Research on Contribution of Steel Products to Society-wide Energy Conservation from LCA Perspectives (1)[1]

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1. Objective of Research

Since being hit by the oil crises of the 1970s, the Japanese steel industry has been making strenuous efforts to make its iron- and steelmaking processes less energy-intensive and to drastically cut energy intensity by 20 – 25% through technology development—typically continuation or simplification of processes and exhaust heat recovery. However, since the beginning of the 1990s, improvement of energy intensity has been slowing down. This can be attributed to factors such as the larger number of manufacturing processes and treatments involved in the production of high-functional steel products, deteriorating thermal efficiency due to smaller quantities of production, and the greater use of environmental equipment.

On the other hand, steel products featuring high functionality are in many cases proving more energy-efficient than their conventional counterparts when in use. A good example of this is high-tensile steel sheets (hi-tensile sheets), which can make automobiles lighter and thus contribute to lowering fuel consumption. Also, high-functional steel products used instead of conventional products can slash energy needs for final product manufacturing. For these reasons, when considering what impacts the growing popularity of high-functional steel products can have on energy consumption, we must be sure to take factors such as these into account.

Comprehension of the energy-saving effects of high-functional steel products requires a broader perspective covering the stages not merely of their manufacturing but also of their utilization. In other words, we need in addition to conduct an analysis/assessment from LCA (social contribution) perspectives. The most important approach is to select rational and

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effective measures by reviewing the total life of steel products from their manufacture to the stage of utilization of steel-made products. To date, however, few systematic and quantitative analyses of energy conservation have been made from such perspectives.

This way of viewing energy conservation from LCA perspectives is very significant in a consideration of how our society can concertedly and rationally combat global warming, one of the world's top priorities since the 1990s. With such concerns in mind, this research is designed to make an overall analysis/assessment of the energy-saving effects of high-functional steel products from LCA perspectives by covering steelmaking processes and beyond–i.e, the stages of manufacturing and utilization of steel-made products. On the basis of the analysis results, we also consider the ideal forms of energy conservation and CO_2 reduction measures.

2. Research Method

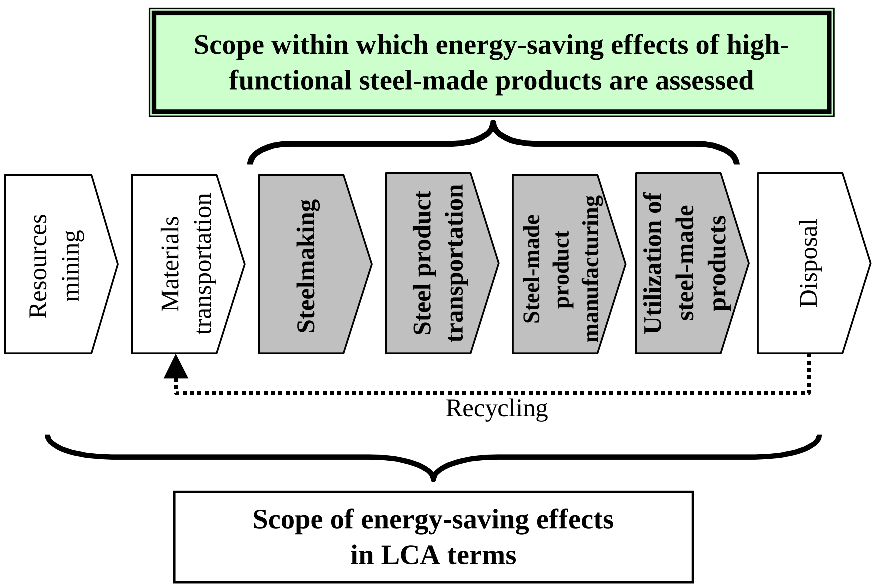
2-1 Basic concept of energy-saving effect in LCA method

With the LCA method, energy consumption must be assessed by covering the life cycle of each product, from mining of resources to disposal, as shown in Fig. 2-1.

This time, focusing on the scope within which high-functional steel products can have social effects, we have analyzed/assessed energy consumption in "steelmaking," "steel product transportation," "manufacture of steel-made products" and "utilization of steel-made products." Within this scope, we have investigated the energy-saving effects of higher functionality by assessing energy consumption involved in "conventional steel-made final products" compared with that in "high- functional steel-made products."

For our research, we selected six types of high-functional steel products. These were

Fig. 2-1 Scope of Energy Conservation Assessment of High-Functional Steel-made Products



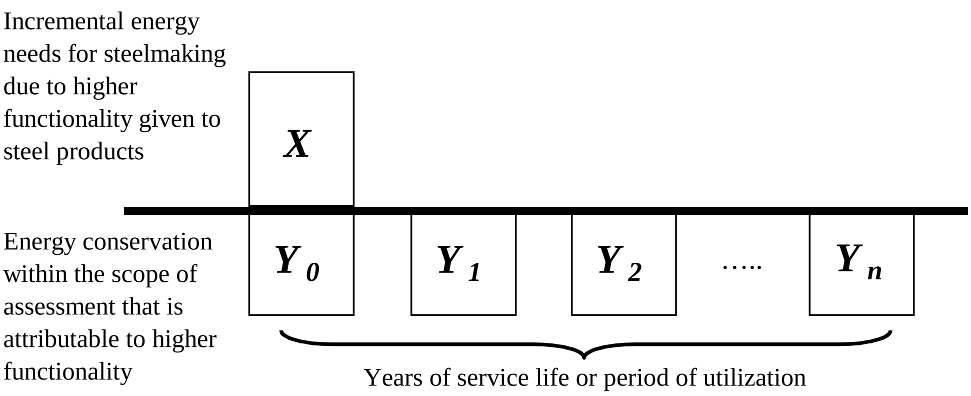
high strength steel sheets for automobiles, hi-tensile steel plates for vessels, stainless steel plates for railway cars, high strength H beam fringes for steel frames of buildings, grain-oriented silicon steel sheets for transformers, and heat-resistant high strength steel tubes for boilers.

When quantification was possible of any parts of a particular product to be analyzed, we evaluated its actual records, then calculated what it would be in the future, while taking account of the characteristics of manifesting energy-saving effects shown in Fig. 2-2. There are two approaches employed in our assessment. One is the case of flow-type assessment, where we estimate how much energy is saved in a single year of manufacturing as a result of lower steel needs for manufacturing, lower energy needs for processing, etc. resulting from the higher functionality given to steel products the production of which involves incremental energy. The other is the case of stock-type assessment, where an estimate is made of the cumulative amount of energy conservation during full service life for all the years in which a product is in use.

Stock-type assessment is applied to steel sheets for automobiles, plates for vessels, electromagnetic sheets for transformers, tubes for boilers and sheets for electric cars. Hi-tensile wide beam fringes used as building materials are subjected to flow-type assessment.

We evaluated energy consumption at five points of time in total—that is, actual records in the three years of 1990, 1995 and 2000, and future energy forms in the two years of 2005 and 2010. In addition, we simulated a potential case in which the potentials of wider applications of technology—for example, even higher functionality—were assumed.

