Energy saving Potential of China

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In this study, we conducted a survey on the energy consumption efficiency of China by sectors in terms of physical quantities, and estimated the energy saving potential of China by comparing the results with that of Japan. The purpose of this research is not to substantiate the qualitative proposition that energy consumption might be inefficient in China, but to evaluate how inefficient if it is.

The analysis method we adopted is to compare energy intensity in terms of physical quantities. This enabled us to avert the problem of over- or under-estimation that comparisons in terms of monetary amounts are subject to.

Principal results of the analysis showed that energy saving potential in China is 25% in the energy transformation sector, 26% in the final consumption sector, and 26% in the primary energy consumption sector, respectively. In addition to the fact that some comparisons favored China, the results did not take into account energy saving factors such as structure change and institutional improvement and so on, so that it can be surmised that China has more energy saving potential than that stated above.

The total energy consumption of the sectors investigated in this research accounts for 70% of the aggregate energy consumption, so that these results can be considered reliable.

Introduction[*1]

It is widely believed that China's energy consumption is inefficient from the international point of view. Probably few will deny this argument. The important thing is, if the energy consumption of China is inefficient, how inefficient is it? If there is no quantitative verification, it is unfair for China to be said inefficient in energy consumption, and in addition, it might make it difficult to forecast the future of the world's second-largest energy-consuming country.

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In the first place, as one reason why the energy consumption efficiency of China is said to be inefficient from international standards, it is often pointed out that the energy consumption per GDP (energy intensity of GDP) is remarkably low in China.

In Table A, energy intensity of countries are shown in terms of monetary amounts. GDPs are converted into common unit (here the U.S. dollar was adopted) using foreign exchange rates. This table shows that the energy intensity of GDP in China is ten times as large as Japan (in the year 2000, and from now all data are based on the year 2000 unless a certain year is otherwise specified). The energy intensity of GDP itself is meaningful, however the conclusion that energy consumption efficiency of China is ten times as bad as Japan will be puzzling to anybody. The reason why the difference in energy consumption efficiency was undoubtedly overestimated is that the exchange rates put too much weight on traded goods.

Table. International comparison of energy intensity of GDP (China=100)

Method	China	Japan	South Korea	India	United States	UK	Germany	France
A. In terms of exchange rates	100	10	40	102	22	16	17	19
B. In terms of PPP	100	68	104	92	105	73	73	78

In order to avoid this overestimation, there is an approach that compares energy intensity of GDP in terms of PPP (Purchasing Power Parity). But in this case, the opposite problem of underestimation arises. As described in method B in Table, in addition to becoming two-thirds as good as Japan, the energy consumption efficiency of China has become better than South Korea and the U.S. What caused this underestimation in comparison in terms of PPP is that PPP rates put too much weight on goods for final consumption and intermediate production processes that consume large quantities of energy were ignored.

Therefore, it follows that by how much the energy consumption of China is inefficient cannot be indicated simply by comparison in terms of monetary amounts. And that which analysis method is trustable is hardly known because two comparisons give huge difference.

Meanwhile, comparisons of energy consumption efficiency in terms of physical quantities, in contrast to monetary amounts, are considered to be an ideal method. Because, for example, in the case of crude steel production, the energy consumption rate is measured using the same unit of weight, and even if the quality of crude steel is improved, the energy intensity does not change drastically as it does when it is measured by added value.

