Article # 43

Energy Intensity and other difficult to understand terms - Graph 8

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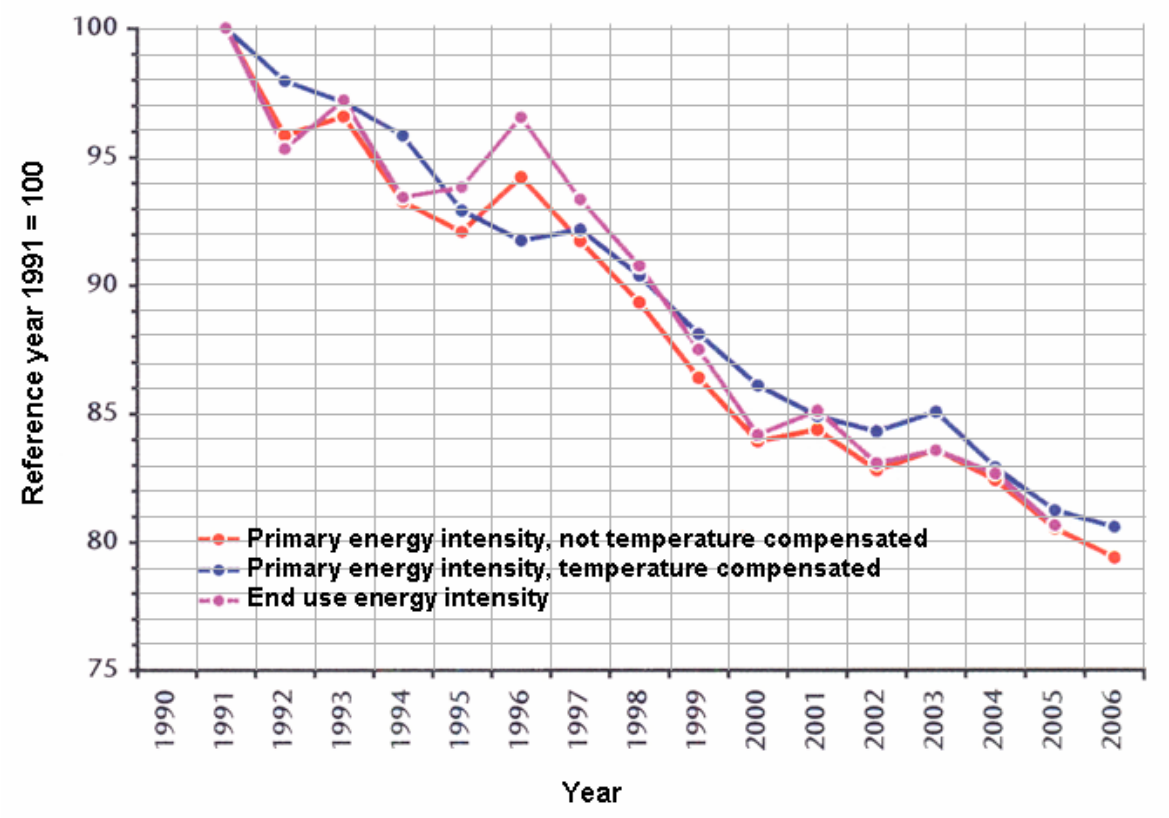
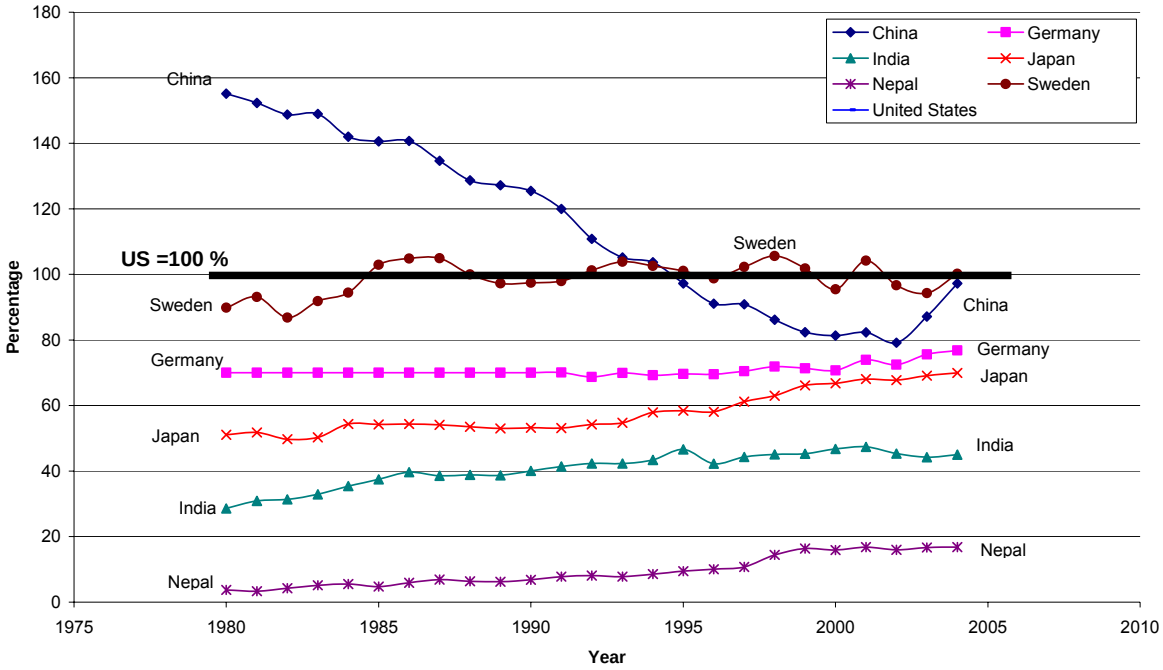
Graph 1 shows the steady decline of the energy intensity of Germany over the last 25 years. Recall that energy intensity is the ratio of "energy unit/ monetary unit". Example: $\frac{\text{Tons of oil equivalent}}{\$\,1000\ (\text{GDP})}$. The energy intensity is one of the most misused indicators in arguments and counter arguments about the "energy efficiency" of a nation. But relax, contrary to common believe the energy intensity cannot be properly correlated to energy efficiency and has often little to do with energy efficiency in particular in developing economies. Graph 2 shows the energy intensity of 7 countries in % of the figure for the USA, for every year. In this graph energy intensity is adjusted by the purchasing power parity (PPP).