Fig. 2-2 Concepts of Energy Conservation Assessment



1. Stock-type assessment
   Assessed amount = X – (Y0 + Y1 + Y2 + ….. + Yn)
   [automobile sheets, vessel plates, transformer grain-oriented silicon steel sheets, boiler tubes, railway car stainless steel sheets]
2. Flow-type assessment
   Assessed amount = X – Y
   [H beam fringes for building steel frames]

2-2 Concepts for examination of impacts produced by high-functional steel-made products on energy consumption

We examined the impacts that were produced on energy consumption by high functional steel-made products, adopting the concepts summarized in Table 2-1. First, because increased strength of steel products can reduce the weight of steel-made products, hi-tensile steel-made products are less energy-intensive than conventional steel-made products when in use. In addition, hi-tensile steel-made products can be produced with a smaller amount of steel products, which means that energy needs for manufacturing can also be reduced. It should also be mentioned that lower energy needs for steel product transportation and processing contribute to energy conservation to some extent. This matter, however, is not dealt with by the present quantitative analysis.

Table 2-1 What Are the Impacts of High-Functional Steel-made Products on Energy Consumption?

Higher functionality given to steel products	Better functionality of steel-made products	Changes in energy consumption
A. Increased strength of hi-tensile sheets	A. Lighter weight	A. Less energy consumption when in use
B. Improved corrosion resistance	B. Longer service life (corrosion resistance, weather resistance)	B. Less energy consumption during transportation
C. Improved heat resistance	C. Higher energy efficiency	C. Lower steel needs for final product manufacturing
D. Improved electromagnetic properties		D. Less energy consumption during processing Omission of processes by steel-consuming industries
E. Improved workability		

Second, improved corrosion resistance of steel products helps to enhance product durability, which in turn reduces steel requirements for final product manufacturing. This benefit, however, is not dealt with by our present research. Third, better heat resistance of steel products leads to higher efficiency of energy conversion, which results in lower energy consumption when such steel-made products are utilized. Likewise, upgraded electromagnetic characteristics bring about similar benefits. Fourth, high-functional steel products can increase processing efficiency at the manufacturing stage of steel-made products. This allows the steel-consuming industries to omit some of their processes, which results in energy conservation.

With these impacts on energy consumption taken as the basic concepts, we prepared specific calculation methods for each of the steel products, and then conducted analyses and assessments. These specific calculation methods will be described later together with the results for each steel product.

Table 2-2 summarizes the concepts and contents of energy conservation relevant to the six types of steel products we analyzed. It shows the concepts of energy-saving effects taken in our evaluation of actual records in 1990, 1995 and 2000, giving estimated predictions for 2005 and 2010, and those assumed for the additional potential case, both product by product.

We made our calculated predictions for 2005 and 2010 by extrapolating the concepts of energy-saving effects applied to our evaluation of actual records. For the potential case, we estimated the additional potentials of functionality by assuming that high-functional steel products will be used in a broader range than now, and that shifts are likely from conventional products to high-quality high-functional steel products.

Table 2-2 What Energy-saving Effects Are Gained from Steel Products?

	Energy-saving effects assumed for 1990 - 2010	**Potentials of enhanced energy-saving effects**
Automobile sheets	* Share of hi-tensile sheets 30.5% → 45%. ; Lighter car body improving fuel economy. ; Increased strength reducing steel sheet needs for car manufacturing.	* Share of hi-tensile sheets 50%. * Pursuing secondary benefits of lighter car body and weight reduction in wheel-related parts ; Lighter car body improving fuel economy. ; Increased strength reducing steel sheet needs for car manufacturing.
Vessel plates	* Share of hi-tensile plates in vessels in service 70%, halved (50% each) by YP315(HT32) and YP355(HT36). ; Lighter ship body improving fuel economy. ; Increased strength reducing plate needs for shipbuilding.	* YP355 (HT36) to hold a 100% share of hi-tensile plates. ; Lighter ship body improving fuel economy. ; Increased strength reducing plate needs for shipbuilding.
Boiler tubes	* Assessed items were 598 – 600 deg C -class coal-fired power plant construction records and plans. ; Generating efficiency at 598 deg C -class 41.5% → 43.1%	* In addition to 598 – 600 deg C -class coal-fired plant construction plans in 2000 – 2010, assessed items were changes from originally planned 566 deg C -class coal-fired plant construction for the same period to 598 – 600 deg C -class ones.
Wide beam fringes for buildings	* Share of hi-tensile wide beam fringes in use 22.6% → 31.2% * Changing shares held by hi-tensile sheets 490Nmm2 and 590Nmm2 ; Increased strength reducing wide beam fringe needs for building.	* Share of hi-tensile wide beam fringes to increase, along with greater share held by 590Nmm2. ; Increased strength reducing wide beam fringe needs for building.
Railway car stainless steel sheets	* Stainless sheet reducing weight by 6.6 tons/car. ; Lighter cars reducing energy consumption while in service. ; Introduction of stainless sheets reducing steel needs for electric car manufacturing.	* Originally planned production of steel-made electric cars to be changed to stainless steel-made cars.
Transformer steel sheets	* Old-type transformers to be replaced with new ones made of electromagnetic sheets featuring low core loss, thus reducing energy consumption of transformers.	* Old-type transformers to be replaced with new ones made of electromagnetic sheets featuring low core loss, thus reducing energy consumption of transformers.

3. Research Results

Tables 3-1 and 3-2 summarize product by product the energy-saving effects of high-functional steel products from LCA perspectives, and describe the effects of curbing CO_2 emissions, respectively. The aggregated energy-saving effects of the six types of products are also stated in the bottom columns of the tables. On the basis of the numerical figures given in the table, we generalize our research results and consider their implications below.

Table 3-1 Summary of Energy-saving Effects of High-Functional Steel Products from LCA Perspectives

