# Energy Intensity of GDP as an Index of Energy Conservation

## Problems in international comparison of energy intensity of GDP and estimate using sector-based approach

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Introduction

Internationally, we are more interested in energy conservation. Behind this background are soaring energy prices and global warming. Japan is said to be the most advanced country with regard to energy conservation, and its energy-reduction technology is highly evaluated. The most eminent example of this is the energy intensity of GDP (gross domestic product) or energy consumption per GDP. Energy intensity of GDP is easy to calculate and is often used as an energy-conservation index for a country. Comparing energy intensity internationally, you will know while that of the U.S. is 1.7 times as large as that of Japan, that of China and India, where energy demand is increasing, is 6.2 times and 4.5 times larger, respectively, highlighting their large potential for energy conservation. However, if you calculate it by GDP converted to purchasing power parity, China's energy intensity is reduced to 1.3 times as large as that of Japan, and that of India is 0.7 times as large as that of Japan, showing that India is a better energy-saving country than Japan.

Even though the results of an evaluation based on energy intensity of GDP vary, largely depending on the currency conversion rate used, there is no international consensus for a calculation method. However, it is inconvenient to leave such gaps unchanged for future energy-conservation analysis and policies, and they had better be resolved. This paper first sorts the concept of energy intensity of GDP and then points out problems with the estimate. It also suggests an estimate using a sector-based approach taking these problems into consideration and performs a new calculation of energy intensity.

1. What is energy intensity of GDP?

Energy conservation means decreasing the quantity of energy used without changing the amount of work gained (production, temperature, brightness, distance and so on). In other words, it means increasing the amount of work without changing the quantity of energy used. As a measurement of energy conservation, "energy intensity," which is the amount of energy consumption per work unit, is often used. Although the term "energy conservation" often is used in relation to technological energy efficiency, there also is energy conservation based on consumer energy-saving behavior, or changes in industrial structure and in lifestyle, and there are needs for measuring entire energy conservation of a country,

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including all such technological, structural, and behavioral factors. This is what "energy intensity of GDP" is for.

Now, why is GDP used here? It's not preferred to treat GDP, which shows the amount of money and energy as a physical quantity in the same measure. However, it is difficult to show the "amount of work" of the whole country as a physical quantity. GDP is a popular index reflecting a country's economy and is easy to obtain because many countries estimate it. This is probably the reason GDP is often used. Then, how should we interpret the "amount of work" gained by using energy quantity? One way is to regard it as the amount of production. GDP is a country's total value of production, and in economics, the amount of labor or capital is often used as the necessary input factor for production. GDP per labor unit (working person or working hour) is called labor productivity. Similarly, energy is considered an input factor for production, and this is the concept of energy productivity (and its reciprocal number is energy intensity).[1] That is to say, the idea of energy efficiency and energy intensity of GDP show how efficiently you can increase production from the viewpoint of energy.

Another interpretation is the concept of utility. Through machinery, such as TVs and air conditioners, we gain utility (or comfort and convenience), such as information or warmth/coolness. In other words, we can say we consume energy in order to enhance utility. Therefore, the total amount of utility gained from machinery in a country would represent the country's living standard. Because it is difficult to quantify the living standard, the level of income is often used as a substitute. When comparing wealth among countries, average income per capita often serves as the index. GDP is a country's total value of production as well as its total value of income.[2] Given this perspective, energy intensity of GDP can be something that illustrates how efficiently the living standard can be enhanced from the viewpoint of energy.

As seen above, energy intensity of GDP can be said to contain the two concepts of energy efficiency on the production system and energy efficiency on lifestyle. However, their directional characters are not necessarily the same. Manufacturing productivity in economically developing countries is generally inefficient while their living standard is lower and energy consumption is smaller. In other words, they have energy-intensive production systems and a non-energy-intensive lifestyle (different from energy conservation) at the same time. Meanwhile, economically mature countries have high

[1] However, because energy is an intermediate input factor, some people point out that it cannot be dealt with as an input factor in parallel with labor or capital. GDP is the amount of added value and energy cannot be considered as an input factor when added value is allocated to the input factors.
[2] GDP's Principle of Equivalent of Three Aspects. Production (supply), distribution (income) and expenditure (demand) are equal.

manufacturing productivity but the convenient lifestyle results from the possession of many electrical appliances and automobiles. In other words, they simultaneously have non-energy-intensive production systems and a energy-intensive lifestyle based on large-scale energy consumption. In short, there is a tendency for energy efficiency of the production system to increase and that of the lifestyle to decrease as the economy develops.

When comparing energy intensity of GDP internationally, you need to pay attention to the level of economic development as stated above. Even if a country is small in energy intensity, it does not necessarily mean that the country is advanced in energy conservation; it can mean that they only have a non-energy-intensive lifestyle because of the low level of living. In addition, you need to take natural conditions and geographical conditions into consideration as well. For example, people need heating in cold areas in order to maintain life even if the standard of living is low. Also, efficiency tends to decrease in countries with a wide land area because of the diffused population. Because energy intensity of GDP is estimated by abstracting such various conditions, you need to be careful when handling the data.

2. Problems in the estimate of energy intensity of GDP

When estimating energy intensity of GDP in order to conduct country-by-country comparison, you need to be careful about GDP conversion, which is a denominator of energy intensity. The Organization for Economic Co-operation and Development (OECD) points out that there are four necessary conditions when numerically comparing GDP among countries: (1) the definition of GDP must be the same, (2) measuring methodologies must be the same, (3) the currency units used must be the same, and (4) the evaluated levels of prices must be the same. Basically, there are no problems regarding the 1st and 2nd conditions because GDP is calculated in accordance with the System of National Accounts (SNA)[3] proposed by the U.N., except data from developing countries and other countries where statistics are not well developed.[4] The 3rd condition shows that, because GDP generally is calculated in each country's currency, currency units have to be converted to one unit. U.S. dollars are often used. The 4th condition indicates that the currency conversion rate has to be set so that each currency is equivalent in terms of quality and quantity of goods/services it can buy (e.g. when one U.S. dollar is valued at 100 yen, the quality and quantity of goods/services it can buy with one U.S. dollar has to be the same as what 100 yen can buy).

In short, the 3rd and 4th conditions require the use of a proper currency exchange rate. In

[3] Currently, 93SNA which U.N. member states were advised to introduce in 1993 is the standard.
[4] There seems to be confusion in accordance with transition from Material Product System (MPS) to SNA in ex-socialist countries.

the real world, the market exchange rate(MER) is used when exchanging a country's currency for another currency. It is also often used when converting GDP to U.S. dollars. Another rate to translate the currency of a country into a common unit is purchasing power parities (PPP), which is a currency exchange rate taking each country's level of prices into consideration[5] and estimated by OECD and the World Bank.

