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ENVIRONMENTAL IMPACTS OF BIOREDUCER PRODUCTION

HANNU SUOPAJÄRVI,
University of Oulu, Process Metallurgy, hannu.suopajarvi@oulu.fi

INTRODUCTION

Production of one ton of steel with integrated steelmaking route emits around 2.0–2.5 tons of fossil CO_2 emissions in life cycle basis [1]. Majority of the CO_2 emissions in integrated steel plant are emitted in the blast furnace (BF) process. Biomass-based reductant (bioreducer) use in BF is one possibility to mitigate the fossil CO_2 emissions in steel production [2]. Life cycle impacts of three bioreducers were examined with carbon footprint (CFP) and energy return on investment (EROI) methodologies.

MATERIALS AND METHODS

Carbon footprint calculation is a simplified life cycle assessment methodology with focus solely on CO_2 emissions. EROI defined here is the ratio of energy embodied in the products (bioreducer and energetic by-products) to the energy embodied in fuels (fossil-based) utilized to produce it. The studied system includes all the energy and fuel inputs to produce charcoal, torrefied wood and Bio-SNG for blast furnace reductants (Fig. 1). Finnish wood-based raw materials; logging residues (LR), small-diameter wood (SDW) and stumps (ST) were considered in the work.

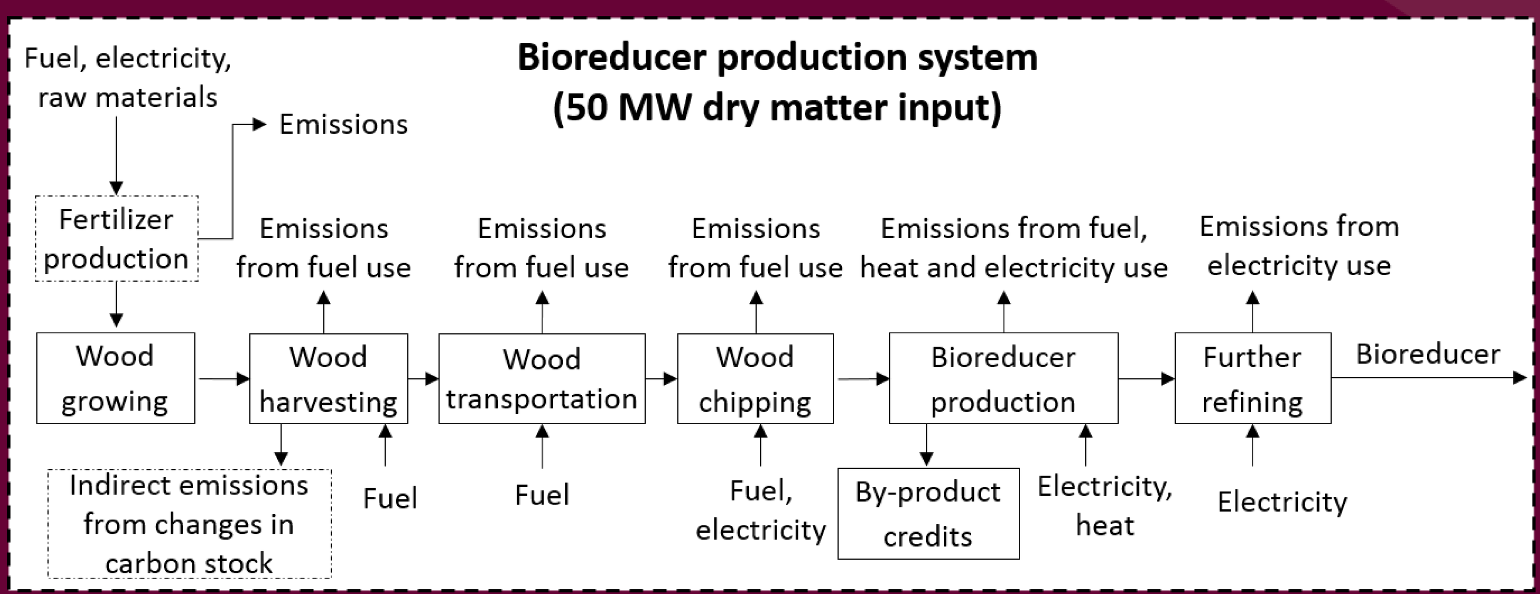

Fig. 1. System description of the study (modified from [3]).

