International Comparisons of Energy Efficiency (Sectors of Electricity Generation, Iron and steel, Cement)

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Sorted international comparison of energy efficiency in electricity generation, iron and steel and cement sectors

1. Electricity Generation Sector

(1) Estimated energy efficiency

Fig.1-1 shows the estimated efficiency of fossil fueled power generation in eleven countries of 2005 based on IEA statistics (Energy Balance of OECD/Non-OECD Countries, 2007). Meanwhile, the higher ratio of gas fueled power plant brings the higher averaged efficiency of thermal power electric generation, and this does not depend only on the level of technology. For reference, Fig.1-2 shows the fossil fuel mix for power generation in 2005. We need to note that IEA statistics do not have an independent column of the electricity output by co-firing

In Japan, coal fired electric power plants have accomplished high efficiency. While, as for natural gas, we can say the United Kingdom has improved the efficiency of power generation since 1990 through replacing aged coal fired power plants with latest combined cycle gas turbines. The averaged efficiency of fossil fuel power plants is almost the same for the two countries, 44.4% and 44.3%, respectively in Japan and in the United Kingdom.

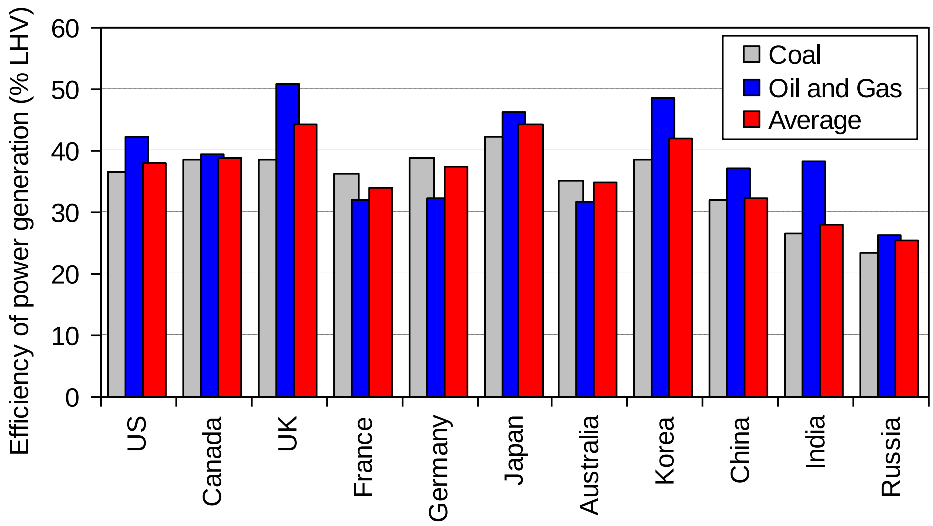

Fig.1-1 Comparison of energy efficiency of fossil fueled power generation of 2005 by region

