Future prospects of zero carbon iron making in Australia: The economic and technical challenges

Mahesh B. Venkataraman*, Alireza Rahbari, Zsusanna Csereklyei, John Pye

Research School of Engineering, The Australian National University, ACT 2601, Australia

The rapidly growing economic and infrastructure development around the world has led to a continually increasing demand for structural steel. The primary energy requirement for production of crude steel may be low compared to other metals, however, the GHG-emissions associated with metallurgical extraction of steel accounts for ∼6% of the total anthropogenic CO_2-e emissions. Integration of renewable energy sources in metallurgical industry and new technologies for zero-carbon metal production are paramount for achieving the targets set out in the Paris Agreement, 2015.

Australia is currently the number one exporter of iron ore and metallurgical coal in the world. The co-location of iron ore resources with renewable energy sources, such as, wind and solar, in the Pilbara region, presents a significant opportunity for Australia to lead the zero-carbon initiatives in the metal production industry sector and also capitalise on a new 300 billion USD/year market. In this work, we evaluate relevant technologies for zero-carbon renewable steel production including direct pyroelectrolytic reduction of iron ore, solar-thermal integrated electrolysis and hydrogen-based steel making wherein H_2 production is potentially done using renewable grid supported electrolysis. A theoretical evaluation of primary energy requirement and C-abatement potential in different technological routes will be presented and compared with the state-of-the-art.

The technology readiness level for the three evaluated pathways ranges between 2–3 for the pyroelctrolytic process and 5–6 for electrowinning and H_2-DRI based reduction. The challenges in commercialisation and potential research areas for future are identified, including technical and socio-economic issues. A case study relevant to the Pilbara region, with emphasis on policy, trade and market requirements for success of zero-carbon metal production in Australia, is also presented.

*Corresponding author: mahesh.venkataraman@anu.edu.au