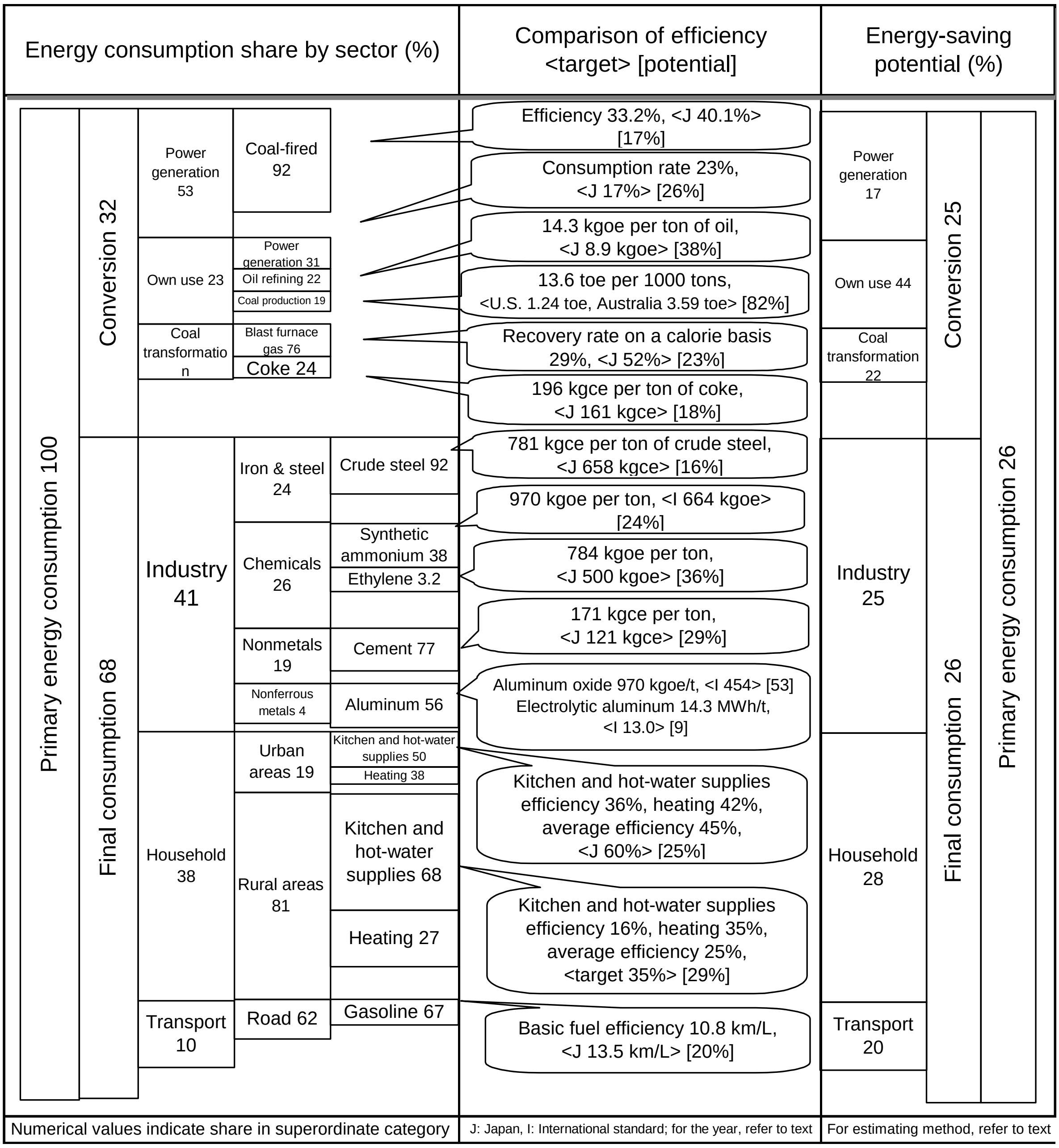
Comparisons in terms of physical quantities are often carried out only for specific sectors; however hardly any comparisons of energy intensity are conducted for the country as a whole. This is because when comparing in terms of physical quantities, the number of related sectors is so large that it is extremely difficult to collect all the necessary data.

In this paper, the energy saving potential of China was evaluated in terms of physical quantities. But the reason why this approach is adopted is not that these difficulties were all overcome. Actually the number of sectors adopted in the comparison in terms of physical quantities is only 14. Specifically these include the following 14 sectors: thermal power generation, own use (power generation, oil refining, coal production), and coal transformation (blast furnace gas, coke production) in the energy transformation sector; crude steel production, synthetic ammonium production, ethylene production, cement production, and aluminum production in the final consumption sector; the household sector (urban areas, rural areas); and fuel efficiency of gasoline-fueled vehicles. It will be obvious that these 14 sectors only cover a limited part of an uncountable number of consumption sectors. But the total energy consumption of these 14 sectors accounts for 70% of the aggregate energy consumption. Thus, as to the remaining sectors, which cover 30% of the aggregate consumption energy, the energy consumption efficiency can be estimated based on an appropriate hypothesis without the whole comparison results deviating markedly from the actual figures.

1. Measurement of Energy saving Potential

Analysis procedure hereafter is simply to break down the whole energy consumption by sector and analyze them one after another as shown in Fig. 1-1, which also shows the principal data and main results.

Fig. 1-1 Energy saving potential of China



The analyses are described below in order of energy transformation sector and then the final consumption sector following Fig. 1-1.