RESULTS

The CFP of bioreducers without co-product credits, fertilizer use or indirect carbon stock change (CSC) is: 214.1–266.7 kg/t for charcoal, 105.9–122.3 kg/t for torrefied wood and 368.4–425.7 kg/t for Bio-SNG. The CFP calculated per produced unit of energy is 7.2–9.0 gCO_2/MJ, 4.9–5.6 gCO_2/MJ and 7.4–8.5 gCO_2/MJ for charcoal, torrefied wood and Bio-SNG, respectively. The contribution of each stage of bioreducer production to CO_2 emissions in base case is depicted in Fig. 2 a).

The EROI of charcoal without by-products (pyrolysis gas) is 3.2–3.9, depending on the feedstock. The EROI of Bio-SNG is slightly lower, 3.1–3.5, whereas the EROI of torrefied wood is the highest 5.4–6.2. If the pyrolysis gas from charcoal production is taken into account, the total EROI of charcoal would be 5.7–6.5 (Fig. 2 b).

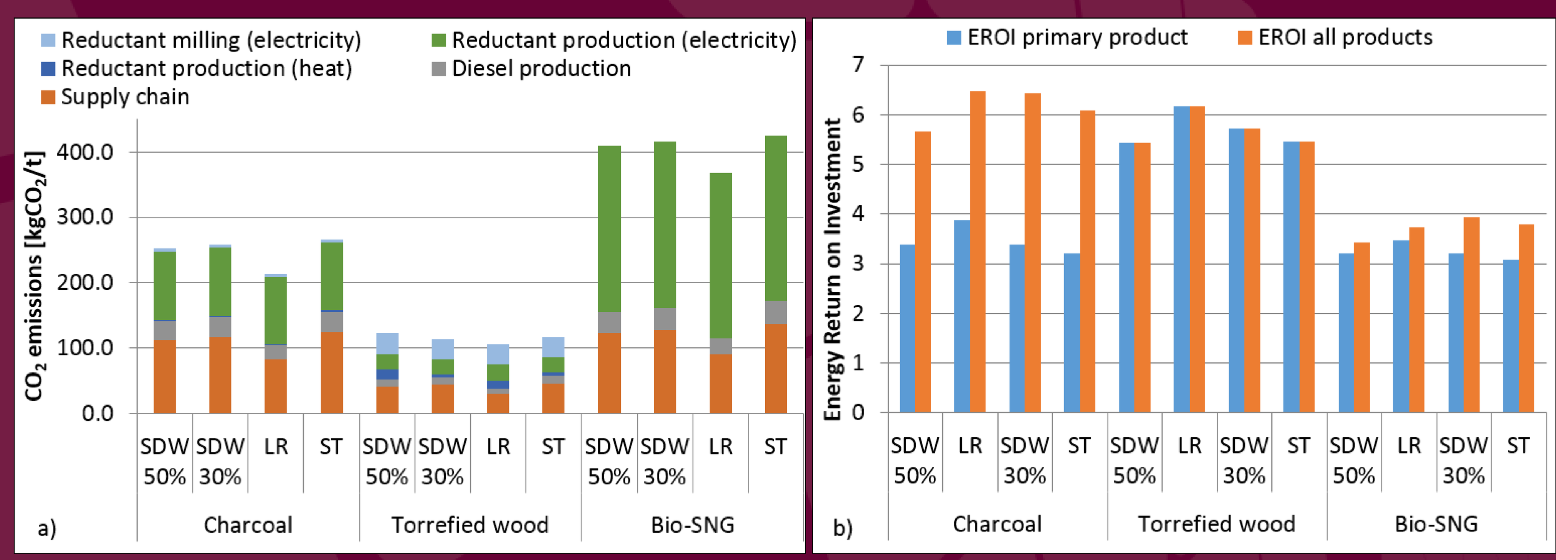

Fig. 2. CFP a) and EROI b) of bioreducers (modified from [3]).

CO_2 emissions per produced unit of energy (gCO_2/MJ), with different stages taken into account, is presented in Fig. 3. It can be seen that CFP of bioreducers is highly dependent on the raw materials, definition of the system boundary and allocation of emissions. CFP of charcoal may range from 7.2 to 116.8 gCO_2/MJ.

