

CO2 Reduction Potentials in Iron and Steel Sector (Converter Steel) December 18, 2012 Systems Analysis Group, RITE

"2010 Energy intensity (Converter Steel; Iron and Steel Sector)" was posted on the web on September 25, 2012 [1].

(http://www.rite.or.jp/Japanese/labo/sysken/about-global-warming/download-data/Comp arison EnergyEfficiency2010steel.pdf) The paper shows how energy intensity has changed since 2000 by country, including Japan. Also, various factors that the energy intensity of each country is different at the time of 2010 are also discussed.

In this report, based on the estimated energy intensity at the time of 2010, CO2 reduction potentials are calculated only if the most excellent technology currently available (BAT) diffuses ideally in iron and steel sector (converter steel). Seeing the wide world, steel production scale, energy intensity and so on are diverse, and under such a circumstance CO2 reduction potential estimates with BAT diffusion are significant and serve as basic data for considering and implementing the effective CO2 reduction measures throughout the world

IEA have conventionally indicated energy saving and CO2 reduction potentials, but it cannot be said that the calculation basis is clear enough. In addition, since the European regions are aggregated into one area and presented as one, the potential of Germany ([2] - [4]), for example, cannot be referred. RITE analyses whose methods of calculating CO2 reduction potentials are explicit [5] and which are consistent with energy intensity make it possible to compare with a region within EU(Germany, for example).

1. Overview: Estimate of CO2 Reduction Potentials

On the following main assumptions, CO2 reduction potentials are estimated.

Converter steel production and BAT level

- Converter steel production was the 2010 value [6]. As a result, CO2 reduction
 potentials can be easily calculated when the production scale has changed in the
 future.
- The BAT level is 21.2GJ/t crude steel. It is also used to estimate energy intensity at the time of 2010 [1]. The value, 21.2GJ/t crude steel is more or less a fairly high



level which only 100% diffusion of coke dry quenching (CDQ) equipments, dry type of blast furnace top pressure power generation (TRT), recovery units of converter gas (LDG) and so on could lead to. Please refer to Oda, Akimoto [7] about the details of about twenty BAT assumptions (almost all energy-saving technologies).

Fuel consumption composition ratio and CO2 emission intensity of grid power by country

- Fuel mix of each country in the steel and iron sector is referred (fuel mix is calculated based on IEA energy balance table [8]). Coal is primary fuel but natural gas ratio is high in the U.S. and Russia (Fig. 1).
- Grid power CO2 emission intensity of each country (kgCO2/kWh) is referred (calculated based on IEA energy balance table in [8] as well).



Fig.1. Fuel mix in iron and steel sector in major regions (calorie basis, %) [2010] Source: RITE estimates based on IEA [8]

Correction of pig iron and steel ratios

- In regions where the pig iron and steel ratio (defined as "pig iron production volume/converter steel production volume" in this analysis) is less than 1.025, the regional rates are effective for the reference. On the other hand, in regions where the pig iron and steel ratio is more than 1.025 (= the world average in 2005), the standard set by RITE, the ratio is corrected to 1.025 and CO2 reduction potentials are calculated (refer to energy intensity shown in boldface in Table 1).
- This assumption makes it possible to present the CO2 reduction potentials in accordance with the measures in the regional steel plants whose pig iron and steel ratios are low, as well as the CO2 reduction potentials consistent with energy intensity per crude steel production in the regions where pig iron steel ratios are

high.