		Steel output (1,000t)	Energy conservation (10,000kl)			Incremental energy needs (10,000kl)			Energy conservation grand total (10,000 kl)
			Lower steel needs	Product use	total	Larger steel needs	Higher functionalit	total	
Automobile sheets	1990	651	47.4	225.3	272.7		-1.2	-1.2	271.5
	1995	517	37.5	190.7	228.2		-0.9	-0.9	227.3
	2000	631	46.1	198.3	244.4		-1.1	-1.1	243.3
	2005	713	52.1	217	269.1		-1.3	-1.3	267.8
	2010	830	60.4	245.5	305.9		-1.5	-1.5	304.4
	Potentials	1,395	121.1	497.8	618.9		-2.5	-2.5	616.4
Vessel plates	1990	1,037	16.1	36.3	52.4		-2.9	-2.9	49.5
	1995	1,396	21.7	49.1	70.8		-3.9	-3.9	66.9
	2000	1,531	23.8	63.9	87.7		-4.3	-4.3	83.4
	2005	1,442	22.4	61.7	84.1		-4	-4	80.1
	2010	1,246	19.4	54.5	73.9		-3.5	-3.5	70.4
	Potentials	1,225	21.5	60.4	81.9		-3.9	-3.9	78
Stainless sheets	1990	6	0.2	7.2	7.4		-0.1	-0.1	7.3
	1995	7	0.3	8.9	9.2		-0.2	-0.2	9
	2000	8	0.3	9.3	9.6		-0.2	-0.2	9.4
	2005	7	0.3	8.8	9.1		-0.2	-0.2	8.9
	2010	8	0.3	9.8	10.1		-0.2	-0.2	9.9
	Potentials	10	0.4	11.6	12		-0.2	-0.2	11.8
H beam fringes for building	1990	1,674	41.2		41.2		-0.5	-0.5	40.7
	1995	1,802	44.8		44.8		-0.6	-0.6	44.2
	2000	1,531	38.6		38.6		-0.5	-0.5	38.1
	2005	1,614	40.4		40.4		-0.5	-0.5	39.9
	2010	1,856	48.3		48.3		-0.6	-0.6	47.7
	Potentials	1,938	54.5		54.5		-0.7	-0.7	53.8
Transformer steel sheets	1990	23	0.8	107.1	107.9				107.9
	1995	30	1	123.9	124.9				124.9
	2000	55	1.6	200.5	202.1				202.1
	2005	43	1.2	134.1	135.3				135.3
	2010	60	1.5	111	112.5				112.5
	Potentials	60	1.5	111	112.5				112.5
Boiler tubes	1990	0		0	0	0	0	0	0
	1995	0.26		13.5	13.5	0	0	0	13.5
	2000	1.37		71.2	71.2	0	0	0	71.2
	2005	1.54		79.7	79.7	0	0	0	79.7
	2010	0.38		19.6	19.6	0	0	0	19.6
	Potentials	2.05		107.4	107.4	0	0	0	107.4
Total	1990	3,391	105.7	375.9	481.6	0	-4.7	-4.7	476.9
	1995	3,753	105.3	386.1	491.4	0	-5.6	-5.6	485.8
	2000	3,757	110.4	543.2	653.6	0	-6.1	-6.1	647.5
	2005	3,821	116.4	501.3	617.7	0	-6	-6	611.7
	2010	4,000	129.9	440.4	570.3	0	-5.8	-5.8	564.5
	Potentials	4,630	199	788.2	987.2	0	-7.3	-7.3	979.9

(Note) On stainless steel, the figures obtained from 1992 data are taken as 1990 figures.

Table 3-2 Summary of CO_2 Reduction Effects of High-Functional Steel Products from LCA Perspectives

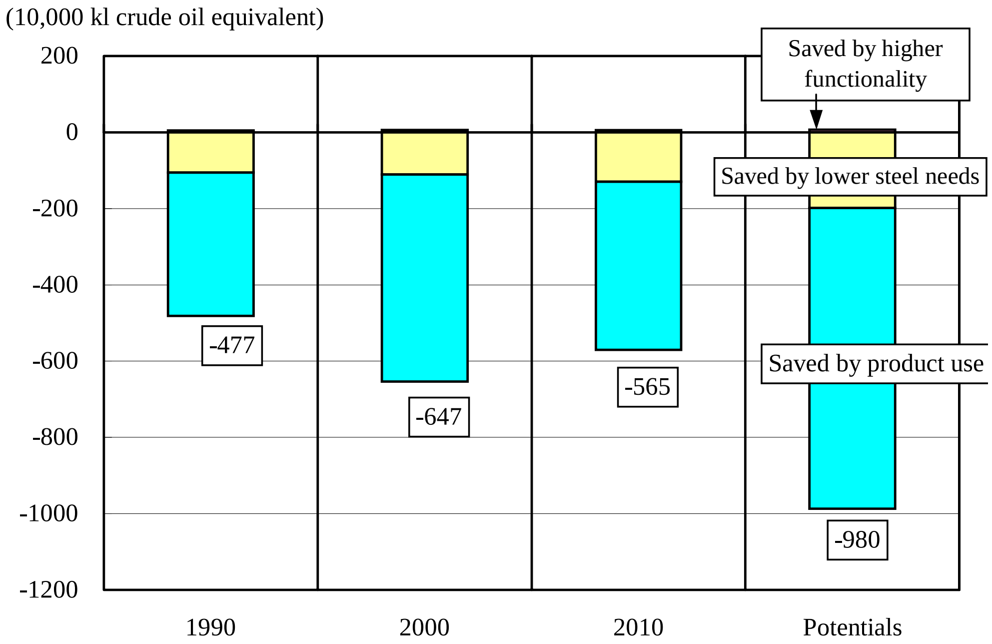
		Steel output (1,000t)	CO2 reductions (10,000 t- CO2) total			Incremental CO2 emissions (10,000 t- CO2) total			CO2 reductions grand total (10,000 t-CO2)
			Lower steel needs	Product use	total	Larger steel needs	Higher functionality	total	
Automobile sheets	1990	651	144.4	573	717.4		-3.5	-3.5	713.9
	1995	517	113.1	485.2	598.3		-2.8	-2.8	595.5
	2000	631	138.7	504.3	643		-3.4	-3.4	639.6
	2005	713	158.7	552	710.7		-3.8	-3.8	706.9
	2010	830	185.8	624.4	810.2		-4.5	-4.5	805.7
	Potentials	1,395	372.6	1,266.20	1,638.80		-7.6	-7.6	1,631.20
Vessel plates	1990	1,037	49.1	100.6	149.7		-8.8	-8.8	140.9
	1995	1,396	65.4	135.7	201.1		-11.8	-11.8	189.3
	2000	1,531	71.6	176.8	248.4		-12.9	-12.9	235.5
	2005	1,442	68.2	170.6	238.8		-12.3	-12.3	226.5
	2010	1,246	59.6	150.5	210.1		-10.7	-10.7	199.4
	Potentials	1,225	66.2	166.9	233.1		-10.5	-10.5	222.6
Stainless sheets	1990	6	0.7	11.9	12.6		-0.4	-0.4	12.2
	1995	7	0.8	13.6	14.4		-0.5	-0.5	13.9
	2000	8	0.8	13.5	14.3		-0.5	-0.5	13.8
	2005	7	0.8	12.8	13.6		-0.5	-0.5	13.1
	2010	8	0.9	14.2	15.1		-0.6	-0.6	14.5
	Potentials	10	1.1	16.8	17.9		-0.7	-0.7	17.2
H beam fringes for building	1990	1,674	125.5		125.5		-1.5	-1.5	123.9
	1995	1,802	135.3		135.3		-1.7	-1.7	133.6
	2000	1,531	116		116		-1.4	-1.4	114.6
	2005	1,614	122.9		122.9		-1.5	-1.5	121.4
	2010	1,856	148.7		148.7		-1.9	-1.9	146.8
	Potentials	1,938	167.7		167.7		-2.2	-2.2	165.5
Transformer steel sheets	1990	23	2.4	175.1	177.5				177.5
	1995	30	2.9	188.1	191				191
	2000	55	4.8	288.8	293.6				293.6
	2005	43	3.6	193.1	196.7				196.7
	2010	60	4.6	159.8	164.4				164.4
	Potentials	60	4.6	159.8	164.4				164.4
Boiler tubes	1990	0		0	0	0	0	0	0
	1995	0.26		45.3	45.3	0	0	0	45.3
	2000	1.37		239.1	239.1	0	0	0	239.1
	2005	1.54		267.9	267.9	0	0	0	267.9
	2010	0.38		66	66	0	0	0	66
	Potentials	2.05		360.7	360.7	0	-0.1	-0.1	360.6
Total	1990	3,391	322	860.6	1,182.60	0	-14.2	-14.2	1,168.40
	1995	3,753	317.5	867.9	1,185.40	0	-16.8	-16.8	1,168.60
	2000	3,757	331.9	1,222.50	1,554.40	0	-18.2	-18.2	1,536.20
	2005	3,821	354.2	1,196.40	1,550.60	0	-18.1	-18.1	1,532.50
	2010	4,000	399.6	1,014.90	1,414.50	0	-17.7	-17.7	1,396.80
	Potentials	4,630	612.2	1,970.40	2,582.60	0	-21.1	-21.1	2,561.50

(Note) On stainless steel, the figures obtained from 1992 data are taken as 1990 figures.