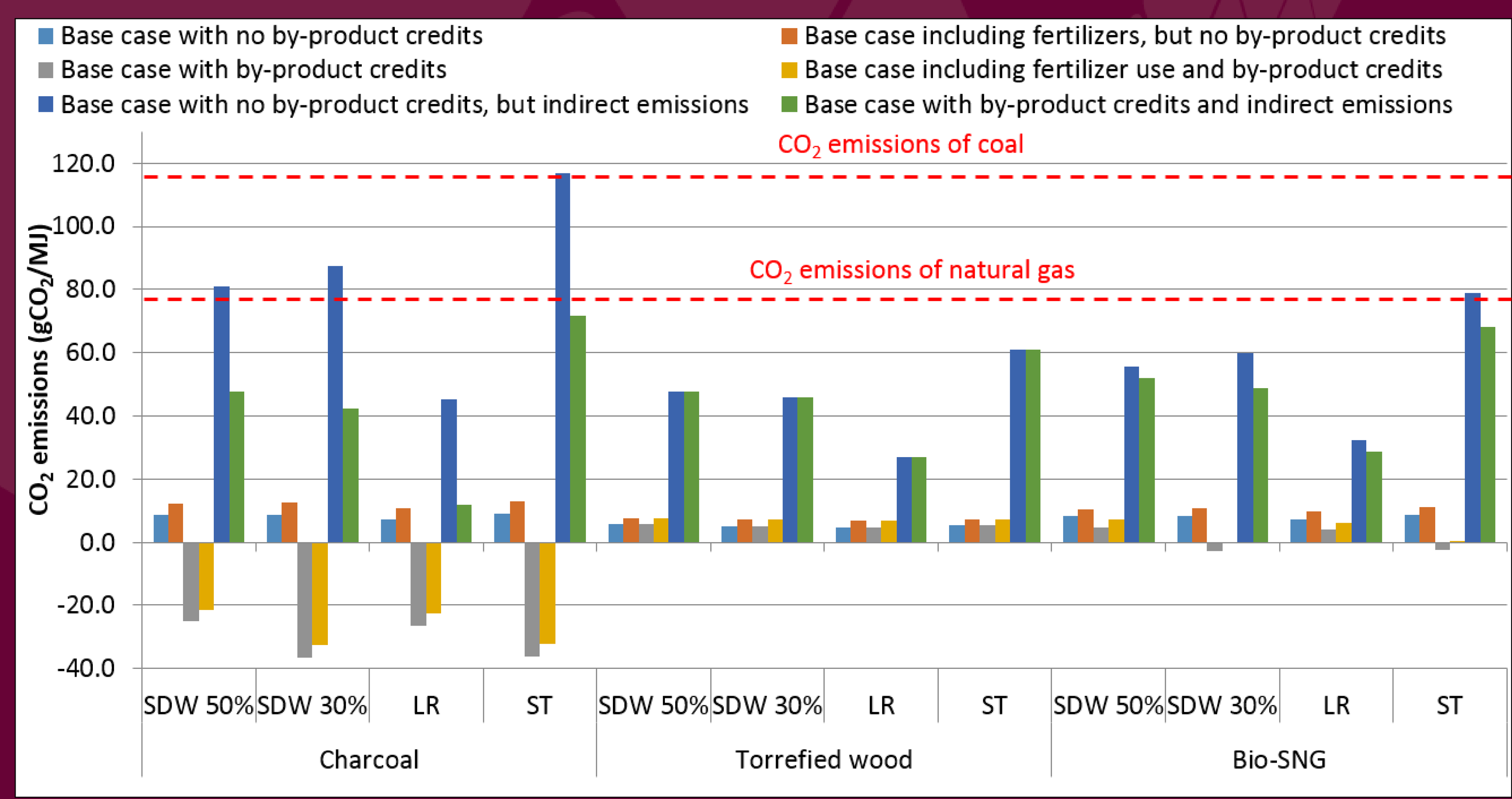

Fig. 3. CFP of bioreducers depending on system boundaries (modified from [3]).

CONCLUSIONS

The CFP calculations showed that life cycle emissions of bioreducers are considerably lower than fossil-based reductants if CSC is not accounted. This means that there is a substantial potential to decrease the fossil CO_2 emissions of steelmaking by utilizing bioreducers in the BF. The EROI calculation confirmed that production of bioreducers from wood-based feedstock is feasible from an energetic point of view (EROI > 1).

REFERENCES

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