

## **ECOLOGICAL ASPECTS OF THE CEMENT PRODUCTION**

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Cement is one of the most widely used building materials in the world due to its versatility, strength and durability. The growth in demand for cement is associated with the active development of infrastructure and urbanization, which is especially noticeable against the background of global population growth. However, its production has a significant negative impact on the environment, as it is one of the main sources of greenhouse gas emissions and consumes significant amounts of energy.

The cement production process involves burning limestone, which releases large amounts of carbon dioxide. In addition, fossil fuels are traditionally used to maintain high temperatures in the kilns, which also causes significant CO<sub>2</sub> emissions. Air pollution is compounded by emissions of nitrogen and sulfur oxides, as well as the formation of fine dust, which negatively affects air quality and human health.

The cement industry is also characterized by a high level of consumption of natural resources. The extraction of limestone, clay and other minerals changes natural landscapes, causes soil erosion and threatens biodiversity.

In the context of increasing attention to sustainability issues, finding ways to reduce the negative impact of cement production is an important task. Manufacturers are increasingly turning to alternative energy sources, such as biomass or waste, which allows them to reduce fossil fuel consumption. Carbon capture and storage technologies are being introduced, which allows them to reduce emissions. A common approach is the use of mineral additives, such as slag or fly ash, which can partially replace clinker and thereby reduce the carbon footprint of cement.

Optimization of production processes and modernization of equipment contribute to reducing energy consumption. The use of modern heat exchange systems allows for more efficient use of energy, and the use of innovative flue gas cleaning methods helps minimize pollution. In addition, new types of cement are being actively researched, in particular geopolymers, which have a significantly lower impact on the environment.

At the state level, more and more attention is paid to environmental standards. In Ukraine, the environmental modernization of the cement industry is an important stage on the way to harmonization with European standards and fulfilment of international obligations in the field of greenhouse gas emission reduction. In accordance with the strategic directions of development, a gradual transition to more environmentally friendly production technologies is envisaged.

The future of the cement industry depends on its ability to balance growing construction needs with environmental concerns. Innovative solutions, improved production efficiency and the introduction of alternative materials offer opportunities for sustainable development.