Graph 1: Energy Intensity Trend Germany
Ref: BWK 4/2007



Graph 3 shows the total per capita primary energy consumption of each country as a percentage of the consumption in the USA for each year.

Graph 2: Energy Intensity-Total Primary Energy Consumption per Dollar of Gross Domestic Product Using Purchasing Power Parities, 1980-2004
Data Source: http://www.eia.doe.gov/emeu/international/energyconsumption.html

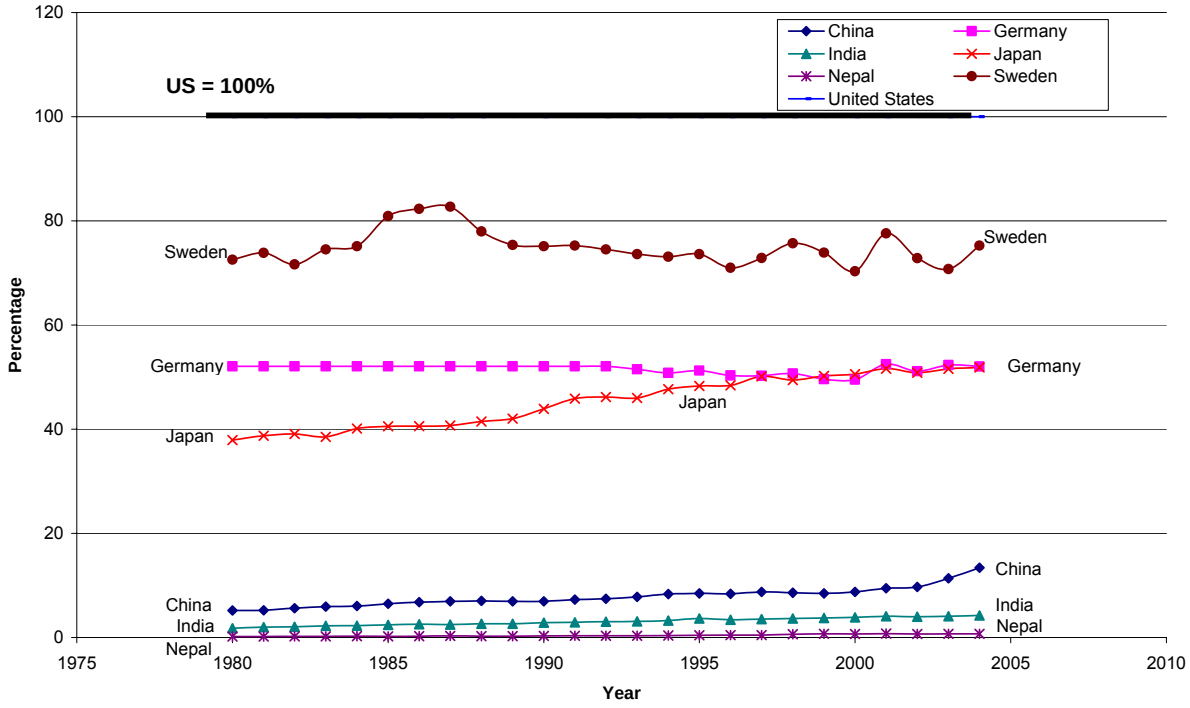


Observe that based on these graphics it does not make sense to relate energy efficiency to energy intensity of a country. If PPP adjusted figures are used than Nepal would be one of the most energy efficient societies in the world. In case we use energy intensity without PPP adjustment