

Market Assessment and Cogeneration Potential of High-Temperature Gas-cooled SMRs for Green Steel Production in Saudi Arabia

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Saudi Arabia's steel industry is undergoing significant expansion, with plans to increase crude steel production from approximately 10 million tons today to 20 million tons by 2030 in pursuit of self-sufficiency. This growth aligns with the industrialization goals of Vision 2030 and the national commitment to achieving net-zero emissions by 2060, necessitating the decarbonization of steelmaking. Currently, the sector relies heavily on fossil fuels, primarily natural gas for Direct Reduced Iron (DRI) and oil/gas-fired power for Electric Arc Furnaces (EAF), resulting in estimated annual CO₂ emissions of 10 to 14 million tons.

This study explores the potential of High-Temperature Gas-cooled Reactors (HTGRs) to enable green steel production by 2060, through the cogeneration of carbon-free electricity and high-grade heat for hydrogen production. A hydrogen-based DRI-EAF route is proposed as the pathway to achieving net-zero steel, with the integration of advanced HTGRs ($\geq 900^\circ\text{C}$ outlet) into Saudi steel plants. A mid-term hybrid scenario (2025-2035) deploying current-generation HTGRs (~300 MWe / 750 MWt) serves as a transitional approach, while the long-term focus shifts toward next-generation HTGRs for a fully hydrogen-driven process by 2060.

Our findings indicate that HTGR-SMRs are optimally suited for this application. A single 300 MWe / 750 MWt HTGR can deliver approximately 5 TWh of electricity and 10 TWh of high-temperature heat annually, sufficient to support the production of around 2 million tons of steel via conventional DRI-EAF. Alternatively, if its output is dedicated to high-temperature electrolysis, the reactor can produce up to 210,000 tons of green hydrogen per year, enabling approximately 3.8 million tons of green steel through a 100% hydrogen-based DRI process. In both cases, substantial CO₂ emissions reductions can be achieved, positioning HTGR-SMRs as a strategic enabler of Saudi Arabia's industrial decarbonization goals.

Technical Track

Nuclear Applications and Radiation Processing

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