Figure 1 shows primary energy intensity of GDP calculated using MERs (Japan = 1). Japan's energy intensity is one of the best in the world,[6] that of European advanced countries is 1.0 to 1.8 times as large as that of Japan, and that of developing countries is 2 to 40 times as large as that of Japan, showing large differences among countries. Figure 2 shows energy intensity calculated using GDP converted to PPP. Some countries' energy intensity based on this method is smaller than that of Japan, which is not necessarily the smallest level in the world. Except for some countries, each country's energy intensity is 0.5 to 4 times as large as that of Japan, and the differences are smaller than those based on MERs. In addition, while OECD countries are concentrated in the upper level on the MER basis, it's not necessarily so on a PPP basis. Developing countries, such as Brazil and India, are in the upper level when using this method. China's energy intensity, especially, is a focus of attention, and the difference with that of Japan decreased from 6.2 times larger on a MER basis to 1.3 times larger on a PPP basis.

As seen above, estimates largely differ between those based on MERs and PPP. In particular, the differences in energy intensity between the two are remarkable in OECD countries. This is attributed to the 4th condition (the levels of prices evaluated have to be the same) on an international GDP comparison. MERs in economic theory are fixed to where the levels of prices between two (or more) countries become the same in accordance with international "law of one price." However, the law of one price is possibly true only with traded goods under international competition. That is to say, MERs cannot reflect the prices of services that are not tradable, so it cannot be said to be meeting the 4th condition.[7] Meanwhile, PPP theoretically meets the 4th condition (or PPP was developed to meet the condition), and is more ideal for internationally comparing GDP. The viewpoint of purchasing power (i.e. quantity of goods/services that can be purchased with a certain amount of income) is especially important when using GDP as an index for the standard of living.

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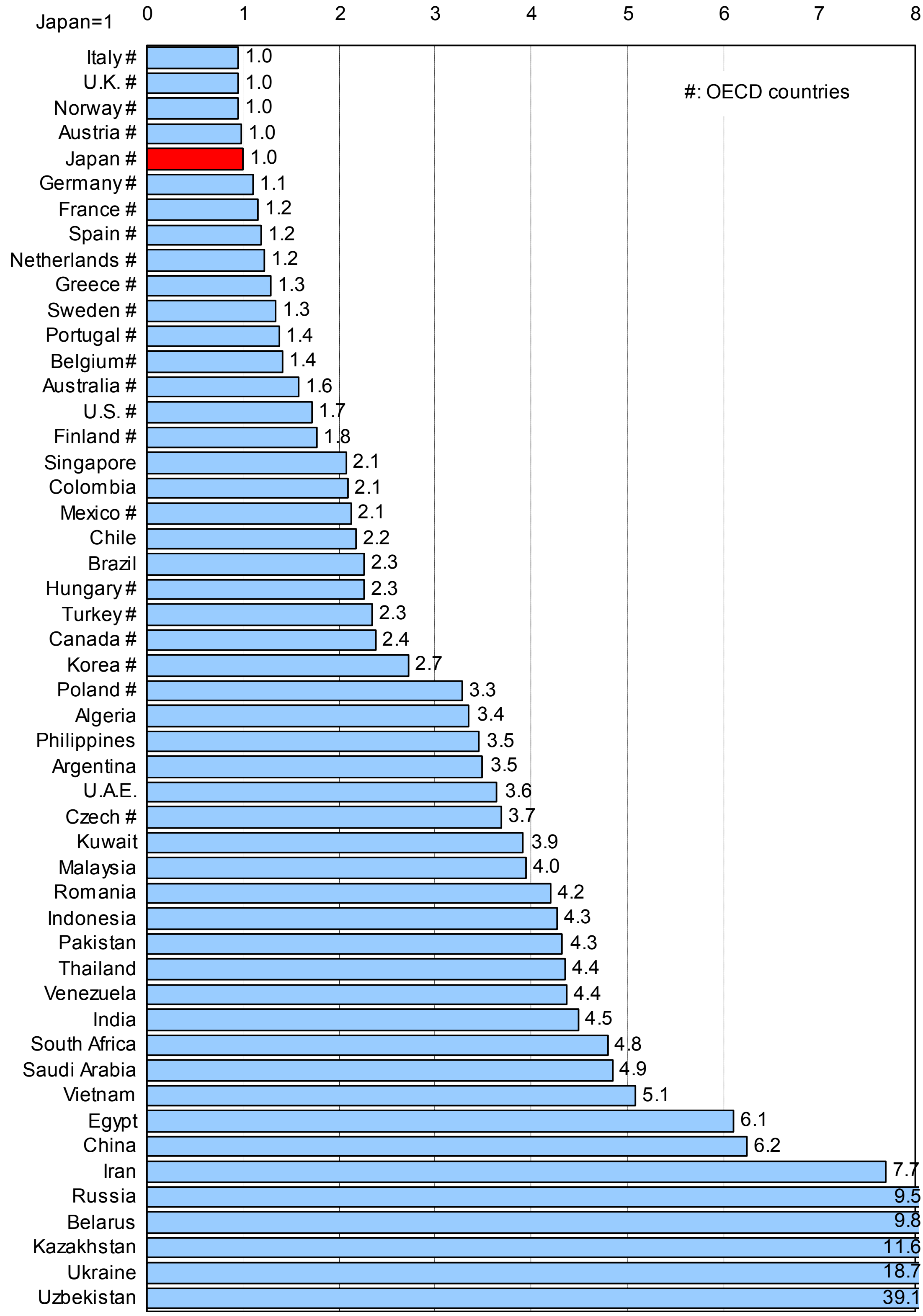
5 For example, when the price of a hamburger is 100 yen in Japan and 1 dollar in the U.S., the conversion rate is 1 dollar = 100 yen. PPP applies this idea to all goods and services.

6 Many examples show that Japan's is the smallest by evaluation based on its real GDP in 2000 price. The value of Euro in 2004 was about 25% higher than that in 2000, so European countries' energy intensity of GDP unit is favorably evaluated.

7 In addition, because MERs directly are set based on supply and demand of target currencies, there also are major influences from such factors as exchange speculation, interest, and capital movements in addition to the level of prices.