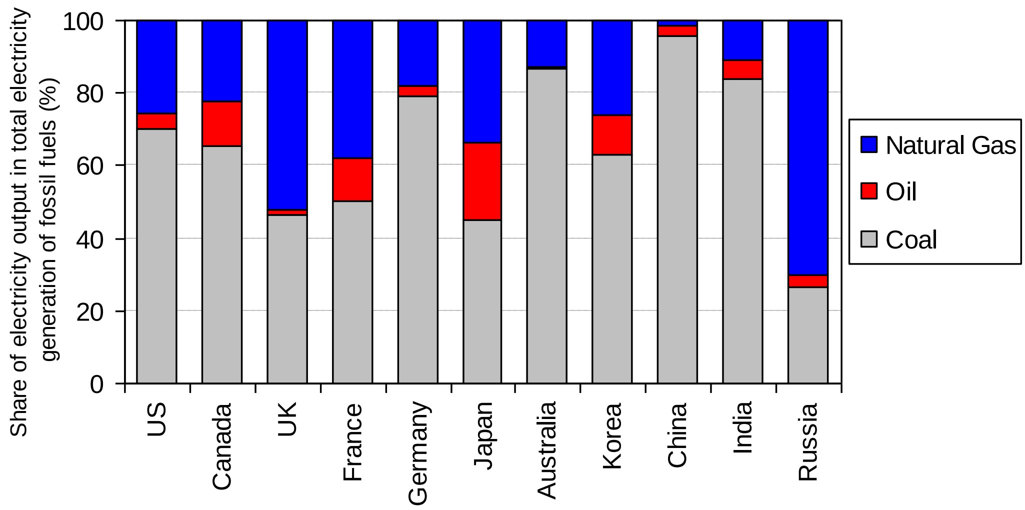

Fig. 1-2 Comparison of fossil fuel share for power generation of 2005 by region

(2) Estimated mitigation potentials of CO_2 emissions

Fig1-3 shows mitigation potentials of CO_2 emissions from the power generation efficiency in 2005 by country based on the assumption that each country accomplishes the current efficiency level of coal and oil fired power generation of Japan and that of gas fired power generation of UK. In this case, CO_2 mitigation potential is estimated about 2.1 $GtCO_2$/yr in global total. It is noted that it requires a long time to realize this mitigation potential, since the lifetime is long.

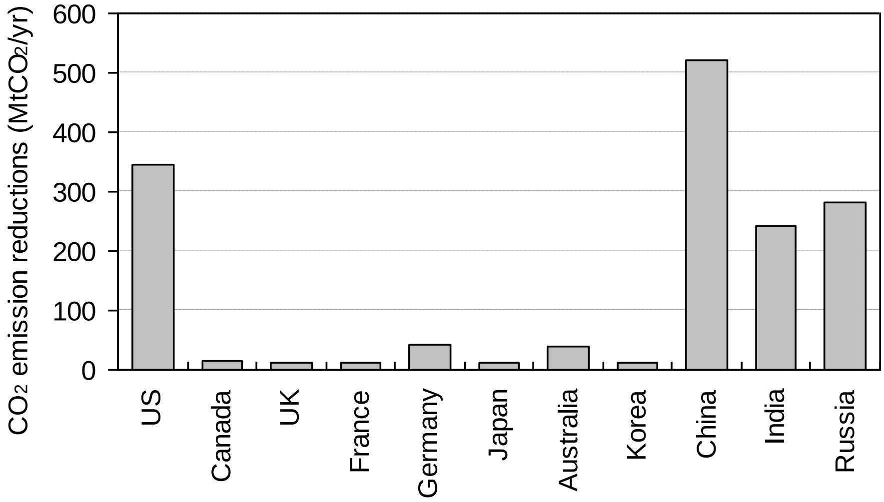

Fig.1-3 CO_2 emission mitigation potentials of fossil fuel power generation in case of efficiency improvement to the current level of Japan

2. Iron and steel

(1) Estimated energy efficiency

We estimated the energy consumption per unit production of crude steel of 2000. The steel making process was divided into three groups; blast furnace to basic oxygen furnace (BF-BOF), scrap based electric arc furnace (scrap-EAF), and direct-reduced-iron based electric arc furnace (DRI-EAF), and their energy efficiencies by region was estimated. Fig.2-1 and 2-2 show the energy efficiency of BF-BOF and scrap-EAF. Japan and Korea have more efficient BF-BOFs than other regions. Those facilities in the two countries have effective utilization of by-product gases, and energy-saving facilities, e.g., coke dry quenching (CDQ) and top pressure recovery turbine (TRT).

The averaged energy efficiency of total crude steel production without disaggregation of BF-BOFs and scrap-EAFs makes no sense under current global trade of steel products and scrap because the energy efficiencies are quite different for the two routes due to their process difference in principal; BF-BOFs make steel from iron ore while scrap-EAFs from scrap steel.

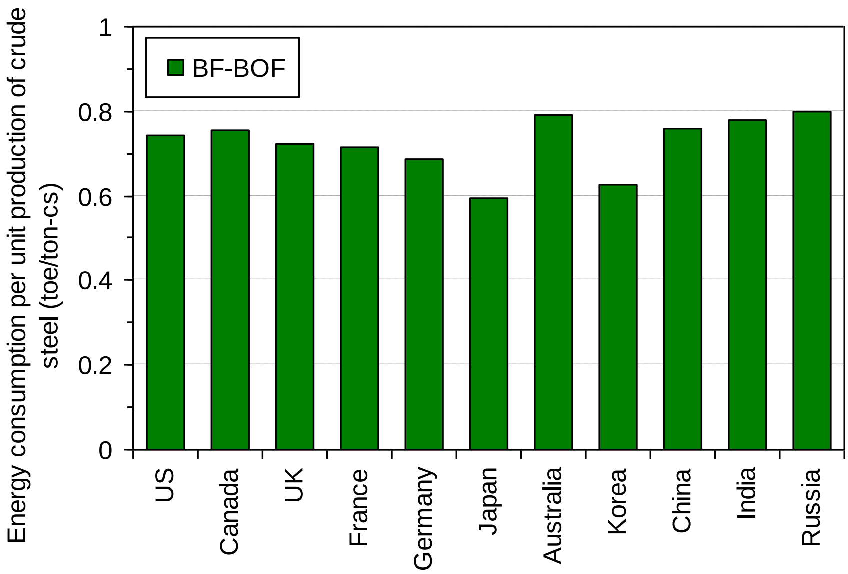

Fig. 2-1 Estimated energy efficiency of BF-BOF of 2000 by region
(Electricity is converted at 1MWh=0.086/0.33toe)

