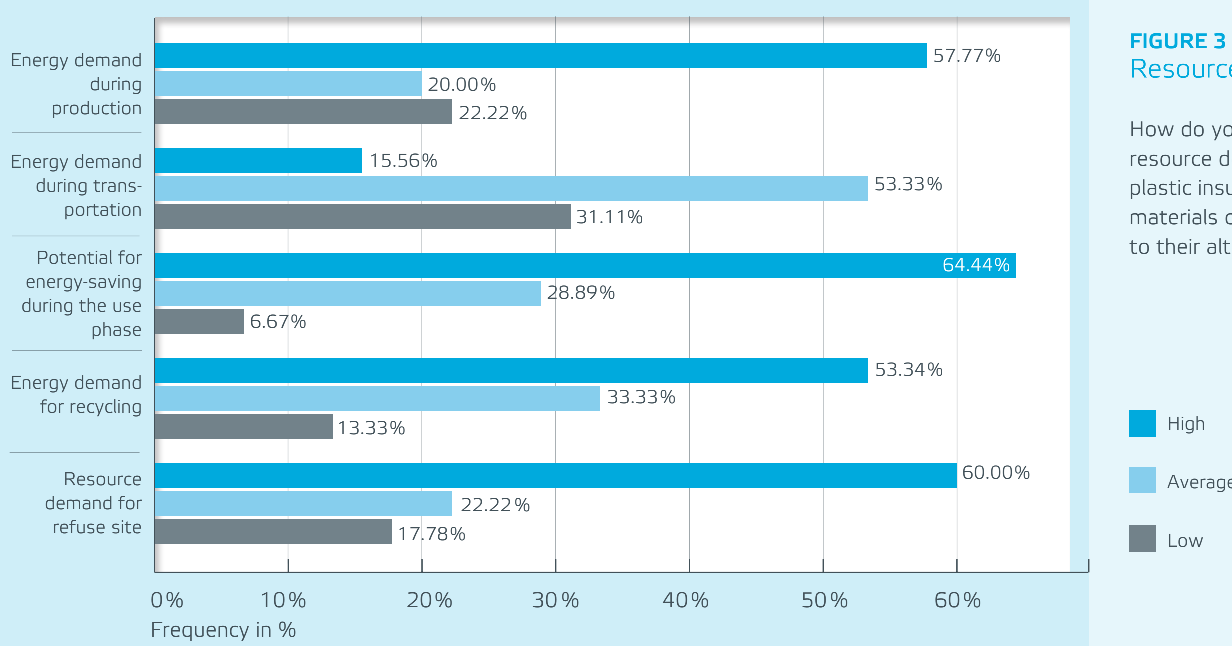
Different approaches in industrialised, developing and emerging economies.

1 Hexabromocyclododecane (HBCD)

2 Expanded polystyrene (EPS)

FIGURE 3
Resource demand

How do you estimate resource demand for plastic insulation materials compared to their alternatives?



Source figures right site: ISC_3 Online Survey, 2019

The report guides the reader through the different aspects of plastics in the construction sector and their life cycle. Overall socio-economic, technical and regulative conditions and resources can vary tremendously in each country and region. Depending on climate, the raw materials available and other local conditions, sustainable solutions are not uniform and should be developed specifically for each region.

In contrast to developing and emerging economies, low prices for virgin plastics in industrialised countries make recycled plastics unattractive for these markets. In most African, Asian and Latin American countries, affordable housing is the first priority, while environmental degradation and poor waste management are not ranked among top priorities at all. It is precisely in these regions that the use of plastic waste as building materials is far more widespread. The use of plastics in composites can be seen as a substitute for a lack of either sand or binder and as cleaning the environment of waste. On the other hand, a planless use of such plastic waste mixed with other materials relocates the problems to the future. The consequences are health hazards from toxic additives in the waste during the use phase as well as environmental pollution and impossible recycling after the life of these materials. This means that binding standards and quality inspection are required here, together with careful planning.