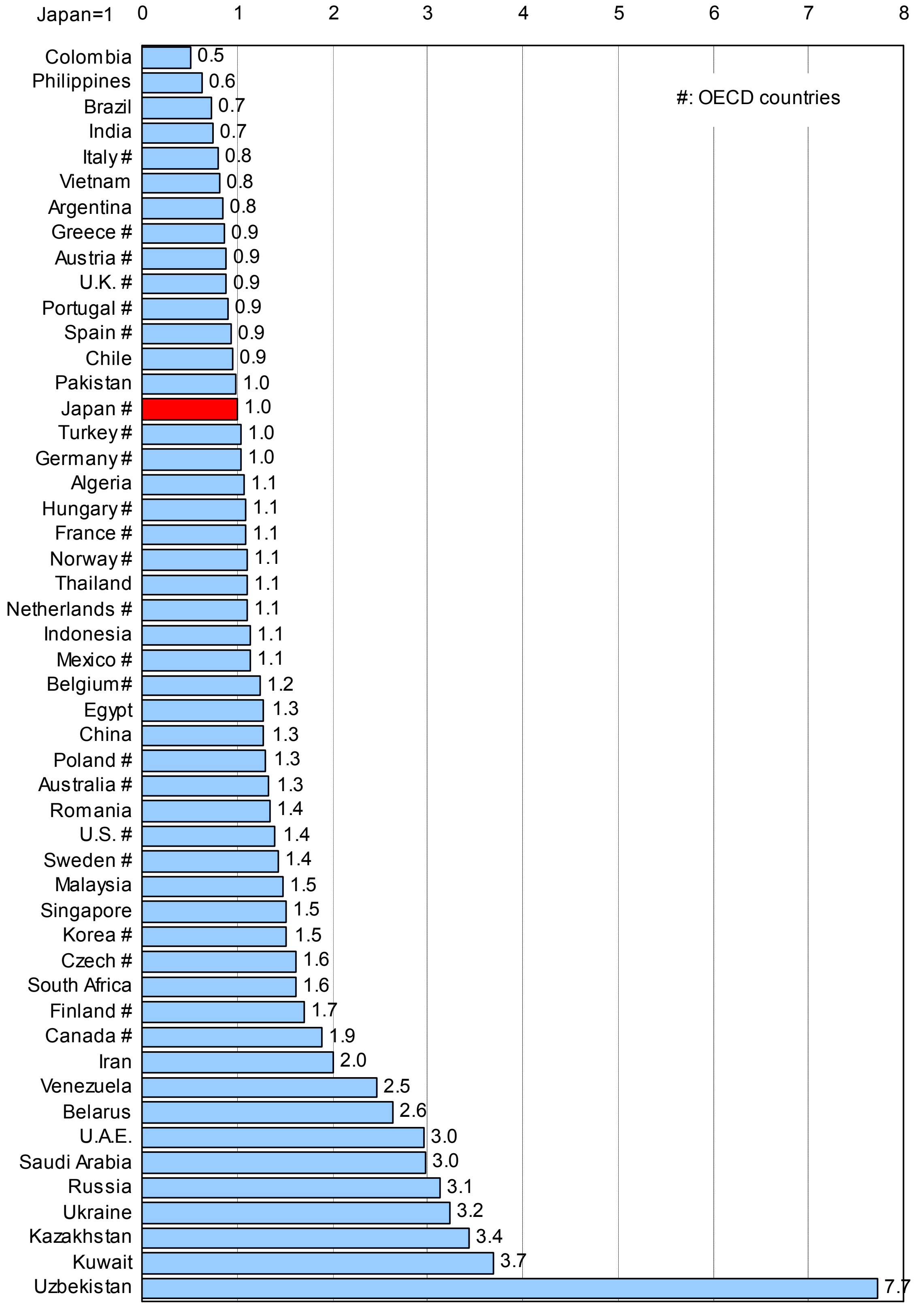
Figure 1. Primary energy intensity of GDP evaluated with market exchange rates (2004)




Resource: Author's estimate based on IEA's "Energy Balances of OECD/Non-OECD Countries" and World Bank's "World Development Indicators"

Note: Fifty countries with more primary energy consumption were chosen. However, countries without sufficient statistical data, including GDP, were excluded.

Figure 2. Primary energy intensity of GDP evaluated with purchasing power parity (2004)




Resource: Same as those of Figure 1

Generally, the MER tends to be higher than PPP in economically advanced countries.[8] In other words, conversion based on a MER tends to overestimate advanced countries' GDP (underestimate in the case of developing countries). Therefore, it is highly likely that advanced countries' energy intensity of GDP based on the MER is evaluated as smaller than it really is (higher in the case of developing countries). Although OECD countries' energy intensity is concentrated in the upper level, we must consider such tendencies included.

Meanwhile, even theoretically adequate PPP also has problems in the actual estimate. Although prices of all goods and services must be compared among countries for the PPP estimate, this is practically impossible. That being said, OECD samples and estimates the prices of about 3,000 items (about 1,000 items in the case of World Bank), so the methodology can be quite comprehensive. However, the price of an item could largely differ depending on the quality. Quality has to be the same in order to compare prices, but it is quite difficult to accurately evaluate quality of goods and services.[9] Generally, the goods and services of developing counties are lower in quality than those of advanced countries, so their prices can be underestimated. That is, it is highly likely that the GDP of developing countries based on PPP is overestimated (underestimated in the case of advanced countries) and also energy intensity of GDP based on the PPP exchange rate is evaluated as smaller than it really is (as larger in the case of advanced countries).

In addition, PPP is an index focusing on consumer purchasing power and therefore is

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[8] The Balassa-Samuelson theory, which studied this from the differences in productivity among sectors, is famous. Supposing that the levels of prices of industry M (tradable goods, e.g. manufacturing industry) and industry N (non-tradable goods, e.g. service industry) are, respectively, $p_m$ and $p_n$, and that the wages (w) of M and N are on the same level because of competition in the labor market, the labor productivity of the industry N, which is labor-intensive, generally is lower than that of the industry M, which is capital-intensive, and therefore the level of prices to the wage, $n$ ($=p_n/w$), is larger for the industry N ($n/m>1$). In addition, if the increase of the industry *M*'s labor productivity is faster than that of the industry N, $n/m$ will gradually become larger.
As for country A, an economically advanced country, and country B, an economically developing country, it is considered we have an inequality of $(n^A/m^A) > (n^B/m^B)$. Suppose that the level of prices is $p=p_n^{\alpha} p_m^{1-\alpha}$ based on the Cobb-Douglas function, country A's general prices are $p^A= (n^A/m^A)^{\alpha} p^A_m$. Similarly, $p^B= (n^B/m^B)^{\beta} p^B_m$. Because the ratio of the industry N is larger in advanced countries than developing countries, it is considered that $\alpha > \beta$. As the purchasing power parity (f) of country A to country B is $p^A/p^B$, we have an equality of $f = [(n^A/m^A)^{\alpha} / (n^B/m^B)^{\beta}] \cdot [p^A_m/p^B_m]$. Here, if we suppose that the law of one price internationally is applied to industry M, as far as ($p^A_m=ep^B_m$ (e is the market exchange rate)), $\alpha > \beta$ and also $(n^A/m^A) > (n^B/m^B)$, we have an inequality of $f>e$. That is, it is understood that MER is higher in an economically advanced country (A) than its PPP exchange rate (the lower the figure, the higher the country's currency in value is).
[9] Taking an example of taxi fares, while those within Japan are basically about the same, in China the highest price is about twice as expensive as the lowest. If you use "distance" as a criterion, you need to compare the two countries' average prices per a certain distance. However, because China's highest-class taxis are equivalent to Japan's standard taxis in automobile rank, it also can be said that comparing these two is fairer. In this manner, price level varies in accordance with how you interpret what quality means. Furthermore, because it is complex and difficult even to define the meaning of quality as for many goods and services, some arbitrariness cannot be avoided in actual estimate procedures.

estimated using retail prices. This indicates that even products with higher productivity and competitive price power are evaluated after adding margins at the time of domestic distribution and other factors. Because advanced countries generally show higher productivity in the industrial sector than in the non-industrial sector (refer to the footnote 8), PPP-based exchange rates underestimate the superiority energy efficiency in the industrial sector.