3-1 Generalization of energy-saving effects of high-functional steel-made products

With regard to the total energy-saving effects of high-functional steel-made products, Fig. 3-1 shows the generalized results at the three points in time of 1990, 2000 and 2010, as well as those of the potential case.

Fig. 3-1 Summary of Energy-saving Effects from 1990 to 2010



	1990	2000	2010	Potentials
Saved by product use (10,000 kl crude oil equivalent)	-376	-543	-440	-788
Saved by lower steel needs (10,000 kl crude oil equivalent)	-106	-110	-130	-199
Saved by higher functionality (10,000 kl crude oil equivalent)	+5	+6	+6	+7
Total energy-saving effects (10,000 kl crude oil equivalent)	-477	-647	-565	-980
Proportion in total energy consumption in steelmaking (%)	-7.5	-10.8	-9.8	-17
Proportion in Japan's total primary energy supply (%)	-0.9	-1.1	-0.9	-1.6

It shows the total energy-saving effects broken down by factor into incremental energy in steelmaking due to higher functionality given to steel products and reduced energy consumption during utilization of steel-made products as a result of the higher functionality of such products. Its proportion in total energy consumption in iron- and steelmaking[2] and in Japan's total primary energy supply is also shown.

[2] Because our research includes energy-saving effects of using high functional steel-made products, to compare such research results with iron- and steelmaking energy consumption cannot be consistent in terms of denominator and numerator. Yet, we did make such comparisons simply for convenience or as a means to highlight weight of energy-saving effects. The same is true to CO_2 reduction effects discussed in the next section.

The energy-saving effects of high-functional steel products grew from 4.77 million kl crude oil equivalent in 1990 to 6.47 million kl in 2000. The magnitude of energy saved in 2000 was equivalent to 10.8% of total iron- and steelmaking energy consumption, and to 1.1% of Japan's total primary energy supply.

When the present trends of use of high-functional steel products were extrapolated to 2010, our estimation results gave a future image in which the Japanese economy overall will basically move in the direction of a stable saturated situation, which will influence demand for each of the high-functional steel products we analyzed. In specific terms, energy-saving effects in 2010 were estimated at 5.65 million kl, down from 2000. However, the potential case, which assumes greater use of high-functional steel products, shows that as much as 9.80 million kl could be saved by 2010, which suggests that the energy-saving effects of high-functional steel products can increase only if conservation-oriented moves are strengthened.

A breakdown of the energy-saving effects in 2000 by factor reveals that energy conservation at the stage of utilization of high-functional steel-made products amounted to 5.43 million kl crude oil equivalent, which accounted for 84% of total energy-saving effects. Energy conservation resulting from lowered steel needs due to higher functionality amounted to 1.10 million kl, accounting for 17% of the total effects. Incremental energy in steelmaking due to higher functionality totaled just 60,000 kl, corresponding to only 1%.

These results demonstrate that producing higher-functional steel products leads to incremental energy in steelmaking processes to some extent. This, however, can be overwhelmingly offset by the energy-saving effects resulting from lower steel needs in manufacturing and use of high-functional steel-made products. Overall, from steelmaking to the stage of utilization of steel-made products, our analysis results suggest that massive gains are achieved through energy conservation.

The preceding analysis results ("Energy Assessment of Steel Product Use from LCA Perspectives," 1997) also showed that even though reduced-energy-intensive transportation of steel products and omission of secondary processing of steel-made products can have energy-saving effects, these account for as little as 1%, each, of total energy conservation. Given these results overall, the largest energy-saving effect in LCA terms can be expected from the stage of utilization of high-functional steel-made products.

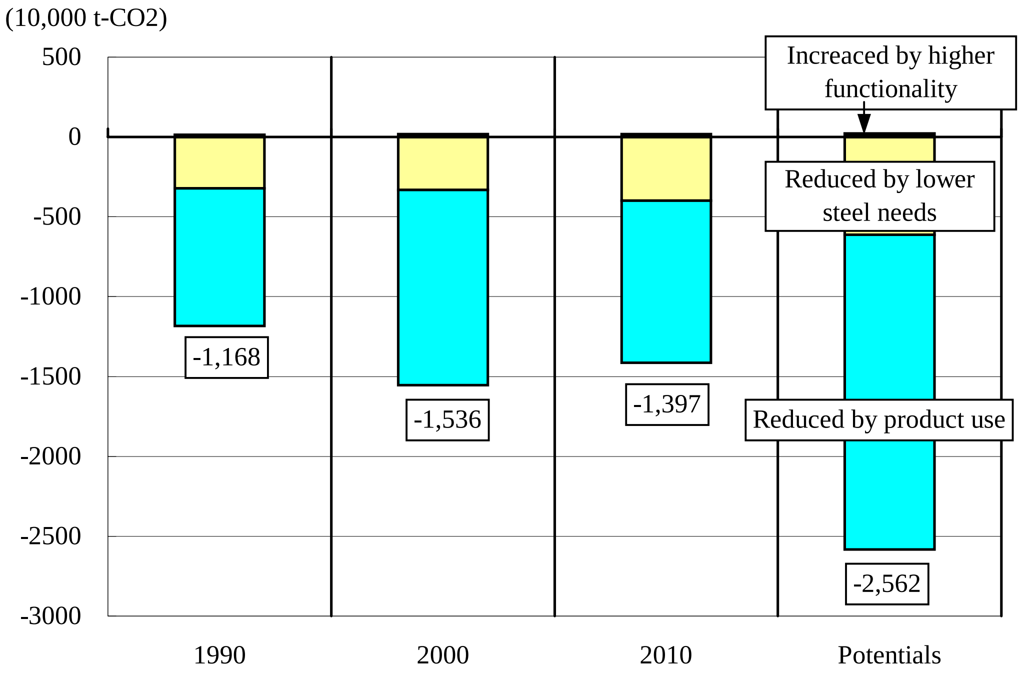
3-2 Generalization of CO_2 reduction effects of high-functional steel-made products

Fig. 3-2 gives a general idea of the total CO_2 reduction effects resulting from high-functional steel-made products at the three points of time of 1990, 2000 and 2010, as well as in the potential case.

It illustrates CO_2 reduction effects broken down by factor, namely, larger CO_2 emissions from steelmaking due to higher functionality being added, energy conservation resulting from lower steel needs for final product manufacturing, and lower CO_2 emissions in utilization of steel-made products thanks to higher functionality. It also shows the proportion occupied by high functionality-attributable CO_2 reductions in total CO_2 emissions from steelmaking and in Japan's total CO_2 emissions stemming from energy use[3].