1-1 Energy Transformation Sector

The energy consumption of the transformation sector accounts for 32% of the primary energy consumption. The breakdown gives 53% for power generation, 23% for own use consumption, 11% for coal transformation, and 87% for the total consumption of the three accounts.

1-1-1 Power Generation Sector

[Conclusion]

Coal-fired power generation accounts for 92% of the energy consumption in the power generation sector. For the amount of electricity generated, hydroelectric power generation accounts for 16%, but the calculation was carried out in terms of the amount of fuel input. The efficiency of coal-fired power generation in China is 33.2% and for Japan it is 40.1%, so that the energy saving potential for China is 17%[*2] in this case.

[Analysis]

The reason why the efficiency of thermal power generation in China is so low is considered mainly to be that the unit capacity of power generation facilities in China is too small. Power generated by facilities with unit capacity of less than 0.3 million kW accounts for 86% of the total thermal power generation capacity of China, standing at 0.299 billion kW in 1999[*3]. In Japan on the other hand, out of a total coal-fired power generation capacity of 0.245 billion kW, only 18% is cover by small facilities with unit capacity of less than 0.3 million kW. The factor that caused small-scale coal-fired power generation to become the mainstream in China was the virtual incentive measure, “who generates, who benefits”, a policy enacted by the central government in order to resolve the severe power supply shortages from the ’80s to the early ’90s.

It has been estimated that there is room to improve the power generation efficiency by 17% for coal-fired power generation, which accounts for 92% of the energy consumption in the power generation sector; however how to estimate the power generation efficiency of the remaining part, which accounts for 8%, is still subject to further discussion. Equal energy saving potential has been assumed uniformly throughout this paper. Specifically, for example, in the power generation sector, the energy saving potential was assumed to be 17% even in power generation sectors other than coal-fired power generation. This assumption was made simply by referring to similar sectors and was not based on specific research. But coal-fired power generation accounts for 92% of the energy consumption in the power generation sector, so that this assumption is considered to be an allowable compromise. In other words, unless there is an incommensurable error in the assumption about the remaining non-coal-fired power generation sector, which accounts for 8%, its influence on the whole is considered to be small.

Limiting consumption to the power generation sector alone makes things relatively simple. In addition to coal-fired power generation, there are also hydroelectric, oil-fired, and nuclear power generation. The reason why the energy consumption efficiency of these fuel sources was not analyzed in this report is that the share of coal-fired power generation is 92% and we decided that this accounts for almost all of the energy consumption efficiency in the power generation sector. By this I mean that in order to avoid unnecessary complications in the analysis, as long as the major subsectors of energy consumption are covered, the analysis can be kept simple by making assumptions about the minor subsectors.

In order to determine the influence of those subsectors that were omitted in the survey, the

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*2 Energy-saving potential refers to the ratio of saving to energy consumption in this paper. That is to say, when the power generation efficiency improves from 33.2% to 40.1%, it means the necessary energy consumption per electricity demand decreases from 1/0.332 to 1/0.401, or 17% when converted into a ratio.

*3 Coal-fired power generation prevails overwhelmingly in China, and coal-fired power plants with capacities of less than 30 thousand kW account for 86%.

energy saving potential of all sectors was also calculated by assuming the energy saving potential of these subsectors to be 0%, that is by maintaining the status quo. The values for the energy saving potential obtained for all sectors are given in the appendix.

[Average of power generation sector]

If the energy saving potential of non-coal-fired power generation is assumed to be 17%, following the principle described above, the improvement ratio is estimated to be 17% taking into account the weighted average of coal-fired and non-coal-fired power generation[*4].

1-1-2 Own use Consumption

The breakdown of own use consumption is 31% for power generation, 22% for oil refining, and 19% for coal production; the total for the three accounts for 72%.

[Conclusion]

The own use consumption ratio in the power generation sector is 23%. This ratio is 17% in Japan. The energy saving potential for China is then 26%. In the oil refining sector, the energy consumption per tonnage of flowed-oil is 14.3 kgoe (*oe* is an abbreviation for *"oil equivalent"*. The same applies from now on), and in Japan it is 8.9 kgoe, so that the energy saving potential for China is 38%. In coal production, the energy consumption per tonnage is 13.6 toe in China, while the international level for advanced countries is 2.4 toe (here, this is average of 1.24 toe for the U.S. and 3.59 toe for Australia), and the energy saving potential for China is thus 82%.