From the point of view of a CIRCULAR ECONOMY, the dissipative use of products, the dual character of waste and resources, the specific role of time and the entropy dilemma are creating 'stumbling blocks' along the path to successful recycling. Nevertheless, separation of plastic materials from mineral and other organic waste is an indispensable prerequisite for recycling. This leads us to:

Deconstruction instead of demolition!

If material recovery is not possible, incineration of plastics in state-of-the-art waste-to-energy plants can be an acceptable bridging technology. Refurbishment or deconstruction is an option as well, especially in the case of polymers with hazardous additives.

Restriction and substitution of hazardous additives.

Plastics intended for use in buildings must be free of hazardous additives that can be emitted during their lifetime. Hazardous substances in plastics need to be clearly identified and research is needed on the non-regrettable substitution of these substances. An extended producer responsibility regarding recycling and proper end-of-life of product should be considered in the construction market.

Consideration of life cycle assessment already in the design and planning phase.

Recommendations for the planning phase

The sustainable design of materials, buildings and cities is required already in the planning phase. Such design should be based on all phases of the life cycle, from resource extraction to recycling, and consider technical, economic and social aspects. New, unconventional technologies, such as polymer-based photovoltaic façades, lightweight constructions and self-healing materials, need to be monitored and both their possible contribution to sustainability as well as possible adverse effects better understood. Information on the materials used in a building needs to beavailable during the complete life cycle of the building, processed in an understandable way and made accessible for all stakeholders, for example in form of a building passport.

Proper planning and design of construction materials, applications and whole buildings up to city level are essen-tial for sustainability in the construction sector. Such planning should consider various aspects:

Key aspects for sustainable planning and design			
Functional:	**Regional:**	**Health:**	**Environmental:**
▪ Weight/static load ▪ Flexibility ▪ Resilience ▪ Moisture resistance ▪ Insulating properties (warmth, sound) ▪ Longevity, etc.	▪ Availability/scarcity of resources ▪ Demographic situation, ▪ Affordability issues ▪ Need for specific resilience of the materials	▪ Safe handling by the workers on site ▪ Harmful emissions/indoor air ▪ Worst case scenario, such as fire toxicity	▪ Hazardous substances endangering air, soil or water ▪ Microparticles ▪ Life cycle assessment: during all stages: (sourcing, pro¬duction, transportation, building site, use phase, deconstruction, and end-of-life (recycling))
Comparison with other available materials or applications		**Different types of costs besides the upfront costs for construction**	
▪ Traditional building materials, such as clay, stone and wood ▪ Advantages of new technologies, such as polymer-based photovoltaic façades, lightweight constructions and self-healing materials ▪ Regional suitability ▪ Rebound effects and non-regrettable alternatives if substitution is required		▪ Quantifiable costs: operating costs of the building and utilities ▪ Non-quantifiable latent costs (impacts on residents' health and environment): costs associated with 'sick buildings', such as poor indoor environmental quality, poor thermal comfort, poor indoor air quality, poor solid and liquid waste management, water and energy inefficiencies, environmental degradation, poor human settlement planning, flooding, water insecurity and food insecurity ▪ Costs for after-end-of-life phase (deconstruction, recycling, refuse dump, incineration) ▪ Environmental remediation costs ▪ Collateral damage in other areas (soil, ground water)	
Design for separation and recycling			
▪ Possibility to separate different materials and layers, aim for minimisation/avoidance of waste ▪ Apply appropriate technology for recycling and create markets for recycled materials ▪ Requires general principle: deconstruction instead of demolition			

For more details, please see the full version here:

REPORT
www.isc3.org

About ISC$_3$

ISC$_3$ is an international centre promoting and developing sustainable chemistry solutions worldwide. It is a globally acting, multi-stakeholder platform that engages with civil society, politics and the private sector to contribute to international chemicals policies and the formation of a global network for collaboration, innovation, research and education in sustainable chemistry. The centre was founded in 2017 at the initiative of the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the German Environment Agency (UBA). ISC$_3$ is hosted by GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH) and has established a Research & Education Hub at Leuphana University, Lüneburg, and an Innovation Hub at DECHEMA e.V., Frankfurt.

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