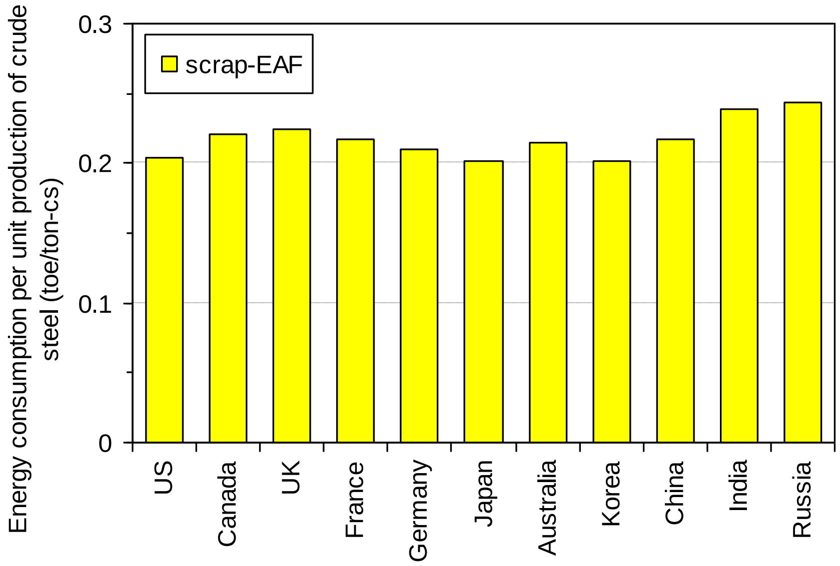

Fig. 2-2 Estimated energy efficiency of scrap-EAF of 2000 by region
(Electricity is converted at 1MWh=0.086/0.33toe)

Detailed explanations are given in the following about the energy efficiency estimation.

In IEA Energy Statistics (Energy Balance of OECD/Non-OECD Countries, 2007), the iron and steel sector is described in two fields; energy conversion and demand. Estimating real energy consumptions of each route, i.e., BF-BOF, scrap-EAP, DRI-EAF, by country is a difficult work because the IEA statistics estimates energy consumptions under different boundaries, i.e., energy consumptions/productions only in two fields of energy conversion and demand of the three routes together. In order to estimate the real energy consumptions, the trade of coke, sintering and pig iron across countries, and input and output of by-product gas, steam and electricity across sectors should be considered. Therefore, in order to estimate the energy efficiency of each of the three iron making routes, RITE referred to not only IEA Statistics and crude iron production statistics of International Iron and Steel Institute (IISI), but also facilities penetration ([1][2]), energy efficiency by technology ([3][4]), and the current status of individual plants ([5]-[16]).

Energy efficiency of Fig.2-1 and 2-2 is calculated using the boundary shown in Fig. 2-3; net energy and energy source flows across the boundary are counted and the energy consumed for the processes outside the boundary is not counted. The electricity is converted to primary energy using the ratio of 1MWh=0.086/0.33toe. The assumed boundary is based on the concept of Fig. 2-4.