[Analysis]

In the energy transformation sector, where a lot of boilers and electric machinery and apparatus are used, the energy consumption efficiency of these facilities becomes an important factor, which has a decisive impact on the energy efficiency in own use sector. For example, the average efficiency of industrial boilers is 60% to 65% in China, while it is said to be more than 80% in Japan. And whether waste heat and exhaust gases are reutilized is also an important factor. In Japan it is common to reutilize these forms of energy, while only certain large-scale facilities do so in China.

Furthermore, three major energy transformation sectors in China—i.e. power generation, oil refinery, and coal production—have a common weakness. That is the smallness of the average production scale as shown in Table 2. This characteristic is considered to be a factor that lowers the consumption efficiency in the energy transformation sector in China.

[Average of own use sector]

Based on the results of the three subsectors, the energy saving potential for the own use sector is estimated to be 44%.

Table.1-1 Comparison of average production scale in energy transformation sector

Note: *1: Numerical value for 1999. Capacity larger than 6 MW. *2: Numerical value for 2002.

	Average capacity of coal-fired power generation plants (MW/unit)	Processing capacity of oil refineries (ten thousand tons/plant)[*2]	Coal production capacity (ten thousand tons/mine)[*3]
China	52[*2]	238	1.6
Japan	409	684	48.6[*4]

*3: Numerical value for 1995. *4: 36.7 in the U.S.

*4 Fig. 1-1 does not include values for the case where the energy-saving potential is assumed to be 0%.

1-1-3 Coal Transformation

[Conclusion]

Coal transformation includes sectors that produce coke and blast furnace gases (utility gas, etc.). Coke production accounts for 24% and blast furnace gas production for 76% of the total energy consumption respectively. The energy intensity for coke production per tonnage in China is 196 kgce (*ce* is an abbreviation for "*coal equivalent*". The same applies from now on), while it is 161 kgce in Japan. That is, an 18% improvement is possible in China. Meanwhile, for blast furnace gases, the recovery rate on a calorie basis is 29% in China, while it is 52% in Japan, so that the energy saving potential for China is 23%.

[Analysis]

As shown in Table 1-2, the number of coke ovens that meet international standard (automatic operation and dry quenching) is only eight (all are installed at Shanghai Baoshan Steel), and their production capacity accounts for only 8%. Even excluding the technologically out-of-date (domestically) coke ovens (because data for these are not available), the average production capacity per unit is only 350 thousand tons.

[Average of coal transformation sector]

The energy saving potential in the coal transformation sector is estimated to be 18%.

[Average of transformation sector]

The energy saving potential for the whole transformation sector is estimated to be 25%.

Table 1-2 Coke ovens in China

	Technological levels			
	International average	Domestically advanced	Domestically general	Domestically lagged
Number of units	8	46	59	N.A.
Production capacity (ten thousand tons)	358	1,803	1,811	387

1-2 Final Consumption sector

The final consumption sector accounts for 68% of the total energy consumption. Major sectors are industrial 41%, household 38% and transportation 10%, and these three accounts for 89% of the final consumption sector.

1-2-1 Industrial Sector

Major energy consumption sectors in the industrial sector are iron & steel 24%, chemicals (including petrochemicals) 26%, nonmetals 19%, and nonferrous metals 4, and the total of the three accounts for 73%.

a) Iron & Steel Sector

[Conclusion]

92% of energy consumption is used for crude steel production in the iron & steel sector. The energy intensity of crude steel production is 781 kgce per tonnage[*5] in China, while it is 658 kgce in Japan, so that there is a 16% room for improvement in China.

[Analysis]

The reasons why the energy intensity of crude steel production in China is high are that the production capacity per blast furnace is small, the continuous casting rate is low, the iron-to-steel ratio is high, and so on (Table 1-3). For example, when the continuous casting rate goes up 1 percentage point, the energy saving effect is about 34 kgce per tonnage of crude steel. And furthermore, lowering the iron-tosteel ratio by expanding to include electric furnaces leads to omitting upstream processes such as coke production, sintering, and pig iron manufacturing, so that considerable energy can be saved.

