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COMPARATIVE ANALYSIS OF THE ENVIRONMENTAL IMPACT OF ENERGY STORAGE SYSTEMS BASED ON LITHIUM-IRON-PHOSPHATE AND LITHIUM-NICKEL-MANGANESE-COBALT-OXIDE BATTERIES

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Introduction. The increasing demand for energy storage solutions has led to a surge in the deployment of battery energy storage systems. These systems play a pivotal role in the integration and optimization of renewable energy sources, grid stabilization, and load management. However, their widespread adoption raises questions about their environmental impact and sustainability. In Russia, lithium-iron-phosphate batteries are usually used as a component of energy storage systems, but now the production of lithium-nickel-manganese-cobalt-oxide batteries is rapidly increasing. Studying and comparing the environmental impact of both types of batteries for energy storage applications is an important objective for sustainable development in the energy sector.

Main body. Based on literature and public databases, an inventory of relevant product system inputs and outputs in the life cycle of energy storage systems using lithium-ion batteries is conducted. Environmental impacts at the raw material extraction, production and processing stages are considered using different indicators, including global warming potential with a 100-year time horizon, mineral, fossil & renewable resource depletion, freshwater ecotoxicity. Priority is given to processes and materials predominant in environmental impacts due to the complexity of the overall analysis and in an attempt to obtain more reliable and interpretable results.

From a total cost of ownership perspective, the lithium-nickel-manganese-cobalt-oxide battery is considered the most optimal, as it has a 5 times longer lifespan than its lead-acid counterpart. The deterrent for many consumers in developing countries is the high initial cost of Li-ion [1]. In the lithium-ion battery manufacturing process, most of the environmental impacts are related to energy use. A large percentage of the energy used in many modern battery manufacturing plants is for evaporating the solvent N-methyl-2-pyrrolidone and maintaining the plant's dry room [2]. Overall, the production of cathode active materials for lithium-nickel-manganese-cobalt-oxide batteries accounts for more than 50 % of GHG emissions over the life cycle of the batteries. The production of aluminium and cathode active material is a major contributor to water consumption over the life cycle of batteries [3].

The percentage contribution of the use phase of lithium-iron-phosphate batteries to the indices is lower than that of the production phase, except for the primary energy consumption and global warming potential. The acidification potential of the different recovery technologies for lithium-iron-phosphate batteries in the recovery process is predominantly determined by the indirect environmental impact from the use of hydrochloric acid and the consumption of electric energy [4].

Conclusion. The analysis of the environmental impact of energy storage systems based on lithium-ion batteries throughout their life cycle was conducted; the most critical aspects of the environmental impact of energy storage systems were identified; a conclusion was made about the potential environmental consequences of mass production of lithium-nickel-manganese-cobalt-oxide batteries and alternative options for the composition of battery cells for energy storage under the conditions of the Russian market.

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