CO_2 reduction effects of high-functional steel-made products grew from 11.68 million tons carbon dioxide equivalent (MT- CO_2) in 1990 to 15.36 MT- CO_2 in 2000. The CO_2 reduction effect in 2000 is equivalent to 8.5% of total CO_2 emissions from steelmaking and 1.3% of Japan's total CO_2 emissions attributable to energy.

Fig. 3-2 Summary of CO_2 Reduction Effects from 1990 to 2010



	1990	2000	2010	Potentials
Reduced by product use (10,000 t-CO_2)	-861	-1,223	-1,015	-1,970
Reduced by lower steel needs (10,000 t-CO_2)	-322	-332	-400	-612
Reduced by higher functionality (10,000 t-CO_2)	+14	+18	+18	+21
Total CO2 reduction effects (10,000 t-CO2)	-1,168	-1,536	-1,397	-2,562
Proportion in total CO2 emissions from steelmaking (%)	-6	-8.5	-7.9	-14.5
Proportion in Japan's total CO2 emissions resulting from energy use (%)	-1.1	-1.3	-1.3	-2.4

[3] Japan's total CO_2 emissions resulting from energy are calculated by multiplying her energy consumption stated in General Energy Statistics by CO_2 conversion factors (see "Energy & Economy Statistical Handbook, 2002 Edition"). They are employed because they can be linked to CO_2 emissions in Long-term Energy Supply and Demand Outlook.

When the present trends of use of high-functional steel products were extrapolated to 2010, our estimation results presented a future image in which the Japanese economy overall will basically move in the direction of a stable saturated situation, which will influence demand for each of the high-functional steel products we analyzed. Our results put CO_2 reduction effects in 2010 at an estimated 13.97 MT- CO_2, down from 2000. However, in the potential case, which assumes greater use of high- functional steel products, CO_2 emissions are expected to be down by 25.62 MT- CO_2 in 2010. The potential case suggests that the CO_2 reduction effects of high-functional steel products could improve strongly if stronger CO_2 reduction measures are taken.

In a breakdown of the CO_2 reduction effects in 2000 by factor, CO_2 reductions at the stage of utilization of high-functional steel-made products amounted to 12.23 MT- CO_2 , accounting for 80% of total CO_2 cuts. The CO_2 reduction effects of lower steel needs for final product manufacturing resulting from higher functionality stood at 3.32 MT- CO_2, or 22% of total reductions. Incremental CO_2 emissions from steelmaking due to higher functionality totaled a mere 180,000 T-C, which is just 1% of the total.

Similarly to the results of energy-saving effects, CO_2 emissions from steelmaking move slightly upward. This trend, however, is more than offset by CO_2 reductions at the stages of manufacturing and utilization of high- functional steel-made products, thanks to lower steel needs and higher functionality. Overall, from steelmaking to the stage of utilization of steel-made products, our analysis results demonstrate massive gains in CO_2 reductions.

3-3 Energy conservation and CO_2 reduction effects of specific high- functional steel-made products

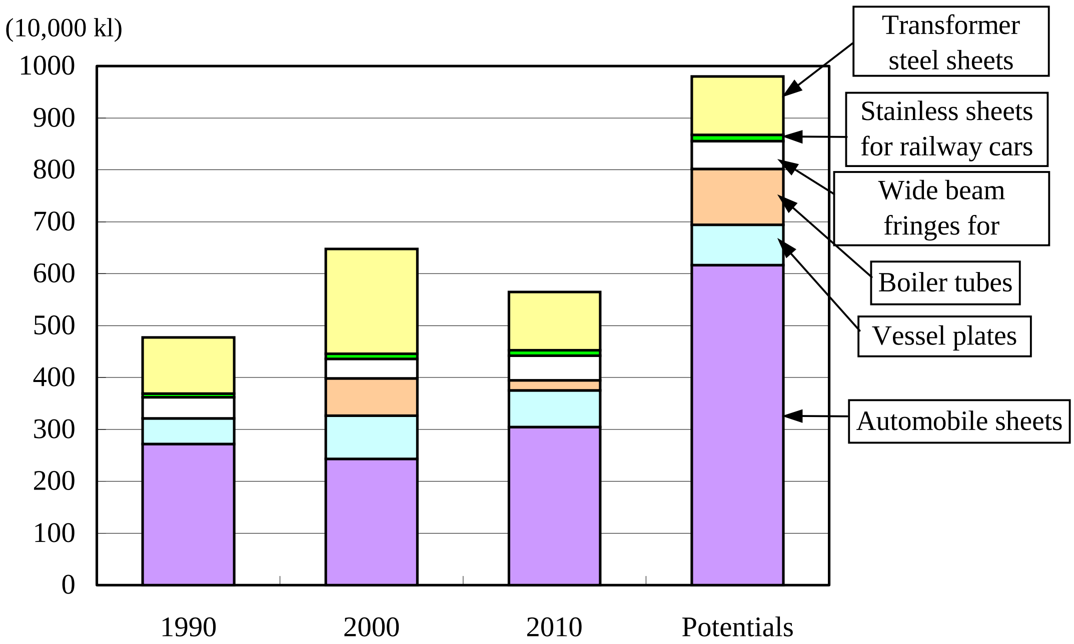
Figs. 3-3 and 3-4 summarize the energy conservation and CO_2 reduction effects, respectively, expected from each of the six types of high-functional steel-made products we analyzed.

In terms of both energy conservation and CO_2 reduction gains in 2000, the effects are seen to be becoming less in the cases of automobile sheets, transformer silicon steel sheets, vessel plates, generating boiler tubes, H beam fringes for buildings and railway car stainless steel sheets, in this order. Compared with its proportion in energy consumption, the case of transformer electromagnetic sheets holds occupies a lower share in CO_2 emissions, mainly because electricity features a relatively small CO_2 intensity on average.

Given the generally accepted view that replacement demands for shipbuilding and old-fashioned transformers will peak in 2000, the energy conservation and CO_2 reduction effects of vessel plates and electromagnetic sheets are expected to fall slightly as compared with 2000 records.