Table 1-3 Comparison of crude steel production between Japan and China

	Continuous casting ratio (%)	Iron-to-steel ratio (%)	Ratio of BOF and electric furnaces (%)	Average production volume (ten thousand tons/company) Note
China	83.4	1.02	81.9	332
Japan	97.3	0.72	100	1,596

Note: Objects of the survey are major steel mills which account for 75% of total production.

b) Chemicals Sector

[Conclusion]

In the chemicals sector, the total for synthetic ammonium (38%) and the five main petrochemical products (7%: ethylene 3.2%, polyester 1.6%, acrylic 0.6%, polypropylene 0.6%, PTA (Pure Terephthalic Acid) 0.5%) account for 45% of the energy consumption. The energy intensity for ammonium is 970 kgoe per tonnage, while the international level in advanced countries is 664 kgoe, so that there is a 24% room for improvement. Ethylene accounts for half of the energy consumption for the five petrochemical products[*6]. The energy intensity of ethylene is 784 kgoe per tonnage, while it is 500 kgoe in Japan[*7], so that the energy saving potential for China is 36%.

Table 1-4 Production scales for synthetic ammonium

	Production volume (ten thousand tons)	Number of plants (units)	Average production scale (ten thousand tons/unit)
China	3,400	785	4.3
United States	1,790	50	35.8
ussia	,060	35	30.3

Note: converted in NH_3

[Analysis]

Comparison of energy consumption efficiency is difficult in the chemicals sector. Because, even if the products are the same, it is difficult to compare the efficiency, unless the main materials, chemical reaction processes, etc. can be compared. There are many factors besides materials that affect the energy consumption efficiency, in the chemicals sector just as with the others. Those factors include production scale, efficiency of equipment and facilities, and the reutilization rate of exhaust gases, etc. For example in ammonium production, 70% of the total amount is produced by small-to-medium-sized firms, so that the energy consumption efficiency is remarkably low. From an international viewpoint, the average production scale of ammonium in China is small as shown in Table.5.

With ethylene production, what is used as the raw material is extremely important. In the U.S., natural gas is abundant, and it is used as the raw material. As a result, the ethylene production rate is only 234 kgoe. On the other hand, naphtha is mainly used in Japan and China. This means that comparisons between Japan and China are possible. The reason why the energy intensity of ethylene production differs significantly between Japan and China is that the content ratio of the naphtha in China is about 50%, while it is almost 100% in Japan. When the content ratio of the naphtha is high, the ethylene yield rate is also high, and then energy intensity becomes low. China harbors a plan to raise the content ratio of naphtha from 50% at present to more than 70% by the year 2020, with a view to improving the energy consumption efficiency of ethylene production.

*6 Four types of petrochemical products other than ethylene were unable to be compared with Japan due to a shortage of data.
*7 Said to be 550 kgoe in South Korea.

c) Nonmetals Sector

[Conclusion]

In the nonmetals sector, 77% of the energy consumption is poured into cement production. The cement production rate in China is 171 kgce per tonnage of cement, while it is 121 kgce in Japan; thus there is a 29% room for improvement in China. As can be seen from Fig 1-2, which gives the transition of energy intensity for cement production in Japan and in China, the energy consumption efficiency in the year 2000 in China is the same as it was in 1974 in Japan.

[Analysis]

There are two main causes for the high energy intensity of cement production in China. One is that international mainstream production technology (dry system with preheating; that is, NSP or SP[*8] system) has diffused 100% in Japan, while the diffusion rate in China is only 12%. The other is that the average production scale in China is significantly small (Table 1-5). The cement production per kiln is 50 thousand tons in China, while it is 13 million tons in Japan, a factor of 260 times as much.

In May 1999, China decided to close its small-scale cement plants, and it is said that a total of 3,940 small-scale plants had been shut down by August 2002. Shutting down small-scale plants can contribute to improvements in the energy consumption efficiency of cement production.

Table 1-5 Comparison of cement production between Japan and China

	Diffusion rate of NSP and SP (%)	Production capacity (ten thousand tons/kiln)
China	12	5 (numerical value for 1997)
Japan	100	1,300

