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CHANGES IN ELECTRICITY DEMAND DUE TO THE DECARBONIZATION OF UKRAINE'S FERROUS METALLURGY

ЗМІНИ ПОПИТУ НА ЕЛЕКТРОЕНЕРГІЮ ВНАСЛІДОК ДЕКАРБОНІЗАЦІЇ ЧОРНОЇ МЕТАЛУРГІЇ УКРАЇНИ

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The steelmaking process is one of the most energy-intensive industries, contributing significantly to greenhouse gas (GHG) emissions both globally and in Ukraine. Up to 7% of global GHG emissions are produced during the production of iron and steel, while in Ukraine, this figure reaches 14%, accounting for almost 57% of annual GHG emissions in the country's industrial sector [1, 2]. The carbon intensity of GHG emissions from traditional steelmaking technologies varies from 1.37 to 2.3 t CO_{2e}/t steel. In the future, this indicator is expected to decrease to nearly zero with the adoption of renewable energy sources (RES) and innovative steelmaking technologies.

The prospective forecast for the decarbonization of the Ukrainian iron and steel industry, which has historically focused on processing ores from the Kryvyi Rih iron ore basin, envisions a gradual replacement of traditional sintering and blast furnace technology (BF+BOF) with direct reduction of iron using hydrogen and an electric arc steelmaking furnace (H_2+EAF) (Fig. 1). As an intermediate (transitional) technology during this replacement process, the sintering and blast furnace technology of steel production using an electric arc steelmaking furnace (BF+EAF) may be utilized.

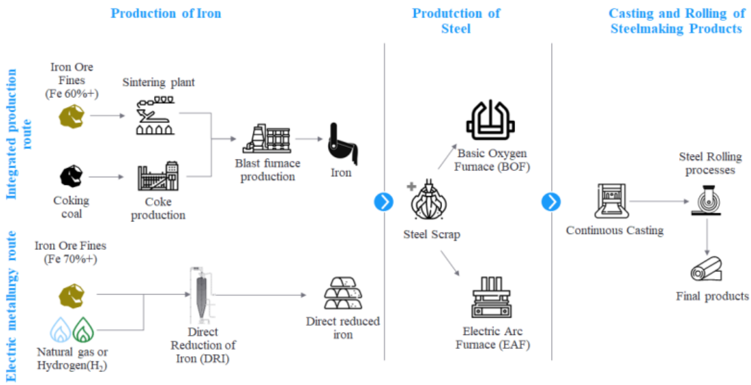

Fig. 1. Technological decarbonization pathways for the steelmaking production in Ukraine

The use of new technologies will require significant amounts of electricity to support the main technological processes: hydrogen electrolysis, direct iron reduction with hydrogen, and steel melting in electric arc furnaces. In fact, the electrification of the steelmaking process is anticipated. This study focuses on modeling changes in energy consumption resulting from the technological decarbonization processes in the steelmaking industry in Ukraine.

The results of variant modeling for the production of 10 million tons of steel per year demonstrate that (Fig. 2), as a result of the overall transition to electrolytic hydrogen production technology, direct iron reduction technology, and electric arc steelmaking technology, electricity consumption will increase from 2.74 billion kWh/year to 35.13 billion kWh/year (a 12.84-fold increase) compared to traditional sintering and blast furnace technology using a basic oxygen furnace. The results of the calculations also indicate the need to increase installed electricity generation capacity from 0.48 GW to 6.15 GW, which is equivalent to the total capacity of the Zaporizhzhia Nuclear Power Plant (NPP). Given the continuous technological process of steel production and the current state of development of Ukraine's energy system, only nuclear power plants can guarantee such electricity generation capacity.

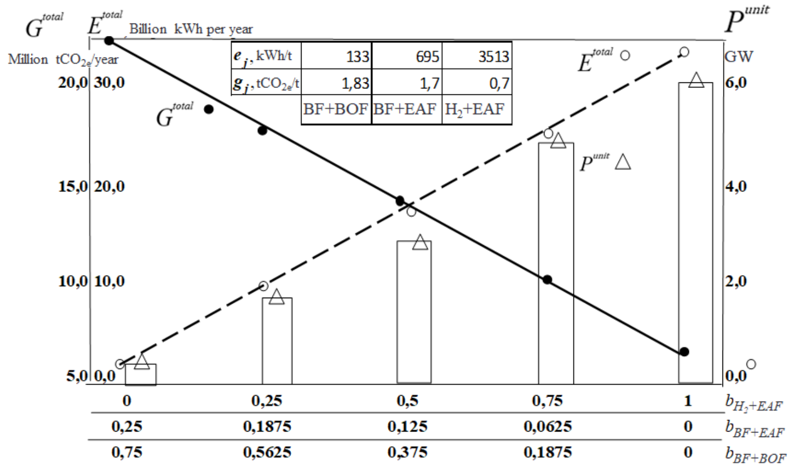

Fig. 1. Change in electricity consumption, installed capacity requirements and GHG emissions during the decarbonization of steelmaking industry (10 million tons of steel/year)

Variant calculations for the total annual steel production of 10.0 million tons per year indicate that the use of electrolysis technology for hydrogen production, direct iron reduction technology, and electric arc steelmaking technology will increase electricity consumption from 2.74 billion kWh/year to 35.13 billion kWh/year (a factor of 12.84) compared to the traditional sinter-blast technology for steel production using basic oxygen furnace. The required power generation capacity will rise from 0.48 GW to 6.15 GW (also a factor of 12.84). Greenhouse gas emissions resulting from this transformation will decrease from 17.98 million tons of CO2-eq/year to 7.0 million tons of CO2-eq/year (a reduction factor of 2.57). The results of this study can be utilized in the forecast planning for the development of power generating capacities within the United Energy System of Ukraine.

Bibliography:

1. Decarbonization Pathways for Steel and Cement Industries. URL: https://cdn.ihsmarkit.com/www/ pdf/0622/Infographic---Decarbonization-Pathways-for-Steel-and-Cement-Industries.pdf

2. WorldSteel Sustainability Indicators 2023 report. URL: https://worldsteel.org/steel-topics/sustainability/sustainability-indicators-2023-report/

3. Guevara Opinska, L., et al. 2021, Moving towards Zero-Emission Steel, Publication for the committee on Industry, Research and Energy (ITRE), Policy Department for Economic, Scientific and Quality of Life Policies, European Parliament, Luxembourg. URL: https://www.europarl.europa.eu/committees/en/supporting-analyses/sa-highlights

4. Information on the volumes and share of each energy source used to produce electricity sold on the day-ahead market and/or intraday market for January-December 2023. URL: https://www.oree.com.ua/index.php/web/55