| | World | China | Ukraine | India | Brazil | Russia | US | EU(27) | Germany | Korea | Japan |
|-------------------------------------|-------|-------|---------|-------|--------|--------|------|--------|---------|-------|-------|
| Energy intensity ^{(Note 1} | 27.0 | 27.3 | 29.8 | 37.5 | 31.8 | 30.3 | 26.1 | 24.9 | 23.1 | 23.8 | 21.7 |
| (GJ/t crude steel) | 27.1 | 26.8 | 33.2 | 28.3 | 28.3 | 31.1 | 30.3 | 27.2 | 25.7 | 23.8 | 22.9 |
| Iron and steel ratio (%) | 1.02 | 1.04 | 0.86 | 1.43 | 1.43 | 0.98 | .86 | 0.94 | 0.93 | 1.03 | 0.96 |
| Pig iron (Mt) | 1026 | 590 | 27 | 39 | 39 | 48 | 27 | 95 | 29 | 35 | 82 |
| Converter steel (Mt) | 1007 | 565 | 32 | 27 | 27 | 49 | 31 | 100 | 31 | 34 | 86 |
| All crude steel (Mt) | 1417 | 627 | 33 | 68 | 68 | 67 | 80 | 173 | 44 | 58 | 110 |

Table 1 Data of major regions

Note 1) the top of energy intensity column = no correction of iron and steel ratio, the bottom = the corrected iron and steel ratio, and etc. (referred to [1]), numbers in boldface for calculation of CO2 reduction potentials (The energy intensity of EU(27) and the world are not in boldface, since they are not directly referred)

Note 2) Production amount of each country is referred to worldsteel, Steel Statistical Yearbook, 2006-2011

2. Results: CO2 reduction potential estimates

Under the assumption above, CO2 reduction potentials are estimated. (Fig. 2) The followings are discussion about Fig. 2

- From a global viewpoint, a tendency of improvement in energy intensity can be seen, however, ubiquitously various regions in the world still have CO2 reduction potentials.
- CO2 reduction potential of the world total is 420 million tCO2 (the left axis in Fig. 2). Quantitatively, China, which accounts for 56 percent of the global converter steel production has a reduction potential of 280 million tCO2.
- In terms of reduction potential per unit of converter steel (the right axis), obviously, the regions where energy intensity is inferior have higher reduction potential per unit. Among them, China and India have higher reduction potential per unit, where ratios of coal use and energy intensity of grid power are high.
- On the other hand, the U.S. has relatively low reduction potential per unit, where the pig iron steel ratio is low and natural gas is combined. (See Fig. 1) Brazil has relatively low reduction potential per unit, where biomass is also combined in 2010. (See Fig. 1)
- Comparing Germany, South Korea and Japan, South Korea has the highest CO2 reduction potential per unit, and Germany and Japan, respectively. South Korea has a large potential for CO2 reduction, due to higher iron steel ratio and coal ratio of energy mix than Germany. BAT diffusion in Japan makes CO2 reduction potential

very small, estimated about 1% of the total CO2 emissions from converter steel production in this report.



Fig. 2 RITE estimate of CO2 reduction potentials (2010)

Note 1) The actual converter steel production in 2010 as well as energy intensity is referenced Note 2) The reduction potential of EU (27), 27(MtCO2 / year), is included Germany's.

3. Comparison: IEA analysis and RITE estimates

CO2 reduction potentials are in ETP 2008, IEA [2] and energy-saving potentials in IEA ETP 2010 [3] and IEA ETP2012 [4]. The following FIG 3 and FIG 4 [2] are from ETP 2012 [4] and ETP 2008 for comparison. Figure 5 and Figure 6 show RITE estimate results of the reduction potentials at time of 2005 and 2010. (Fig. 5 and Fig.6 are estimated by the same methods.)



Figure 16.8 CO₂ emission reduction potentials in 2005, based on best available technology

Fig. 3 CO2 reduction potentials in 2005 presented in IEA ETP2008 [2] Note) CO2 reduction potential per ton on the right axis is "per ton of all crude steel".





Note 1) Energy-saving potential per ton on the right axis is "per ton of all crude steel".
 Note 2) Presuming that "reduction potential of 20%" are specified in the text, this figure presents "primary energy reduction potentials" rather than "final energy reduction potentials".



Fig. 5 RITE estimates of CO2 reduction potentials in 2005

Note 1) For comparison with the IEA analysis, CO2 reduction potential per ton (the right axis) is "per ton of all crude steel" as well as the IEA analysis. (Please note that the energy efficiency improvements of electric furnace are not considered in RITE analysis.) Note 2) Crude steel production and energy intensity are 2005 data.