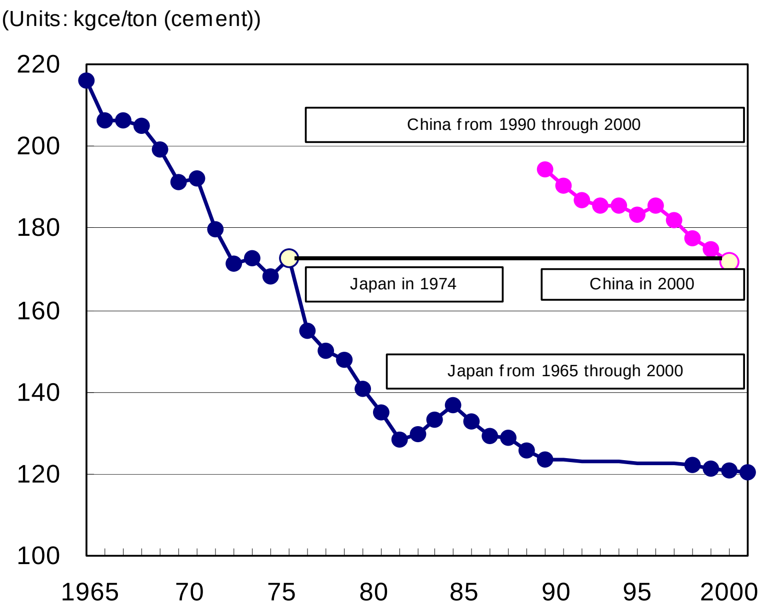


Fig. 1-2 Energy intensity for cement production in Japan and in China

*8 NSP is an abbreviation for New Suspension Preheater. And SP stands for Suspension Preheater.

d) Nonferrous Metals Category

[Conclusion]

The nonferrous metals sector accounts for 4% of industrial energy consumption. In particular, aluminum production accounts for 56% of the energy consumption in the nonferrous metals sector. Room for improvement in the energy consumption efficiency for the production of aluminum oxide from raw ore stands at 53%, and for the production of electrolytic aluminum from aluminum oxide the figure is 9%. The ratio of energy consumption between these two processes is approximately 6 to 4, and the energy saving potential is estimated to be 35%.

[Analysis]

Production of aluminum oxide is mainly carried out using the Bayer method or the Complex method. The energy consumption efficiency of the Bayer method is more than twice as good as for the Complex method; however the ore quality in China is not good, so that the Bayer method is not widely used. China lags considerably behind international levels in the Complex method. Small-scale production prevails in the aluminum sector as in the other industries. In the year 2000, the number of companies was 116 and aluminum production stood at 2.86 million tons, so that average production per company was only 25 thousand tons, which is one seventh of the international average of 183 thousand tons. What remains to be done is to improve the energy consumption efficiency by weeding out small-scale plants and boosting the average production scale, as well as scaling up electrolysis vessels.

[Average for the industrial sector]

Based on possible improvement rates in energy consumption in the iron & steel, chemicals, nonmetals sector, and nonferrous metals sectors, the energy saving potential of the whole industrial sector is estimated to be 25%.

1-2-2 Household Sector

[Conclusion]

Household sector accounts for 38% of the final energy consumption sector. About 70% (200 million toe) of that is noncommercial biomass. In urban areas, 460 million people (36% of the total population) consume 19% of the household energy. In rural areas, 810 million people (64% of the total population) consume 81% (9% when noncommercial biomass, which accounts for 72%, is excluded). The characteristics of household energy consumption in urban areas obviously differ from those in rural areas in China, so we will analyze household energy consumption in these two sectors separately.

Energy consumption for kitchen and hot-water supply use accounts for 50% in urban areas, and the spread in the use of gas has boosted the energy consumption efficiency for that usage to 36%. In rural areas, kitchen and hot-water supply use accounts for 68% of the energy consumption, which means the percentage of that usage is larger in rural areas than in urban areas. Most rural areas still depend on biomass such as firewood, so the energy consumption efficiency for kitchen and hot-water supply use is as low as 16%. The mean energy consumption efficiency for kitchen and hot-water supply use, heating, and lighting and power is 45% in urban areas and 25% in rural areas. Taking into account the fact that circumstances in rural areas differ from those in urban areas, we set the target energy consumption efficiency for rural areas at 35%. In this scenario, the energy saving potential of rural areas is 29%. Meanwhile, when the target energy consumption efficiency of urban areas is set at 60%[*9], the same efficiency as in Japan, the energy saving potential is 25%.