3. Estimate of energy intensity of GDP by sector-based approach

As we have seen so far, there are problems in estimating energy intensity of GDP using either the MER or the PPP exchange rate. Generally, the prices of a country are not taken into consideration for MERs and therefore GDP of developing countries where prices are low tends to be underestimated (energy intensity is thereby overestimated), and the prices are taken into consideration for PPP, and therefore the GDP of developing countries is conversely overestimated (energy intensity is thereby underestimated). The appropriate figure is probably somewhere between them.

I pointed out that energy intensity of GDP contains the two concepts of energy efficiency on the production system and that of the lifestyle. Generally, advanced countries are characterized by a non-energy-intensive production system and a energy-intensive lifestyle, and developing countries are characterized by a energy-intensive production system and a non-energy-intensive lifestyle. Energy intensity of the production sector is larger in developing countries than in advanced countries and that of the living sector is larger in advanced countries than in developing countries.

Therefore, the differences between the sectors must be considered rather than evaluating the economy of a country as one sector. If you take a procedure where you estimate each sector's energy intensity and regard their weighted average as a country's energy intensity of GDP (i.e. sector-based approach), traditional bias in estimated figures, including extreme overestimation and underestimation would be eased. If you take the two sectors of the production sector (sector m) and living sector (sector n) into consideration, energy intensity of GDP of a country is shown by the formula below.

$$\text{Energy intensity of GDP by sector-based approach} = w_m \cdot E_m/Y^f_m + w_n \cdot E_n/Y^f_n$$

$Y^f$ here means GDP based on PPP. $W_m$ and $w_n$ are the weight to calculate the average figure, but we use here composition ratio of each sector's energy consumption ($E_m$ and $E_n$). Unfortunately, however, there are no international statistics regarding sector-based GDP using PPP ($Y^f_m$ and $Y^f_n$).[10] Then, given that $r_m$ and $r_n$ are the ratio of domestic and foreign prices of the industrial sector and living sector, GDP of each sector will be as follows.

$$Y^f_m = r_m \cdot Y^e_m$$
$$Y^f_n = r_n \cdot Y^e_n$$

$Y^e$ shows GDP based on a MER. International statistics of sector-based GDP based on MERs are available. $Y_m$ here is mainly tradable goods, and therefore the law of one price could be true to some extent, so the ratio of domestic and foreign prices $r_m$ can be set at "1."[11] In addition, that of the living sector ($r_n$) can be solved as follows.

$$Y^f = r_m \cdot Y^e_m + r_n \cdot Y^e_n$$
$$r_n = (Y^f - Y^e_m) / Y^e_n$$

Using $Y^f_m$ and $Y^f_n$ estimated by the above-mentioned procedure, I measured energy intensity of GDP of the industrial sector and living sector as well as entire energy intensity of a country, which is the average of the two. Incidentally, assuming that the actual statistical data might be used for statistics by IEA (International Energy Agency) or World Bank, I use the terms of the "industrial sector" and "non-industrial sector" (instead of the living sector) here.

When evaluating energy intensity of GDP by the sector-based approach, the method of handling the energy conversion sector is the problem. The sector is mainly represented by the power generation sector, and because thermal power generation requires about three times as much energy input as the amount of electricity generated, it cannot be ignored in countries where electricity is spread out. While energy intensity is larger in countries where electrification is ubiquitous, countries with higher generation efficiency can make it smaller. We have to look at energy intensity of GDP considering all such conditions. Then, how should we deal with the energy conversion sector? The result will largely differ depending on whether you include it into the industrial sector in accordance with the GDP categorization or regard it as non-tradable goods[12] and include into the non-industrial sector. Including it in the industrial sector means to impose all increments of the power generation sector due to the electrification development of the household sector onto the

[10] There is some research literature comparing sector-based PPP among certain countries (such as EU member states and Japan and China).

[11] This is a bold assumption for some countries. For example, this assumption is not necessarily true for countries that protect their domestic industry by quantitative restraint or tariffs, countries that introduced a fixed exchange rate system or managed a floating system, etc.

[12] Import and export of electricity are actually conducted in some countries. However, because development of the infrastructure and unification of the system are necessary, electricity can hardly be an international product such as other general tradable goods.

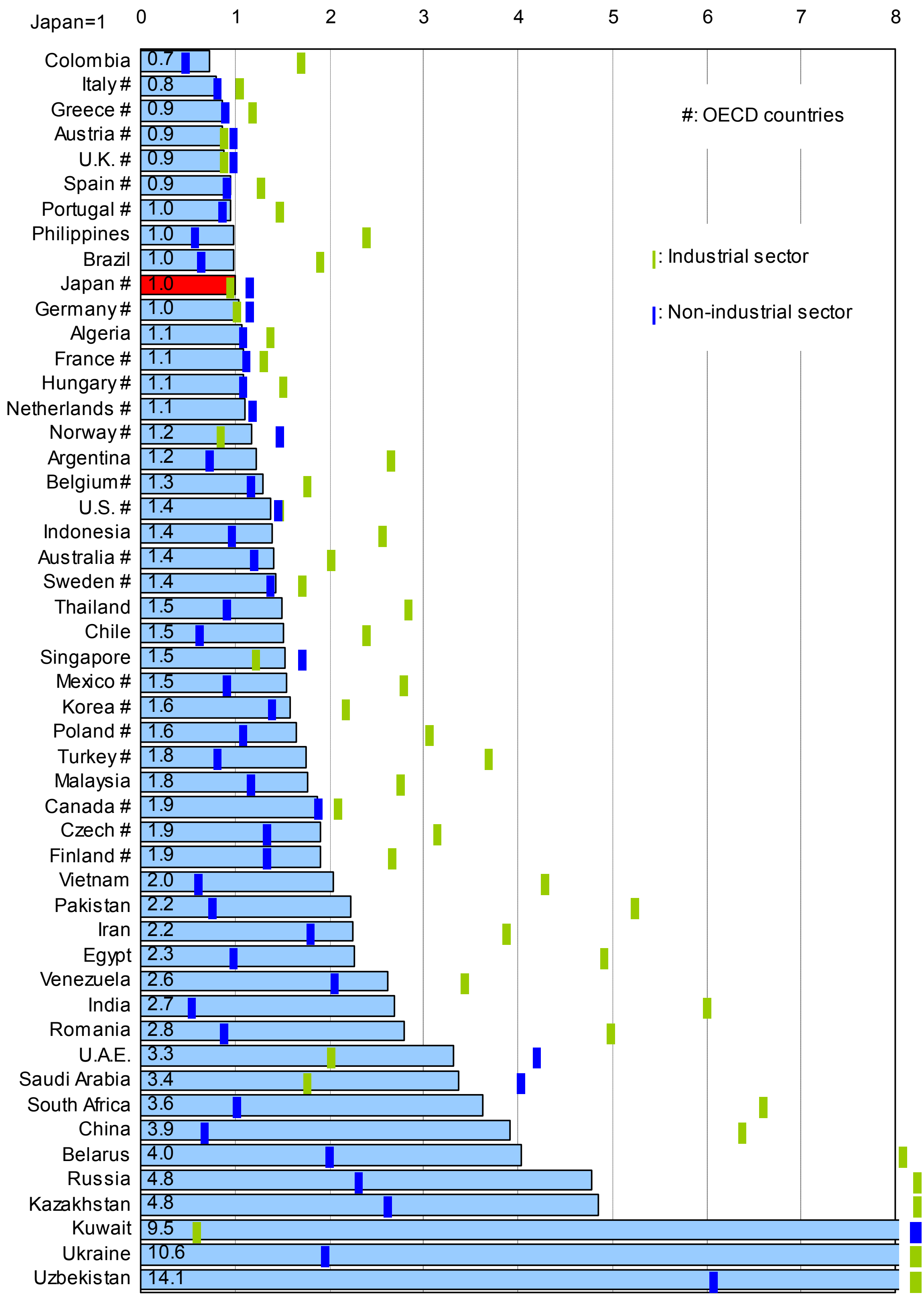
industrial sector. As a measure of addressing such unfairness, you can distribute the power generation industry's energy in proportion to each sector's electricity demand. This method is being used in evaluating $CO_2$ emissions by sector.