Fig. 6 RITE estimates of CO2 reduction potentials in 2010 Note 1) The same data as Fig. 2, though the right axis is per ton of all crude steel Note 2) Crude steel production and energy intensity are 2010 data.

Comparison of the potentials of the world total

Figure 3 (ETP 2008 [2], in 2005) shows CO2 reduction potentials of the world total are 340 million tCO2. On the other hand, RITE estimates show CO2 reduction potentials are 380 million tCO2 in 2005 (Figure 5). From a regional perspective, the IEA ETP 2008 [2] shows smaller CO2 reduction potentials in China and Russia compared



with RITE estimates. Not only retrofit measures but all the existing facilities are assumed to be replaced and each BAT is assumed to exert energy efficiency ideally in RITE estimates. (Applying a uniform rate, 21.2GJ/t crude steel without regional differences) The IEA analyses indicate the possibility that existing facilities in Russia and China are assumed to remain. Above all, small blast ratio of China is high [9], which is considered to make the difference between the IEA analyses and RITE estimates.

The results at the time of 2010 and 2009 are compared. Energy-saving potential of the world total (ETP 2012 [4], evaluation of 2009) is 5.4EJ according to Fig. 4. IEA ETP 2012 [4] does not specify how much 5.4EJ is equivalent to CO2 reduction, but it also describes, "CO2 emissions more than 400MtCO2 can be avoided". IEA ETP 2012 [4] shows the same level of reduction potentials for the world total as nearly 420 million tCO2 of RITE estimates (Fig. 6). Also for China, it shows the relatively close level to Fig.4 and Fig.3.

Potential comparisons by region

- IEA analyses expect large reduction potential of India. RITE estimates evaluate the pig iron and steel ratio 1.025 with the correction which is considered to give a big impact.
- IEA analyses expect the small reduction potential of Russia at the time of 2005, as well as 2009and 2010. As mentioned above, RITE estimates larger potential because not only retrofit measures but all the existing facilities are assumed to be replaced.
- With the exception of the China, India and Russia, regional differences between IEA analyses and RITE estimates are relatively small.

To sum up these, as it is considered IEA analyses and RITE estimates to have differences in underlying presuppositions, they are different in fine points. On the other hand, both show the similar level of CO2 reduction potential of the whole world. Looking at individual regions, though there are differences in India and Russia, which can be explained by presupposition differences.

IEA does not show the presuppositions of analyses, but the discussion could be possible by comparing with RITE estimates. As seen above, it is also important that the basic data quantitatively showing the current situation of steel and iron industry in each region and the effects of BAT diffusion would increase for verification of data reliability and being more convincing.

4. Summary

In this report, based on regional converter steel energy intensity in 2010 [1], CO2 reduction potentials with BAT diffusion are estimated. The global CO2 reduction potentials were estimated 420 million tCO2, assuming converter steel production in 2010. Reduction potential per unit is widely distributed in the world. Reduction potential of China with a large-scale production already stands out in 2010, and it is important for not only China but Southeast Asia and South Asia (such as India) expected an increase in steel demand to accelerate energy-saving technology diffusion.

The reduction potential of Japan with BAT diffusion is only 2 millions tCO2 (1% of the iron and steel sector CO2 emissions). BAT includes only energy-saving technology in this analysis not technology featured to reduce CO2 emissions, such as waste plastics use. In aiming at higher reductions, further expanded measures such as waste plastic use are also required.

RITE analyses above show consistent results with the IEA analyses. However, there is a difference that IEA has not presented analysis presuppositions and national data within Europe but RITE estimates present them. It is important that the whole world would discuss and practice CO2 reductions with BAT diffused, based on the solid basic data.

Reference

[1] 2005 Energy Efficiency (Scrap Steel, Iron and Steel Sector), November 16, 2010, RITE, in Japanese.

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