- Coal mining, ore mining, and these transportation to the steel plant

System boundary

- Coke making, sintering, and pellet making
- Oxygen making
- Hot rolling

- Cold rolling, plating, and special steel making

Fig 2-3. Boundary for steel sector in the estimation of energy efficiency

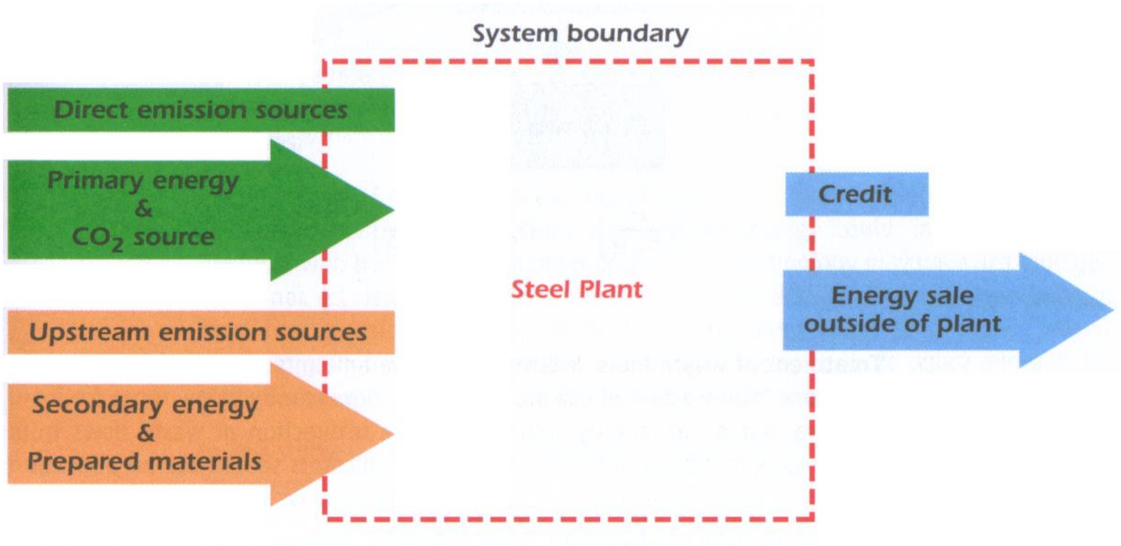

Fig 2-4. Conceptual diagram of boundary for steel sector (2006)([17],[18])

See J. Oda et. al, (2007)[19] for a detailed description of boundary.

(2) Estimated mitigation potentials of CO_2 emissions

Fig.2-5 shows CO_2 emission mitigation potentials by country, based on the estimates of energy efficiency in the iron and steel sector of individual countries in 2000, supposing that each country accomplishes the energy efficiency level of Japan in 2000 in both BF-BOF and scrap-EAF. CO_2 emission reduction potential is estimated about 0.36GtCO_2/yr in global total, assuming electric CO_2 intensity is fixed at the value of 2000 in each country.

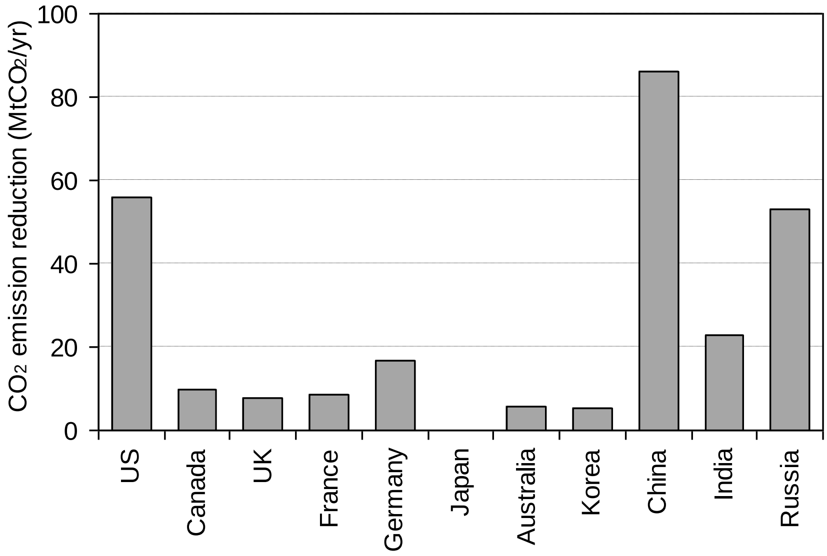

Fig. 2-5 CO_2 emission reduction potentials of iron and the steel sector in case of efficiency improvement to the current level of Japan

Reference of the iron and steal sector

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3. Cement

(1) Estimated energy efficiency

Fig.3-1 shows estimated energy efficiency of 2000 by region. The energy from non-fossil fuels such as biomass, waste plastics and tires is excluded in this estimation. In the same way as the iron and steel sector, the electricity is converted to primary energy using 1MWh=0.086/0.33toe.

Japan and Korea, where dry rotary kilns equipped with suspension preheaters (SPs) or with new suspension preheaters (NSPs) that have not only suspension preheaters but also precalciners are prevailing, are leading in energy efficiency. Former Soviet Union and China have lower energy efficiency facilities, depending on wet rotary kilns and having a large share of vertical kilns respectively.

