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# Optimal Operation Strategy and Gas Utilization in a Future Integrated Steel Plant

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## Highlights:

- Integration of steelmaking with a polygeneration plant can reduce carbon dioxide emission from the system.
- There is a trade-off between economic profit and environmental impact that can be tackled by flexible operation.
- Combination of blast furnace top gas recycling and blast oxygen enrichment may reduce steelmaking emissions.
- Analysis of the system under periodic external power demands provides robust states of operation.

## Abstract

In this work future perspectives of primary steelmaking are numerically studied with the aim to find ways to increase the sustainability of this industrial sector. The key options studied are emerging blast furnace operation technologies combined with carbon capturing and utilization units and integration with a polygeneration system producing district heat, electricity and methanol. A mathematical model is developed using the suggested superstructure to optimize the use of residual gases minimizing the internal energy demand under specified operating costs, simultaneously considering investment costs for new process units. The results of the study, which illustrate both the optimal operation of the blast furnace and the required unit processes for utilization of the residual gasses in the plant, provide guidelines on how this industrial sector can be developed in the future to considerably reduce harmful emissions and to make maximum use of raw materials. A large number of scenarios were studied and the net present value, steelmaking costs, specific emissions and methanol production in the optimal states were analyzed. The results reveal the optimal technology for gas treatment under periodic optimization considering a varying seasonal external energy demand. It demonstrates that the net present value of the system for a time horizon can be increased and that the CO<sub>2</sub> emissions from the system can be reduced by up to 30 % by an optimal design and flexible operation of the system.

**Keywords:** Blast furnace, Optimization, Carbon capturing and utilization, Polygeneration system

## 1. Introduction

Steelmaking is an important industry in many countries, but it is also a very energy intensive sector with a specific energy consumption of about 20 GJ/t of steel (World Steel Association, 2013). In most steel plants residual gases and heat are (partly) recovered to provide electricity and heat for internal and external demands.

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