Figure 3 shows primary energy intensity of GDP after distributing energy consumption of the energy conversion sector in proportion to the electricity demand of the industrial and non-industrial industries (Japan = 1). Energy intensity of the industrial sector is smaller in advanced countries and larger in developing countries. Meanwhile, the non-industrial sector's energy intensity is smaller in developing countries than in advanced countries, although it cannot be generalized due to the difference in natural environment and other reasons. The results were basically as I expected. Comparing entire energy intensity of GDP, which is the weighted average of the energy intensity for the industrial sector and the non-industrial sector, with simple MER-based energy intensity, the tendency that advanced countries concentrate in the upper level remains the same, but the gap between advanced countries and developing countries has become much smaller. In comparison with simple PPP-based energy intensity, the bias in which the industrial sector of developing countries is evaluated as smaller than actuality is eased and their energy intensity is generally evaluated as larger than that of advanced countries. It can be said, as a result of the estimate using the sector-based approach, while there is no large difference gained for advanced countries, extreme overestimations from MER estimates and extreme underestimation by PPP-based estimates are balanced out, generating more moderate estimates.

Although accurate numerical comparisons are difficult, an overview of the results of estimates using the sector-based approach is as follows. First, looking at OECD countries, energy intensity of GDP of major European countries of Italy, the U.K., Germany, and France is 0.8 to 1.1 times as large as that of Japan, at almost the same level as Japan. Their energy intensity in the industrial sector is larger than that of Japan, but smaller in the non-industrial sector, and therefore their level on average is within the same range as Japan. The energy intensity in the United States and Canada is larger in the non-industrial sector than that of Japan probably because of the demand for automobiles and heating. Therefore, their entire energy intensity is a little higher than that of Japan (U.S.A., 1.4 times; Canada, 1.9 times higher). Energy intensity of the non-original OECD countries of Mexico, South Korea, Poland and the Czech Republic is larger than that of other member countries.

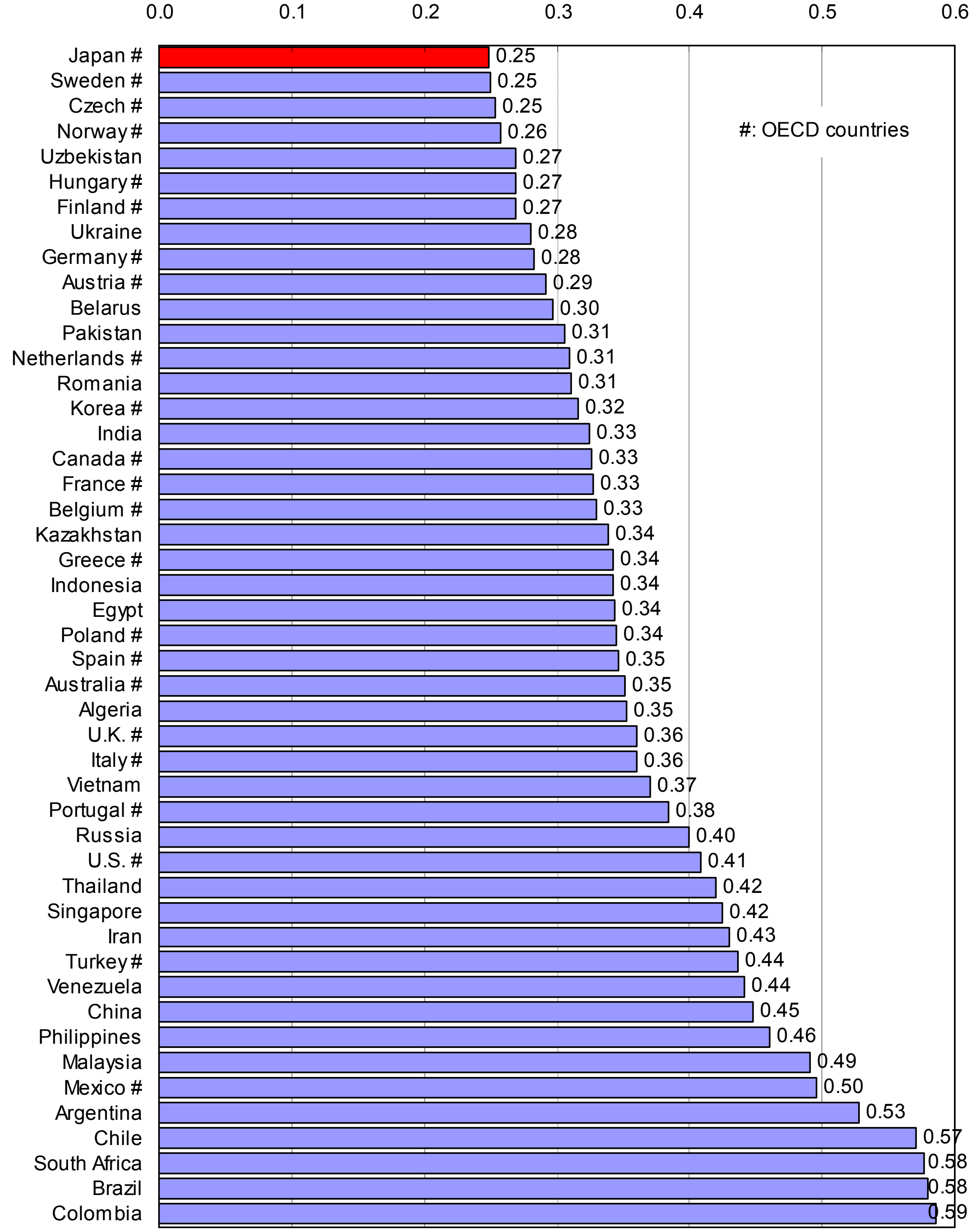
Non-OECD countries, where the ratio of the industrial sector (mining, manufacturing, etc.) in GDP is bigger tend to have larger energy intensity of GDP. Although Asian countries, where industrialization is proceeding, are worse in energy intensity in the industrial sector, their sector-based energy intensity is only 1.5 to 2 times as large as that of Japan because energy intensity in the non-industrial sector is small. However, that of China and India is larger compared to that of other Asian countries partly because power generation is inefficient (China, 3.9 times; India, 2.7 times higher than that of Japan). As for Middle Eastern countries, unlike other developing countries, energy intensity in the non-industrial sector is larger than that in the industrial sector in some countries (such as the UAE and Saudi Arabia). This can be attributed to the fact that energy demand in the non-industrial sector of automobile fuel and civil electricity is larger than energy consumption of the industrial sector, the main industry of which is only petroleum.