than India and China would be one of the least energy efficient countries in the world. Both statements are not true and don't make sense.

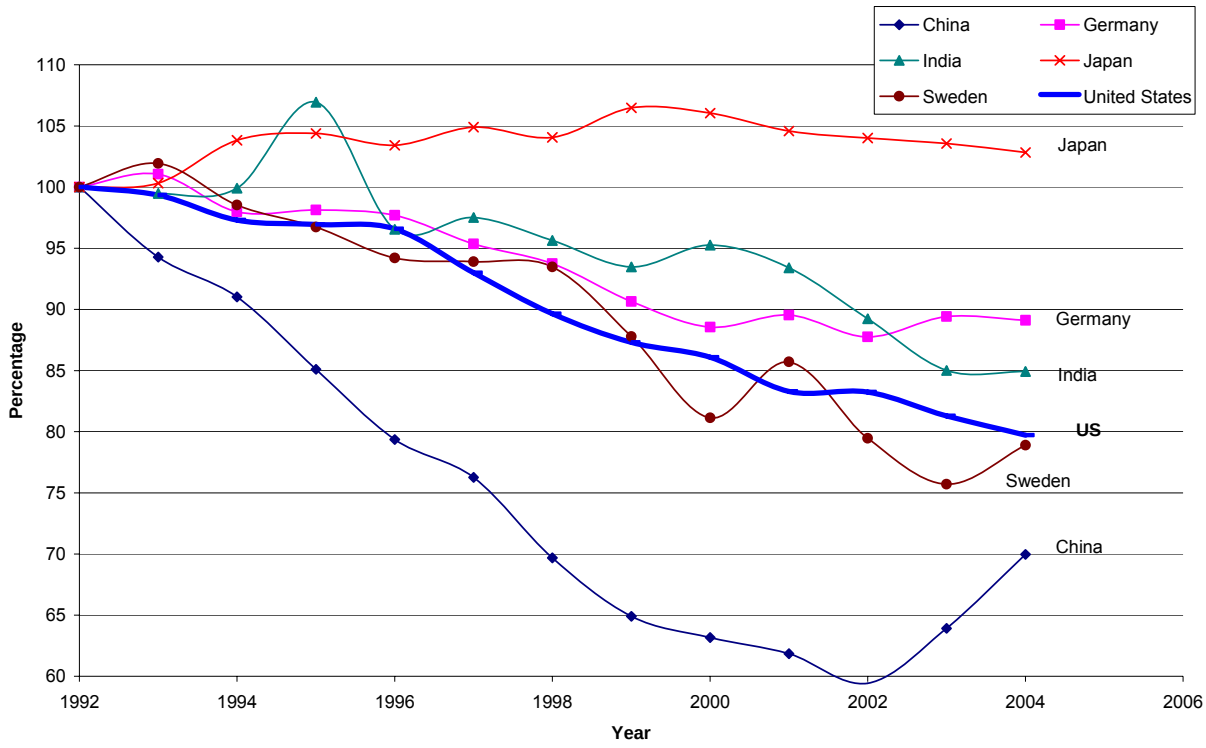
Remember that an improved energy efficiency means only that with the same amount of energy one produces more goods, travels farther with a car, produces more food, lowers specific energy consumption and so on. In fact a high energy intensity may be necessary for a nations development expressed in terms of industrialisation, urbanisation, electrification and consumerism. The graphics about the declining energy intensity by 22% over 25 years of Germany shows only that the annual growth of the German GDP has more and more decoupled from the annual growth in energy

