CONCEPTUAL APPROACHES TO ENHANCING THE EFFICIENCY OF THE MINING INDUSTRY BASED ON RESOURCE-SAVING TECHNOLOGIES AND GREEN ECONOMY PRINCIPLES

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ABSTRACT

The mining industry continues to represent one of the most strategically important yet environmentally challenging sectors of the global economy. Its contribution to industrialization, employment, and export revenues is significant, but these benefits often come with high ecological costs, including excessive energy use, land degradation, and water contamination. This paradox highlights the need for conceptual approaches that link economic efficiency with environmental stewardship and social responsibility. One of the most promising directions lies in the integration of resource-saving technologies with the principles of the green economy, offering a systemic framework for sustainable growth [1].

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Resource efficiency in mining is more than incremental improvements in energy or material consumption. It reflects a fundamental shift toward redesigning technological processes, introducing circular economy practices, and valorizing waste streams. For example, tailings reprocessing and closed-loop water systems not only minimize ecological risks but also generate new revenue sources. Empirical evidence demonstrates that such approaches can reduce freshwater use by up to 40% and extend mine life cycles, making them an essential component of sustainability-oriented mining strategies [2].

The digital transformation of mining further enhances resource-saving efforts. Advanced technologies such as artificial intelligence, digital twins, and big data analytics enable real-time optimization of operations, predictive maintenance of equipment, and continuous monitoring of environmental parameters [3]. These innovations contribute to higher productivity, reduced downtime, and enhanced transparency, creating the foundation for “smart mines” that are not only efficient but also resilient and environmentally responsible.

Case studies from Australia and Canada confirm the viability of such integrated digital–ecological platforms [4].

Yet, technological modernization cannot achieve its full impact without supportive institutional, regulatory, and financial frameworks. The implementation of green financing mechanisms — including sustainability-linked loans and carbon credit schemes — plays a vital role in mobilizing resources for capital-intensive innovation. At the same time, effective regulatory policies that enforce stricter emission standards, water-use permits, and mine-closure obligations create long-term incentives for firms to adopt environmentally sound technologies. Furthermore, inclusive governance involving governments, mining firms, and local communities is essential for ensuring that sustainability policies translate into tangible socio-economic benefits [5].

In conceptual terms, the future efficiency of the mining sector should be assessed not only by conventional economic indicators such as productivity or profitability but also by its contribution to social well-being and ecological resilience. Integrating the mining industry into global sustainability agendas, particularly the United Nations Sustainable Development Goals, strengthens both international legitimacy and access to green investment opportunities [6]. The alignment of national mining policies with SDG 7 (clean energy), SDG 12 (responsible consumption), and SDG 13 (climate action) demonstrates how resource efficiency and green economy principles can serve as practical mechanisms for addressing planetary challenges while maintaining competitiveness.

Overall, the theoretical framework presented emphasizes a multi-layered approach where technological innovation, institutional reform, and green finance instruments operate in synergy. By embedding sustainability and innovation as fundamental pillars, the mining industry can enhance its economic role while minimizing environmental risks and strengthening social responsibility. This conceptual shift ensures that mining will not remain a source of ecological burden but become a catalyst of green transformation in the 21st century.

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