Figure 3. Primary energy intensity of GDP by the sector-based approach (2004)




Resource: Author's estimate based on IEA's "Energy Balances of OECD/Non-OECD Countries" and World Bank's "World Development Indicators"

Figure 4. Gini coefficient[13]




Resource: World Bank's "World Development Indicators"

Note: Data from 1993-2003. Note that the year of measurement varies depending on the country. There are no data for Saudi Arabia, the UAE, and Kuwait.

[13] It is an index measuring the inequality of income distribution in society. The coefficient ranges from 0 to 1. The closer to 0 the figure, the smaller income difference, and the closer to 1 the figure, the larger income difference.

Compared to other countries, the former Soviet Union shows bizarrely greater energy intensity of GDP in both the industrial and non-industrial sectors. Aside from the accuracy of the figures, the former Soviet Union is originally a resource power, and this result probably can be attributed to the past inefficiency in the production system when they were the Soviet Union. The reason that energy intensity of Colombia, the Philippines, Brazil, and Argentine is smaller can be attributed to the large gap between the rich and the poor (refer to Figure 4).[14] This probably is because, while the wealth of some people drives up the entire GDP of the countries, energy consumption among poor people, consisting of the majority, is small, making their energy intensity superficially smaller.

Conclusion

It is impossible to accurately evaluate how advanced a country's energy conservation is and measure it against that of other countries, which are different not only in terms of their economies and welfare level but also in natural and social conditions. However, numerical evaluation of energy conservation levels or potential energy conservation levels for any country is of interest for international politics surrounding environmental problems and energy-conservation policies. Therefore, energy intensity of GDP is often used to see a country's energy-conservation level as the approximate index.

However, energy intensity of GDP, which should be an approximate index, largely differs depending on the currency conversion rate. Conversion based on MERs tends to overestimate the GDP of countries that have higher prices, while conversion based on PPP tends to overestimate the GDP of countries with lower prices. This means energy intensity based on MERs is advantageous to advanced countries with higher prices and that based on PPP is advantageous to developing countries with lower prices. This can be considered a bias from evaluating the economy as a single sector. In order to eliminate the bias, the gap of energy intensity between sectors should be taken into consideration.

This study, in order to address such problems, estimated energy intensity of GDP using the sector-based approach. However, this is based only on a simple assumption and does not solve all the problems. An advantage of energy intensity of GDP is that it can be easily calculated. In that sense, it should be avoided that the calculation procedures are made complex by pursuing accuracy too much. Establishment of a calculation method balancing accuracy and convenience will be our future task.

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[14] As for Brazil, another factor is the high ratio of hydropower. IEA statistics regard the power generation efficiency as 100% in primary energy conversion.

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[Country data (2004)]

| Region | Country | Total primary energy supply | Nominal GDP | | | Energy intensity of GDP | |
|---|---|---|---|---|---|---|---|
| | | | MER-base | PPP-base | Gap between domestic and foreign prices | MER-base | PPP-base |
| | | ktoe | mil. US$ | mil. intl.$ | | toe/mil. US$ | toe/mil. intl.$ |
| North America | U.S. # | 2,325,887 | 11,712,000 | 11,651,000 | 1.005 | 199 | 200 |
| | Canada # | 269,048 | 977,970 | 999,610 | 0.978 | 275 | 269 |
| South and Central America | Brazil | 157,622 | 603,970 | 1,507,100 | 0.401 | 261 | 105 |
| | Mexico # | 165,475 | 676,500 | 1,017,500 | 0.665 | 245 | 163 |
| | Argentina | 61,587 | 153,010 | 510,270 | 0.300 | 403 | 121 |
| | Venezuela | 55,617 | 110,100 | 157,880 | 0.697 | 505 | 352 |
| | Colombia | 23,553 | 97,718 | 325,920 | 0.300 | 241 | 72 |
| | Chile | 23,634 | 94,105 | 175,320 | 0.537 | 251 | 135 |
| European OECD | Germany # | 348,036 | 2,740,600 | 2,335,500 | 1.173 | 127 | 149 |
| | France # | 275,169 | 2,046,600 | 1,769,200 | 1.157 | 134 | 156 |
| | U.K. # | 233,689 | 2,124,400 | 1,845,200 | 1.151 | 110 | 127 |
| | Italy # | 184,460 | 1,677,800 | 1,622,400 | 1.034 | 110 | 114 |
| | Spain # | 142,203 | 1,039,900 | 1,069,300 | 0.973 | 137 | 133 |
| | Netherlands # | 82,147 | 578,980 | 517,590 | 1.119 | 142 | 159 |
| | Turkey # | 81,905 | 302,790 | 556,070 | 0.545 | 271 | 147 |
| | Poland # | 91,742 | 242,290 | 495,390 | 0.489 | 379 | 185 |
| | Belgium# | 57,694 | 352,310 | 324,050 | 1.087 | 164 | 178 |
| | Sweden # | 53,937 | 346,410 | 265,630 | 1.304 | 156 | 203 |
| | Czech # | 45,527 | 107,010 | 198,280 | 0.540 | 425 | 230 |
| | Austria # | 33,188 | 292,330 | 263,800 | 1.108 | 114 | 126 |
| | Finland # | 38,091 | 185,920 | 156,590 | 1.187 | 205 | 243 |
| | Greece # | 30,472 | 205,220 | 245,510 | 0.836 | 148 | 124 |
| | Portugal # | 26,549 | 167,720 | 206,140 | 0.814 | 158 | 129 |
| | Norway # | 27,661 | 250,050 | 176,540 | 1.416 | 111 | 157 |
| | Hungary # | 26,355 | 100,690 | 169,940 | 0.593 | 262 | 155 |
| Non-European OECD | Russia | 638,113 | 581,450 | 1,424,400 | 0.408 | 1,097 | 448 |
| | Ukraine | 140,071 | 64,828 | 303,410 | 0.214 | 2,161 | 462 |
| | Uzbekistan | 53,994 | 11,960 | 48,993 | 0.244 | 4,515 | 1,102 |
| | Kazakhstan | 54,746 | 40,743 | 111,560 | 0.365 | 1,344 | 491 |
| | Romania | 35,432 | 73,167 | 183,880 | 0.398 | 484 | 193 |
| | Belarus | 25,780 | 22,889 | 68,475 | 0.334 | 1,126 | 376 |
| Africa | South Africa | 117,823 | 212,780 | 509,350 | 0.418 | 554 | 231 |
| | Egypt | 55,471 | 78,796 | 305,880 | 0.258 | 704 | 181 |
| | Algeria | 32,819 | 84,649 | 213,660 | 0.396 | 388 | 154 |
| Middle East | Iran | 145,049 | 163,440 | 504,210 | 0.324 | 887 | 288 |
| | Saudi Arabia | 140,413 | 250,560 | 331,110 | 0.757 | 560 | 424 |
| | U.A.E. | 43,813 | 104,200 | 103,920 | 1.003 | 420 | 422 |
| | Kuwait | 25,116 | 55,718 | 47,675 | 1.169 | 451 | 527 |
| Asia | China | 1,390,129 | 1,931,700 | 7,642,300 | 0.253 | 720 | 182 |
| | Japan # | 533,201 | 4,622,800 | 3,737,300 | 1.237 | 115 | 143 |
| | India | 358,476 | 691,160 | 3,389,700 | 0.204 | 519 | 106 |
| | Korea # | 213,045 | 679,670 | 985,650 | 0.690 | 313 | 216 |
| | Indonesia | 126,841 | 257,640 | 785,170 | 0.328 | 492 | 162 |
| | Thailand | 81,200 | 161,690 | 515,270 | 0.314 | 502 | 158 |
| | Malaysia | 53,916 | 118,320 | 255,820 | 0.463 | 456 | 211 |
| | Pakistan | 47,903 | 96,115 | 338,400 | 0.284 | 498 | 142 |
| | Vietnam | 26,538 | 45,210 | 225,520 | 0.200 | 587 | 118 |
| | Philippines | 33,673 | 84,567 | 376,590 | 0.225 | 398 | 89 |
| | Singapore | 25,586 | 106,820 | 119,050 | 0.897 | 240 | 215 |
| Oceania | Australia # | 115,776 | 637,330 | 609,990 | 1.045 | 182 | 190 |