[Analysis]

Energy consuming equipment for domestic use includes various electric appliances, lighting equipment, and firewood, coal, and gas-fired appliances. Improving the energy consumption efficiency of these equipment and appliances counts most in the household sector. In particular, the energy consumption efficiency of firewood-fired kilns used in kitchens in rural

*9 Here we adopt the estimation conducted by the Energy Research Institute, China.

areas is only 10% or so. That of coal-fired kilns used for the same purpose is 25%. And for gas-fired kilns, it can reach as high as 60%. There is a great demand for energy for kitchen and hot-water supply use in both urban and rural areas of China, so that improving the efficiency of the appliances or moving from low-efficiency appliances to high-efficiency ones is considered to contribute significantly to improving the overall energy consumption efficiency.

Meanwhile, heating accounts for 38% of energy demands in urban areas, and 27% in rural areas, so that it carries a lot of weight in both cases. As heating systems in rural areas are of the decentralized type and are operated by burning coal, the heating efficiency is only 35%. As the spread of central heating and air-conditioners is anticipated also in rural areas, an improvement in the energy consumption efficiency of heating can be expected. Boosting the insulation performance of housing is also a key factor.

[Average for the household sector]

By calculating weighted averages for urban and rural areas, the energy saving potential of the household sector is estimated to be 28%.

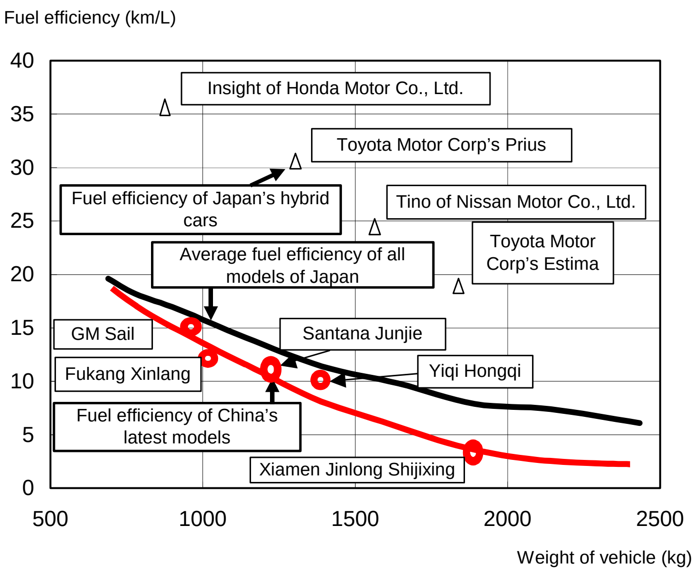
1-2-3 Transport Sector

[Conclusion]

Energy consumption in the transport sector accounts for 10% of final consumption. 62% of that is attributed to road. And 67% of the energy used for road is consumed by gasoline-fueled vehicles. The stock-based fuel efficiency of gasoline-fueled vehicles is 10.8 km/L[*10] in China, while it is 13.5 km/L in Japan. Thus the energy saving potential in China is 20%.

[Analysis]

Improving the energy consumption efficiency in the transport sector, especially in road, holds great significance. Energy consumption in the transport sector accounts for 10% of the final consumption in the year 2000. The number of automobiles increased by an annual average rate of 27% during the period from 1990 through 2000. This tendency seems to be accelerated further in the years 2001 and 2002. The number of vehicles, which is now 16 million, is estimated to reach around 100 million in the year 2020, making the share of energy consumption of the transport sector 14%. Actually, most existing cars are old models and their fuel efficiency is poor in the current situation.



Sources: edited from "Automobile Fuel Efficiency List" and "Almanac of China's Automobile Industry"

Fig. 1-3 Comparison of fuel efficiency between Japan and China

*10 Note that the estimation made here was based on the average fuel efficiency of the latest models in China, 11.2 km/L. This suggests that the average fuel efficiency for all models in China is worse than 11.2 km/L. The stock-based fuel efficiency was estimated referring to the fact that the ratio of the fuel efficiency for new models to stock average was 1: 1.04 in Japan in the '80s. China is favored in this comparison.

As shown in Fig 1-3, the average fuel efficiency of the latest models in China (in the year 2000) is worse than the average figure for all models in Japan. Room for improvement in the fuel efficiency of Chinese cars could practically be higher than 20%. Recently, in the automobile market in Japan, fuel-efficient hybrid cars such Toyota Motor Corp's Prius are selling well. The spread of such fuel-efficient cars should be studied strategically in China where motorization is progressing rapidly.

[Average for the transport sector]

The energy saving potential of the whole transport sector is estimated to be 20%.

[Average final energy consumption]

Based on the energy saving potential of the industrial, household, and transport sectors, the energy saving potential for the final energy consumption sector is estimated to be 26%.