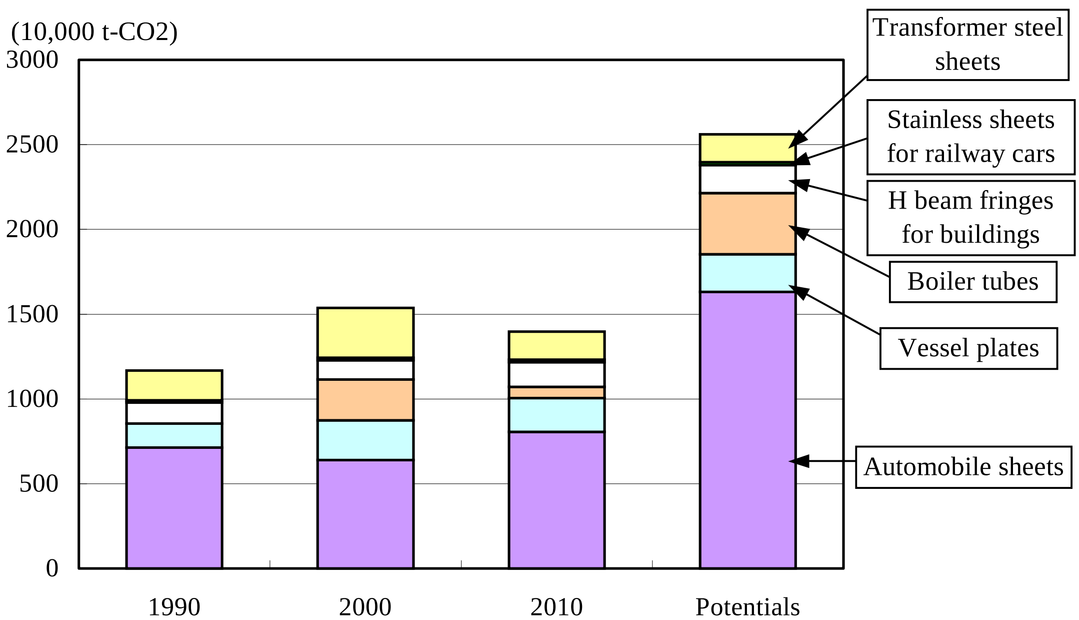
Also in the case of stainless steel sheets for electric cars, the manufacture of stainless steel-made railway cars is expected to be flat overall, which means that significantly greater effects are unlikely. Boiler tubes for power generation depend largely on coal-fired plant construction projects. In the case of boiler tubes, there are large future potentials. This is because, despite the somewhat limited amount of steel in use, high-functional steel products can save much more energy when operating at power plants. The results of the potential case shown here are based on the assumption that coal-fired power plant projects will replace the originally planned conventional steel-made boilers with installation of high-functional boilers designed to withstand higher inlet temperatures.

Fig. 3-3 Product-specific Energy-saving Effects from 1990 to 2010



(Note) The potentials are those resulting from the expanding use of high-functional steel products.

Fig. 3-4 Product-specific CO_2 Reduction Effects from 1990 to 2010



(Note) The potentials are those resulting from the expanding use of high-functional steel products.

On the basis of these characteristics of future demand for high-functional steel-made products, the relative share of automobile sheets is considered likely to increase in terms of both energy conservation and CO_2 reduction effects resulting from high-functional steel-made products from now until 2010.

The most important point for consideration here is not which high-functional steel-made products have the greatest effects of energy conservation and CO_2 reduction as compared with others. All such steel-made products can be effective in conservation and CO_2 reduction, although in different ways, even offsetting incremental energy and CO_2 emissions at the steelmaking stage.

Hence, from an all-round viewpoint (LCA perspectives) including steelmaking, transportation, processing and utilization of products, it is essential to move in the direction of rational energy conservation and CO_2 reduction measures by encouraging the greater use of high-functional steel products.

3-4 Changing energy intensity in steelmaking as a result of higher functionality given to steel products

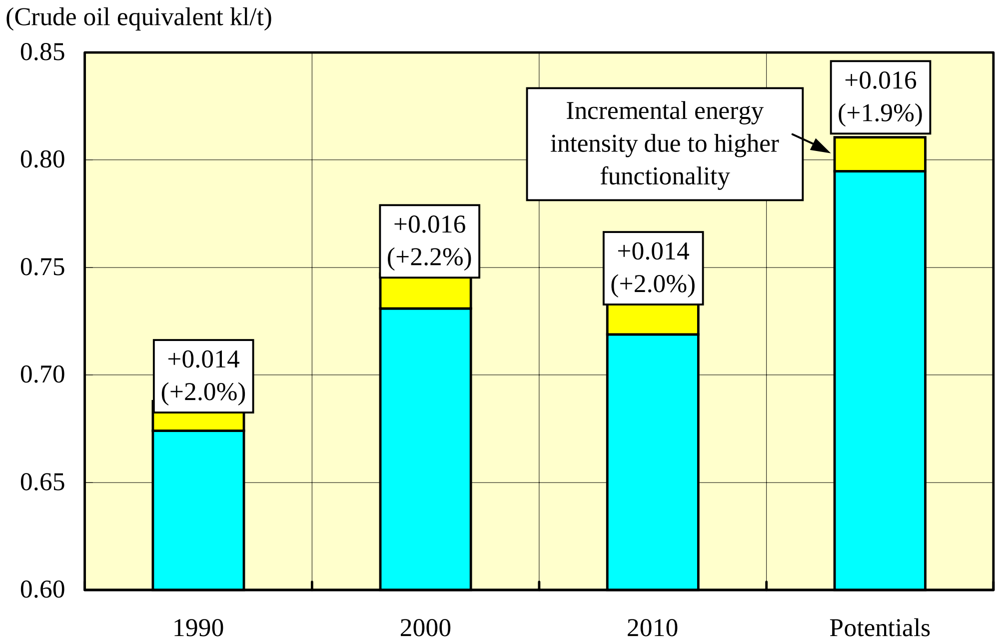
From an investigation of steelmaking energy needs for the six types of high-functional steel products, we calculated the energy intensity per ton of high-functional steel products, and compared the results with energy intensity per ton of conventional steel products to ascertain upward and downward trends. The results are summed up in Fig. 3-5.

These show that the steelmaking energy intensity of the high-functional steel products we analyzed is larger than that of their conventional counterparts by around 1.9 – 2.2% on average.

However, they also show that the energy-saving effects per ton of high functional steel-made products when in use prove to be 1.5 – 2.1 times larger than steelmaking energy intensity. This does not include the energy-saving effects of lower steel needs for manufacturing steel-made products.

Fig. 3-5 demonstrates the massive energy-saving effects that high-functional steel-made products can bring about when being utilized. As already stated, higher functionality given to steel products should not be examined only in the light of the steelmaking process. This figure demonstrates the necessity to consider energy conservation and CO_2 reduction measures from an overall viewpoint in LCA terms by taking into account the whole range of stages from steelmaking to utilization of steel-made products.

Fig. 3-5 Incremental Energy Intensity in Steelmaking due to Higher Functionality and Its Proportion in Energy-saving Effects Gained from Product Use



	1990	2000	2010	Potentials
Energy intensity in steelmaking (crude oil equivalent kl/t)	0.688	0.747	0.733	0.811
Increment attributable to higher functionality (crude oil equivalent kl/t)	0.014	0.016	0.014	0.016
Proportion of the increment in energy intensity (%)	(+2.0%)	(+2.2%)	(+2.0%)	(+1.9%)
Energy saved per ton of steel products in use (crude oil equivalent kl/t)	-1.109	-1.446	-1.101	-1.702
Increase of energy conservation against energy intensity (times)	(1.6 times)	(1.94 times)	(1.50 times)	(2.10 times)