Resource: Author's estimate based on IEA's "Energy Balances of OECD/Non-OECD Countries" and World Bank's "World Development Indicators"

| Region | Country | Nominal GDP (PPP-base) | | | Gap between domestic and foreign prices | | |
|---|---|---|---|---|---|---|---|
| | | mil. intl.$ | Industrial (Estimate) | Non-industrial (Estimate) | | Industrial (Assumption) | Non-industrial (Estimate) |
| North America | U.S. # | 11,651,000 | 2,429,136 | 9,221,864 | 1.005 | 1.000 | 1.007 |
| | Canada # | 999,610 | 288,353 | 711,257 | 0.978 | 1.000 | 0.970 |
| South and Central America | Brazil | 1,507,100 | 210,590 | 1,296,510 | 0.401 | 1.000 | 0.303 |
| | Mexico # | 1,017,500 | 161,890 | 855,610 | 0.665 | 1.000 | 0.601 |
| | Argentina | 510,270 | 50,430 | 459,840 | 0.300 | 1.000 | 0.223 |
| | Venezuela | 157,880 | 53,705 | 104,175 | 0.697 | 1.000 | 0.541 |
| | Colombia | 325,920 | 27,258 | 298,662 | 0.300 | 1.000 | 0.236 |
| | Chile | 175,320 | 38,487 | 136,833 | 0.537 | 1.000 | 0.406 |
| European OECD | Germany # | 2,335,500 | 720,900 | 1,614,600 | 1.173 | 1.000 | 1.251 |
| | France # | 1,769,200 | 399,110 | 1,370,090 | 1.157 | 1.000 | 1.202 |
| | U.K. # | 1,845,200 | 496,100 | 1,349,100 | 1.151 | 1.000 | 1.207 |
| | Italy # | 1,622,400 | 417,190 | 1,205,210 | 1.034 | 1.000 | 1.046 |
| | Spain # | 1,069,300 | 273,530 | 795,770 | 0.973 | 1.000 | 0.963 |
| | Netherlands # | 517,590 | 131,540 | 386,050 | 1.119 | 1.000 | 1.159 |
| | Turkey # | 556,070 | 56,320 | 499,750 | 0.545 | 1.000 | 0.493 |
| | Poland # | 495,390 | 69,160 | 426,230 | 0.489 | 1.000 | 0.406 |
| | Belgium# | 324,050 | 79,717 | 244,333 | 1.087 | 1.000 | 1.116 |
| | Sweden # | 265,630 | 87,069 | 178,561 | 1.304 | 1.000 | 1.452 |
| | Czech # | 198,280 | 36,597 | 161,683 | 0.540 | 1.000 | 0.436 |
| | Austria # | 263,800 | 81,351 | 182,449 | 1.108 | 1.000 | 1.156 |
| | Finland # | 156,590 | 49,927 | 106,663 | 1.187 | 1.000 | 1.275 |
| | Greece # | 245,510 | 41,546 | 203,964 | 0.836 | 1.000 | 0.802 |
| | Portugal # | 206,140 | 38,722 | 167,418 | 0.814 | 1.000 | 0.771 |
| | Norway # | 176,540 | 86,901 | 89,639 | 1.416 | 1.000 | 1.820 |
| | Hungary # | 169,940 | 26,513 | 143,427 | 0.593 | 1.000 | 0.517 |
| Non-European OECD | Russia | 1,424,400 | 182,370 | 1,242,030 | 0.408 | 1.000 | 0.321 |
| | Ukraine | 303,410 | 21,115 | 282,295 | 0.214 | 1.000 | 0.155 |
| | Uzbekistan | 48,993 | 2,587 | 46,406 | 0.244 | 1.000 | 0.202 |
| | Kazakhstan | 111,560 | 15,103 | 96,457 | 0.365 | 1.000 | 0.266 |
| | Romania | 183,880 | 24,254 | 159,626 | 0.398 | 1.000 | 0.306 |
| | Belarus | 68,475 | 7,753 | 60,723 | 0.334 | 1.000 | 0.249 |
| Africa | South Africa | 509,350 | 60,522 | 448,828 | 0.418 | 1.000 | 0.339 |
| | Egypt | 305,880 | 27,337 | 278,543 | 0.258 | 1.000 | 0.185 |
| | Algeria | 213,660 | 44,475 | 169,185 | 0.396 | 1.000 | 0.237 |
| Middle East | Iran | 504,210 | 66,668 | 437,542 | 0.324 | 1.000 | 0.221 |
| | Saudi Arabia | 331,110 | 147,480 | 183,630 | 0.757 | 1.000 | 0.561 |
| | U.A.E. | 103,920 | 56,861 | 47,059 | 1.003 | 1.000 | 1.006 |
| | Kuwait | 47,675 | 32,593 | 15,082 | 1.169 | 1.000 | 1.533 |
| Asia | China | 7,642,300 | 892,940 | 6,749,360 | 0.253 | 1.000 | 0.154 |
| | Japan # | 3,737,300 | 1,409,216 | 2,328,084 | 1.237 | 1.000 | 1.380 |
| | India | 3,389,700 | 171,010 | 3,218,690 | 0.204 | 1.000 | 0.162 |
| | Korea # | 985,650 | 246,560 | 739,090 | 0.690 | 1.000 | 0.586 |
| | Indonesia | 785,170 | 112,640 | 672,530 | 0.328 | 1.000 | 0.216 |
| | Thailand | 515,270 | 70,318 | 444,952 | 0.314 | 1.000 | 0.205 |
| | Malaysia | 255,820 | 59,670 | 196,150 | 0.463 | 1.000 | 0.299 |
| | Pakistan | 338,400 | 22,272 | 316,128 | 0.284 | 1.000 | 0.234 |
| | Vietnam | 225,520 | 18,124 | 207,396 | 0.200 | 1.000 | 0.131 |
| | Philippines | 376,590 | 27,439 | 349,151 | 0.225 | 1.000 | 0.164 |
| | Singapore | 119,050 | 35,257 | 83,793 | 0.897 | 1.000 | 0.854 |
| Oceania | Australia # | 609,990 | 149,357 | 460,633 | 1.045 | 1.000 | 1.059 |