[Average primary energy consumption]

Based on the energy saving potential of the transformation and final consumption sectors, the energy saving potential for primary energy consumption is estimated to be 26%[*11].

2. Review of Energy Saving Potential

Energy saving potential was measured as described above in terms of physical quantities. Of course, the larger the number of sectors becomes, the more accurate the measurement will be. But it is unlikely that the energy consumption efficiencies of those sectors that account for the remaining 30% of the total energy consumption, which nevertheless were not chosen as objects of the analysis, will tend to deviate significantly from those for the sectors adopted in this research. This is because the equipment, appliances, and materials that affect the various energy consumption efficiencies, such as motors, boilers, and the thermal insulation materials used in buildings, have the same energy consumption efficiencies even when these are used in different sectors. Some results of the survey show that in certain areas such as some textile production in the petrochemicals sector, the energy consumption efficiency is better in China than in Japan. But the number of such sectors and their share in the energy consumption are limited; therefore their influence on the accuracy of the overall estimate of the energy consumption efficiency is considered to be small.

The estimated potential is better to be understood as a conservative figure. There are three reasons.

First, some comparisons obviously favored China, such as that of iron & steel sector and transport sector.

Second, the estimates of energy saving potential carried out in this research do not take structural changes into account. For example, the industrial structure in the industrial sector, the urbanization ratio in the household sector, and the structures of transport facilities and automobile types in the transport sector would not change. But if the industrial structure shifts from heavy industries to IT-related or service industries, the energy saving potential can be greater than estimated, and the energy efficiency can be improved further through such structural changes.

Third, possible improvements in the energy consumption efficiency resulting from establishing more efficient energy systems (or a more efficient energy policy) are not taken into consideration. Needless to say, an excellent energy policy or energy system will contribute significantly toward improving the energy consumption efficiency. For example, if there were energy systems that circumvented the protectionism of local governments, there would not be such irrational and inefficient situations such as the one in Guandong Province, in which instead of utilizing the inexpensive hydroelectric power generated in Yunnan Province that costs only 0.2 yuan/kWh, they use provincially-produced electric power which costs 0.7 yuan/kWh. And if a policy that can crack down effectively on the rampant theft of electricity is established, the problem of electric transmission losses, which is as high as 8% (30% in rural areas), can be solved.

*11 Strictly speaking, energy conversion losses saved through the energy saving process in the final consumption category should also be included in the energy-saving potential. They were not taken into account in this research.

In fact, the question is when and by what means these improvements in energy consumption efficiency can be realized. More detailed analyses will probably be necessary to answer this question. One thing for sure is that the estimated energy saving potential is difficult to be achieved during a short period such as five or ten years. The fact that there are so many companies in the cement and iron & steel industries alone is enough to demonstrate that improvements in energy efficiency cannot be achieved overnight. Furthermore, enormous investments will be necessary to realize this goal. Assuming that all power generation facilities with power generation capacities of less than 0.3 million kW, which account for 86% of the total power generation capacity, are replaced by new ones, the total investment amount will be 1.3 trillion yuan, or 14% of the GDP for the year 2000 even if they are replaced by thermal power plants with no desulfurizers because the unit construction cost of the plants amounts to 5,000 yuan/kW; that is to say, a massive investment equivalent to seven times the total amount of investment to construct the Three-Gorge dam.

Conclusion

In this paper, we estimated the energy saving potential of China in terms of physical quantities. In spite of many constraints, this type of measurement is acknowledged to bring about results of higher reliability than comparisons in terms of monetary amounts.

Based on the measurements, we concluded that the energy saving potential of China is 26%. When converted to energy consumption, this equals 300 million tons of oil (in the year 2000). Possible changes in the industrial structure and the establishment of excellent energy systems, which were not taken into account in this research, could further add to China's energy saving potential, as well as to economic development and environmental protection.

<Appendix>

Appendix Table: Energy saving potential of China

(Units: %)

Primary energy consumption 17-26					
Energy transformation 18-25			Final energy consumption 16-26		
Power generation	Own use	Coal transformation	Industry	Household	Transport
16-17	32-44	22-22	10-25	28-28	8-20

Note: Lower limits indicate the case where the energy saving potential of the omitted sectors is assumed to be 0% (status quo).
And upper limits represent the case where the potential of the omitted sectors is assumed to be the same as corresponding sectors.

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