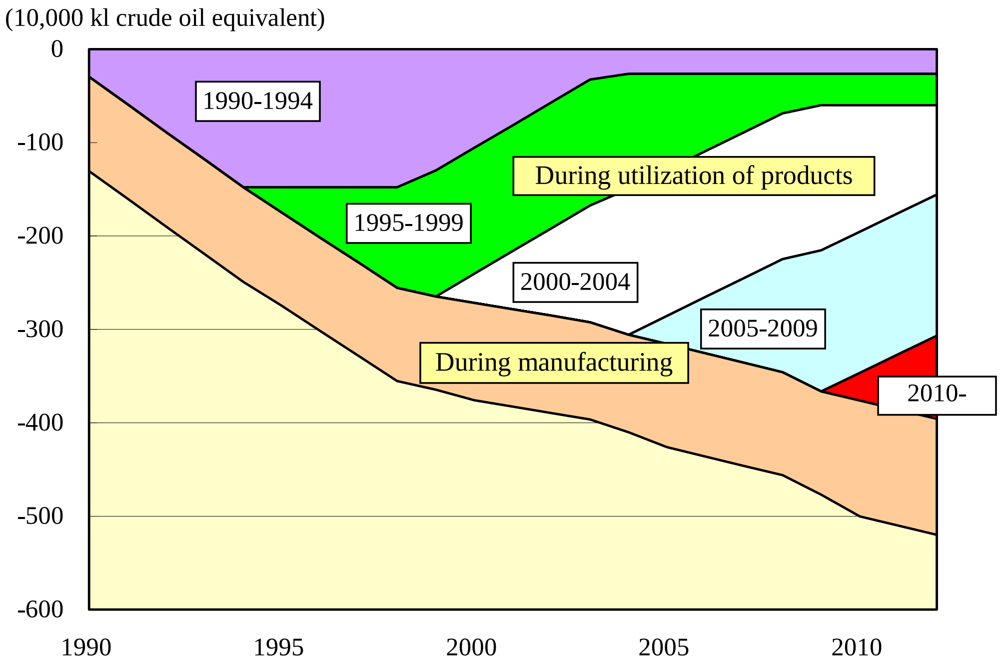
(Note) The upper figures represent incremental energy intensity, and the lower ones in % weight of the increment in energy intensity.

3-5 Energy conservation and CO_2 reduction effects from dynamic viewpoints of high-functional steel-made products

The energy conservation and CO_2 reduction effects of high-functional steel-made products discussed so far are based on general observations ascertained by aggregating all effects that can be gained gradually throughout the service life of steel products, followed by concentrating the outcomes into a single point (year) of manufacturing. In reality, however, the energy conservation and CO_2 reduction effects of high-functional steel-made products are demonstrated gradually throughout their service life, and are thus reflected in actual statistics. In this sense, there is a time-series concept requiring a comprehension of energy conservation and CO_2 reduction effects during the service life of products in a time series, followed by an evaluation of these effects as time-series changes in combination with the effects of lower steel requirements each year in the manufacture of products.

On the basis of the latest analysis results, we organized the energy conservation effects of high-functional steel-made products in terms of when such effects become apparent. The outcomes are shown in Fig. 3-6. Analysis results were available for the five points of time of 1990, 1995, 2000, 2005 and 2010. We accordingly assumed that the products manufactured and used in the 1990 – 1994 period are the same as those in 1990, and that the products used in the 1995 – 1999 are the same as in 1995, and then calculated the likely developments beyond 2010[4]. Fig. 3-6 shows the effects during the period from 1990, the base year of the Kyoto target, to 2010, the last year of the first commitment period[5].

Fig. 3-6 Time Series Changes in Energy-saving Effects of Using High Functional Steel-made Products in LCA Terms



	1990	1995	2000	2005	2010
Energy saved while products in use (10,000 kl crude oil equivalent)	-30	-175	-272	-316	-376
Energy saved during manufacturing (10,000 kl crude oil equivalent)	-101	-100	-104	-110	-124
Total energy-saving effects (10,000 kl crude oil equivalent)	-131	-275	-376	-426	-500
Proportion in total energy consumption in steelmaking (%)	-2	-4.5	-6.2	-7.2	-8.7
Proportion in Japan's total primary energy supply (%)	-0.2	-0.5	-0.6	-0.7	-0.8

[4] Here, on energy-saving effects gained when using the six types of high functional steel-made products, we allocated a-year effects among each of the years the products were in use, including the year of manufacturing. As for energy-saving effects gained at manufacturing stage, particularly as a result of lesser steel needs for product manufacturing, we attributed such effects to each of the years of manufacturing. Concerning energy-saving effects gained when steel-made products were in use, we first aggregated such effects of the six types of the products on a yearly basis, then divided the outcomes intensively into the five-year periods of 1990 – 1994, 1995 – 1999, 2000 – 2004, 2005 – 2009 and 2010 – 2014.

[5] It must be noted that the cumulative results shown here represent our assessments of nothing but the steel products produced and used from 1990 and on. Considering history of development & penetration of high-functional steel products, steel products produced before 1990 can demonstrate energy-saving effects in post-1990 days. Such effects are not covered here.

These results demonstrate that energy-saving effects of roughly the same magnitude have been gained each year at the manufacturing stage, largely in reflection of lower steel requirements for manufacturing as a result of high functionality given to steel products. In addition, they also show that energy-saving effects of using high-functional steel-made products have been cumulative, and are thus increasing year by year.

For example, an analysis started in 1990, the base year of the Kyoto target, showed that energy-saving effects in 1990 amounted to 1.31 million kl crude oil equivalent, which represented 2% of total energy consumption in steelmaking and 0.2% of Japan's total primary energy supply. Because the energy-saving effects of using energy-efficient products are gained in a cumulative manner, the total energy-saving effects kept continued to grow, reaching 3.76 million kl in 2000. These energy conservation gains in 2000 occupied 6.2% of total energy consumption in steelmaking and 0.6% of Japan's total primary energy supply.

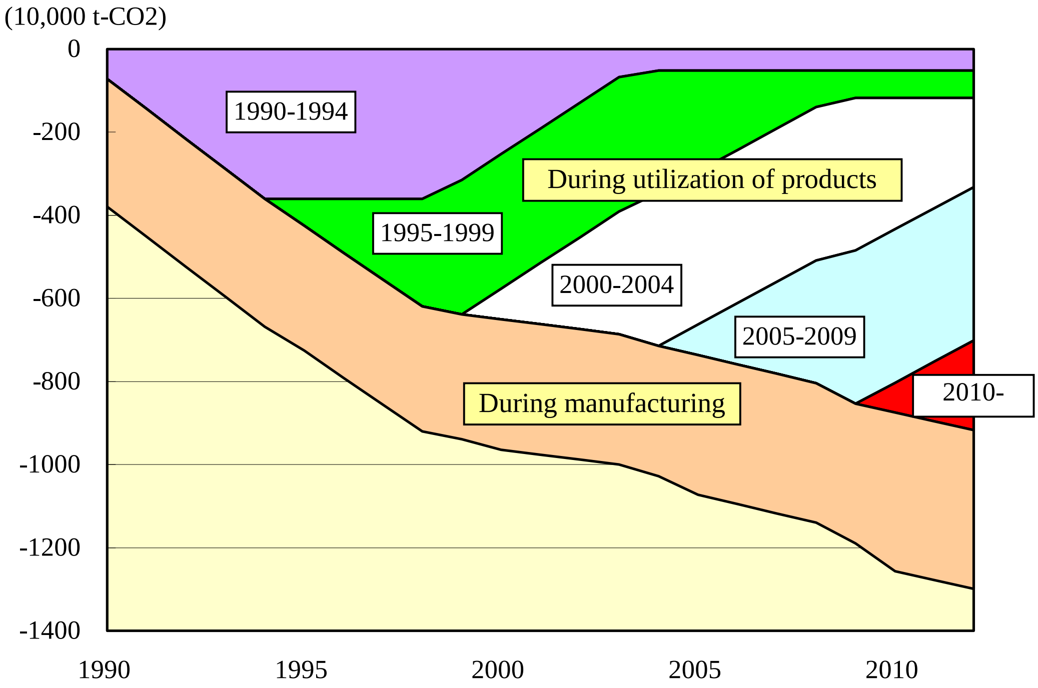
The cumulative energy-saving effects are capable of continuing their growth well beyond 2010 and may reach an estimated 5.00 million kl in 2010, which represents 8.7% of total energy use in steelmaking and 0.8% of Japan's total primary energy supply. As already mentioned, a vitally important factor is that the energy-saving effects gained at the stage of utilization of high-functional steel products are demonstrated cumulatively over a series of years.