Note: Fifty countries with more primary energy consumption were chosen. However, countries without sufficient statistical data including GDP were excluded. Energy consumption of non-OECD countries did not include non-commercial energy (such traditional fuel as firewood and dung).

#: OECD countries

| Region | Country | TPES (After distributed based on electricity demand) | | | Energy intensity of GDP by the sector-based approach | | |
|---|---|---|---|---|---|---|---|
| | | ktoe | Industrial | Non-industrial | toe/mil. intl.$ | Industrial | Non-industrial |
| North America | U.S. # | 2,325,887 | 487,937 | 1,837,950 | 200 | 201 | 199 |
| | Canada # | 269,048 | 83,504 | 185,544 | 270 | 290 | 261 |
| South and Central America | Brazil | 157,622 | 54,730 | 102,892 | 142 | 260 | 79 |
| | Mexico # | 165,475 | 63,004 | 102,471 | 222 | 389 | 120 |
| | Argentina | 61,587 | 18,674 | 42,913 | 177 | 370 | 93 |
| | Venezuela | 55,617 | 25,967 | 29,650 | 377 | 484 | 285 |
| | Colombia | 23,553 | 6,370 | 17,183 | 105 | 234 | 58 |
| | Chile | 23,634 | 12,880 | 10,754 | 218 | 335 | 79 |
| European OECD | Germany # | 348,036 | 96,790 | 251,246 | 150 | 134 | 156 |
| | France # | 275,169 | 70,273 | 204,896 | 156 | 176 | 150 |
| | U.K. # | 233,689 | 56,830 | 176,859 | 127 | 115 | 131 |
| | Italy # | 184,460 | 58,587 | 125,873 | 116 | 140 | 104 |
| | Spain # | 142,203 | 46,643 | 95,560 | 137 | 171 | 120 |
| | Netherlands # | 82,147 | 21,051 | 61,096 | 159 | 160 | 158 |
| | Turkey # | 81,905 | 29,305 | 52,600 | 254 | 520 | 105 |
| | Poland # | 91,742 | 29,693 | 62,049 | 237 | 429 | 146 |
| | Belgium# | 57,694 | 19,342 | 38,352 | 186 | 243 | 157 |
| | Sweden # | 53,937 | 20,549 | 33,388 | 206 | 236 | 187 |
| | Czech # | 45,527 | 16,129 | 29,398 | 274 | 441 | 182 |
| | Austria # | 33,188 | 9,304 | 23,884 | 126 | 114 | 131 |
| | Finland # | 38,091 | 18,639 | 19,452 | 276 | 373 | 182 |
| | Greece # | 30,472 | 6,601 | 23,871 | 126 | 159 | 117 |
| | Portugal # | 26,549 | 7,757 | 18,792 | 138 | 200 | 112 |
| | Norway # | 27,661 | 9,612 | 18,049 | 170 | 111 | 201 |
| | Hungary # | 26,355 | 5,465 | 20,890 | 158 | 206 | 146 |
| Non-European OECD | Russia | 638,113 | 238,169 | 399,944 | 689 | 1,306 | 322 |
| | Ukraine | 140,071 | 63,877 | 76,194 | 1,526 | 3,025 | 270 |
| | Uzbekistan | 53,994 | 13,964 | 40,030 | 2,036 | 5,398 | 863 |
| | Kazakhstan | 54,746 | 19,601 | 35,145 | 699 | 1,298 | 364 |
| | Romania | 35,432 | 17,153 | 18,279 | 401 | 707 | 115 |
| | Belarus | 25,780 | 8,938 | 16,842 | 581 | 1,153 | 277 |
| Africa | South Africa | 117,823 | 56,781 | 61,042 | 523 | 938 | 136 |
| | Egypt | 55,471 | 19,068 | 36,403 | 326 | 698 | 131 |
| | Algeria | 32,819 | 8,247 | 24,572 | 155 | 185 | 145 |
| Middle East | Iran | 145,049 | 36,424 | 108,625 | 323 | 546 | 248 |
| | Saudi Arabia | 140,413 | 35,779 | 104,634 | 486 | 243 | 570 |
| | U.A.E. | 43,813 | 15,932 | 27,881 | 479 | 280 | 592 |
| | Kuwait | 25,116 | 2,416 | 22,700 | 1,367 | 74 | 1,505 |
| Asia | China | 1,390,129 | 810,452 | 579,677 | 565 | 908 | 86 |
| | Japan # | 533,201 | 175,298 | 357,903 | 144 | 124 | 154 |
| | India | 358,476 | 146,124 | 212,352 | 387 | 854 | 66 |
| | Korea # | 213,045 | 74,339 | 138,706 | 227 | 302 | 188 |
| | Indonesia | 126,841 | 40,341 | 86,500 | 202 | 358 | 129 |
| | Thailand | 81,200 | 28,015 | 53,185 | 216 | 398 | 120 |
| | Malaysia | 53,916 | 22,929 | 30,987 | 254 | 384 | 158 |
| | Pakistan | 47,903 | 16,528 | 31,375 | 321 | 742 | 99 |
| | Vietnam | 26,538 | 10,983 | 15,555 | 295 | 606 | 75 |
| | Philippines | 33,673 | 9,135 | 24,538 | 142 | 333 | 70 |
| | Singapore | 25,586 | 5,790 | 19,796 | 220 | 164 | 236 |
| Oceania | Australia # | 115,776 | 41,670 | 74,106 | 203 | 279 | 161 |