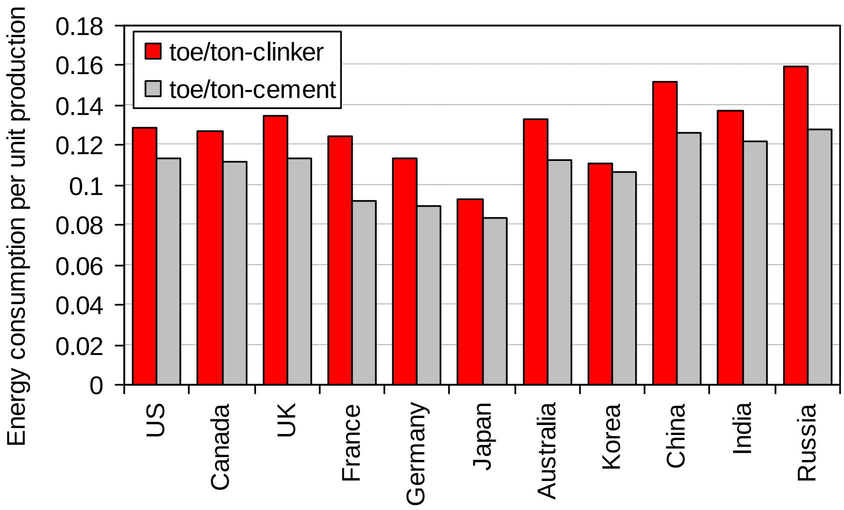

Fig. 3-1 Estimated energy efficiency of 2000

(Electricity is converted to primary energy at 1MWh=0.086/0.33toe)

Detailed explanations are given in the following about the energy efficiency estimation.

In IEA Energy Statistics (Energy Balance of OECD/Non-OECD Countries, 2007), the cement sector is not independent and grouped into [Non-metallic Minerals]. Therefore, energy efficiency have to be estimated from various data such as energy efficiency and characteristics of individual technologies([1], [5], [6], [8]-[10]), scale and transition of productions([2], [3]), regional production processes[10], regional energy efficiency([6], [10]), field survey of cement plants([11], [12]). Fig 3-1 shows estimated energy efficiency by region, especially considering cement production types by region and explicit differences of plant scales.

(2) Estimated CO_2 emission mitigation potentials

Fig.3-2 shows CO_2 emission mitigation potentials by country, based on the estimates of energy efficiency in the cement sector of individual countries in 2000, supposing that each country accomplishes the energy efficiency of Japan in 2000 in clinker production. CO_2 emission potentials all over the world are estimated about 0.22GtCO_2/yr,assuming the electric CO_2 intensity is fixed at the value of 2000 in individual countries. However, China has a large number of dispersed small scale facilities and it is not practical to aggregate all the facilities into large scale facilities, so it will be difficult to accomplish the above mitigation potentials in a short-term.

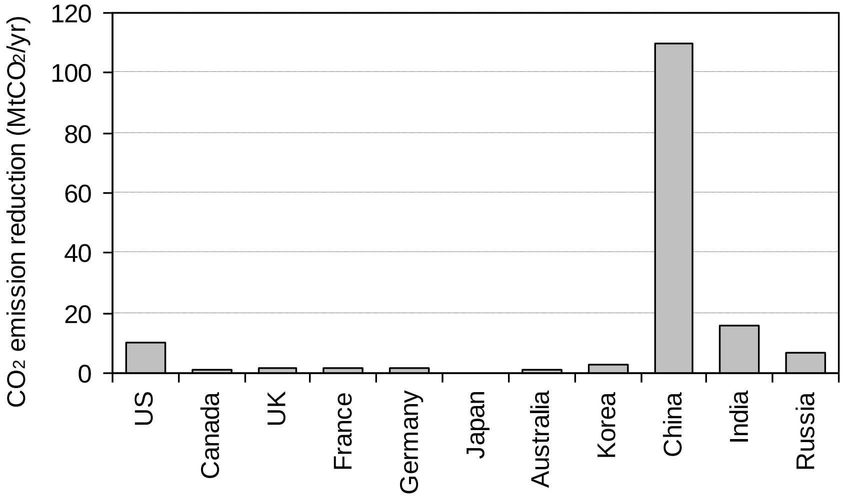

Fig. 3-2 CO_2 emission reduction potentials of the cement sector in case of efficiency improvement to the current level of Japan

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