Modeling energy efficiency of steel industry in Integrated Assessment Model (IAM): a case study for MESSAGE

Shaohui Zhang, International Institute for Applied Systems Analysis, shaohui.zhang@iiasa.ac.at
Oliver Fricko, International Institute for Applied Systems Analysis, fricko@iiasa.ac.at
Volker Krey, International Institute for Applied Systems Analysis, krey@iiasa.ac.at
Fabian Wagner, International Institute for Applied Systems Analysis, wagnerf@iiasa.ac.at
Fei Guo, International Institute for Applied Systems Analysis, guof@iiasa.ac.at
Ernst Worrell, Utrecht University, E.Worrell@uu.nl
Wina Crijns-Graus, Utrecht University, W.H.J.Graus@uu.nl

Overview

Integrated Assessment Models (IAMs), such as the Model for Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE), are widely used for generating scenarios of energy consumption and emissions, as well as modelling the possible greenhouse gas mitigation options. However, because of the complexity in the manufacturing sector, most of IAMs aggregate detailed technology options and thereby miss linkages across sub-sectors. This implies on the one hand that the industrial energy saving potentials derived in this way are often not very realistic, and on the other hand that these models cannot be used to design specific policies, nor adequately estimate the costs implied by such policies. In this study, we identify potential benefits of integrating the iron and steels industry in the MESSAGEix framework, and implement the approach for China. More specifically, we integrate Flow Analysis of material, energy and water into MESSAGEix framework to develop the MESSAGEix – iron and steel industry model. This model can not only assess what the impacts of raw/process materials are on long-term scenario perspectives in the steel industry, but also can forecast consumption of energy and material, as well as relative co-benefits of energy efficiency measures. The results show that actions of adopting energy efficiency measures and switching route from blast furnace- basic oxygen furnace to scrap-Electric arc furnace in the energy efficiency scenario will decrease raw material input by 14% and energy use by 7%, respectively, compared to the baseline scenario. Policy makers need special consideration of industrial characteristics when designing policies. Finally, future directions on how to improve the representation of industry characteristics in IAMs are given.

Methods

MESSAGE –China is the China version of MESSAGE with additional sub-sectors on demand side. It depicts China system with high level of details on material, energy, and the associated technologies. MESSAGE – iron and steel model is a bottom-up model in the MESSAGE-China family, which integrates three main features. First, we integrating Material/Energy Flow Analysis (MEFA) into the MESSAGE model to assess what are the impacts of raw/process materials on long-term scenario perspectives in steel industry. The model hence allows for a more completed description of the process (i.e. iron ore extraction, limestone extraction, coke making, sinter making, pellets making, pig iron making, steel making with basic oxygen furnace, steel making with electric arc furnace, direct reduced iron ore, and casting, rolling, and finishing) involved in the iron and steel industry (see Figure). Second, we modeled the period from 2010 to 2050 with 5-year step. Third, we introduced current best available energy efficiency measures to capture the changes of energy, water, and emissions, based on scenario analysis. A necessary feature of this phase is the introduction of the functional parameter for the process technology and energy efficiency measures where constraint the activity of energy efficiency measures. Note that the steel demand by end-use sectors are not developed yet. Therefore, exogenous assumption on the future activity of steel consumers are obtained from the-state-of-the-art models.

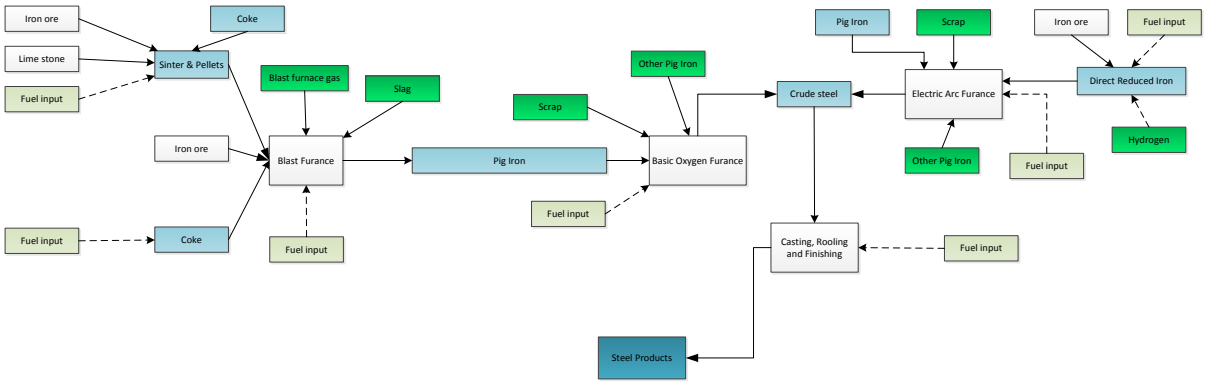

Figure 1 Reference Energy and Material system of MESSAGE-iron and steel model

Results

The results show that energy efficiency measures as a core strategy will simultaneously decrease 26% of raw material, and 20% of energy, compared to baseline scenario.

Conclusions

Finally, we recommend that adding manufacturing sub-sectors linkages to IAMs allows for studying new specific energy/water saving and emission mitigation options and develop more efficient policies, also the co-benefits of improvement options for IAMs will be modelled more accurately.