Next, on the basis of our latest analysis results, we summed up the CO_2 reduction effects of using high-functional steel products. The results are shown in Fig. 3-7. In 1990, such CO_2 reduction effects were 3.80 MT-C, equivalent to 2.0% of total CO_2 emissions from steelmaking and 0.4% of Japan's total CO_2 emissions attributable to energy. Because the CO_2 reduction effects of using high-functional steel products are demonstrated cumulatively, they have increased year by year and reached 9.64 MT- CO_2 in 2000, equivalent to 5.3% of total CO_2 emissions from steelmaking and 0.8% of Japan's total CO_2 emissions originating from energy use.

The cumulative CO_2 reduction effects are likely to keep growing well beyond 2010 and reach an estimated 12.57 MT- CO_2 in 2010, equivalent to 7.1% of total CO_2 emissions from steelmaking and 1.2% of Japan's total CO_2 emissions attributable to energy. The CO_2 reduction effects of using high-functional steel products are best characterized by the fact that they are cumulative and thus continue to grow year by year.

Given that the use of energy-efficient steel products produces cumulative effects from 1990 through 2010, so that the total energy conservation effects and total CO_2 reduction effects alike continue to augment over the period, we have to remain aware of the importance of determining the overall effects from a dynamic viewpoint in LCA terms. As it has already been emphasized, high-functional steel products can help society preserve the global environment. The fact that their effects are cumulative only confirms the vital importance of selecting and implementing rational and timely measures to save energy and curb CO_2 emissions by taking into account the full range of processes from manufacture to the utilization of such products.

Fig. 3-7 Time Series Changes in CO_2 Reduction Effects of Using High-Functional Steel-made Products in LCA Terms



	1990	1995	2000	2005	2010
Reduced while products in use (10,000 t-CO2)	-72	-425	-650	-737	-875
Reduced during manufacturing (10,000 t-CO2)	-308	-301	-314	-336	-382
Total CO2 reduction effects (10,000 t-CO2)	-380	-726	-964	-1,073	-1,257
Proportion in total CO2 emissions from steelmaking (%)	-2	-3.9	-5.3	-6	-7.1
Proportion in Japan's total CO2 emissions resulting from energy use (%)	-0.4	-0.6	-0.8	-1	-1.2

4. Implications of the Results

Our latest analysis results reveal that higher functionality given to steel products causes steelmaking energy needs and CO_2 emissions to grow to a certain extent, but that this trend is more than offset by the energy conservation and CO_2 reduction effects gained by high-functional steel-made products, particularly while they are in use.

Aside from the six types of high-functional steel products that we have analyzed, R&D on many potential products is under way in response to users' wishes, while their greater use is also being promoted. It is also essential to analyze and examine the roles to be played by such potential products under development from an overall viewpoint, from manufacture to the stage of utilization.

The latest analysis results demonstrated the importance of selecting and implementing rational and timely conservation of CO_2 reduction measures at all stages, from manufacture to utilization, of high-functional steel products from an overall viewpoint in LCA terms, rather than considering specific measures at individual stages.

From this standpoint, all industries involved in the chain of product manufacturing and utilization are urgently required to comprehend inter-industry relations and to cooperate in mapping out integrated measures to help high-functional products achieve greater energy conservation and CO_2 reduction effects as a whole.

Higher functionality given to industrial materials, if considered totally from the manufacture of materials to the utilization of final products, plays a vital role in reducing both total energy needs and total CO_2 emissions. In this context, R&D focusing on any high-functional materials that can have such remarkable benefits should be strongly encouraged in the days ahead.

The high-functional steel products that have been developed and are becoming popular in Japan are expected to help Asian developing countries promote their energy conservation and CO_2 reduction efforts. Through technology transfers that make such high technologies from Japan widely available in the developing countries of Asia, it is recommended that Japan should offer strong support in policy terms to promote energy conservation and CO_2 reduction efforts from a global perspective.

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Table 4-1 New Technologies to Promote Use of High-Functional Steel Products (Examples)

Field	New technologies of steel products	Contents of higher functionality and expected energy conservation
Construction & civil engineering	Titanium-cladded steel	To reduce needs for steel products and repairs as result of longer service life of port & offshore structures.
	590-790N-class shapes	To reduce needs of steel products for constructing high-rise buildings.
	FR steel (refractory steel)	To permit omission of the process of spraying refractory coating materials.
	180 kg-class hi-tensile wires	Used in super-large bridges and to reduce needs for suspending wires and strut steel products.
Energy	High-temperature high-strength steel	Used as boiler components and to increase efficiency of ultra supercritical pressure power generation.
	High-strength high-toughness steel	To absorb electricity demand fluctuations by pumped electricity storage at large-scale hydro power plants.
Automobiles	Highly heat-resistant stainless sheets	To increase engine combustion efficiency by improving heat resistance of exhaust system.
	High-strength sheets	To reduce weight by increasing share of high-strength sheets by developing ultra-light steel-made bodies.
	Metamorphosis-inducing-plasticity steel sheets	To reduce weight of highly processed components (weight reduction previously not possible).
	Electromagnetic steel sheets	To be employed in motors of electric cars to make power system less energy-intensive overall.
Railway	Heat-treated rails	To extend the service life of rails with damage prevention and hardening processing.
Vessels	Arrest-resistant sheets	To reduce needs for steel products by realizing a longer service life.
	Stainless sheet honeycomb	To be employed in jetfoil and TECHNOS Super Liner to reduce their fuel needs.
Household electric appliances & information	Pre-coated sheets	To omit part of secondary processing by virtue of efficient processing.
	Lubricity sheets	To enable users to omit processing oil & degreasing equipment and cut energy needs.
Containers	Tin-steel sheets	To make cans thinner by can processing technologies such as diamond cutting.
Wastes	Corrosion-resistant materials	To improve heat recovery rate by developing corrosion-resistant materials applicable to municipal waste/RDF (refuse-derived fuel) power generation and promoting their use.

(Source) Japan Steel Federation, “Energy Assessment of Steel Product Use from LCA Perspectives”

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