consumption. Not more and not less. It does not necessarily show that the energy efficiency of the nation defined as $\eta = \frac{\text{useful energy output}}{\text{energy input}}$ has improved the same way. It may be less or even more ! For instance the transformation of an economy from highly energy intensive goods and services to less energy intensive ones will certainly lower the energy intensity, but not necessarily energy efficiency. In the worst case one may reduce the energy intensity of a country by increasing wasteful use of energy. Only a sectorwise survey to look into the specific energy consumption defined as $SEC = \frac{\text{energy input}}{\text{unit of product}}$ would reveal to what extent an industrial sector, such as steel, cement, pulp and paper, textile, power plants, etc. has become more energy efficient, i.e. produce more goods with the same energy input. The collection and proper analysis of SEC's is one order of magnitude more difficult than calculating the energy intensity, because the product mix may change frequently.

Graph 3: World Per Capita Total Primary Energy Consumption, 1980-2004
Data Source: http://www.eia.doe.gov/emeu/international/energyconsumption.html



Graph 4: Energy intensity trend PPP adjusted of various countries (1992-2004)
Data Source: http://www.eia.doe.gov/emeu/international/energyconsumption.html



The trend in PPP adjusted energy intensity is shown in graph 4. All countries follow a similar downward trend. For Japan as an industralised country with one of the lowest energy intensity it is admittedly difficult to get even better.

Other terms such as incremental energy consumption either defined as $\Delta\left(\frac{E}{P}\right)$ or $\frac{\Delta E}{\Delta P}$ where E stands for energy consumption and P for production output need to be also treated with caution. The term $\frac{\Delta E}{\Delta P}$ is of no use from an analysis point of view. Either ΔE, or ΔP, or both may be zero. Furthermore, if the energy consumption E in two successive years remain the same i.e. $\Delta E = 0$ than the result is zero independent of how production has changed in these two years. Consequently nothing can be concluded and compared. The term $\Delta\frac{E}{P}$ is just a different mathematical expression for

the change in specific energy consumption between two successive years, $SEC_2 - SEC_1$. In other words the SEC is about the only acceptable indicator that gives a true picture how the energy efficiency of a firm or an entire nation has changed for good or worse. The others are of questionable quality and relevance.

However there is one additional interesting indicator. It is the energy intensity based on Gross Value Added (GVA). Gross value added is gross output of a nation or a firm or even a household by deducting intermediate consumption. This indicator avoids double counting of inputs such as energy consumed for manufacturing of goods or providing services. Consequently the GVA energy intensity = $\frac{\text{energy consumption}}{\text{GVA}}$ reveals to what extent an economy is restructing towards more "energy sustainability". For Germany the figures are revealing. For all sectors it were 4.6 MJ/ Euro (GVA), for industry it was 11.0 MJ/ Euro (GVA). It is particularly high for the chemical sector and steel industry. For the service sector it was the lowest with 2.2 MJ/ Euro (GVA). Consequently becoming a predominantly service oriented society would help in the case of Germany. In the case of the USA it did not help. Because per capita energy and electricity consumption is about twice as high as in Germany. The reduction of the German GVA energy intensity was about 14% over 10 years. However this is also due to the fact that the service sector contribution to the GDP went up. The goal of the German Government to half the primary energy intensity from 1990 by 2020 is therefore in doubt. It would require to reduce the primary energy intensity by 3% annually from now on because $78\% / (1.03)^{15} = 50\%$, while only 1.7% reduction per year are observed and predicted at the present business as usual approach. More efforts are therefore necessary. Note that any accelerated switch from fossil fuels to renewable energy will not necessarily accelerate reduction of primary energy intensity. The equation doesn't care which colour your energy has: Green, Blue or Black. On the other hand the "factor four" vision to eventually double economic output by halfing energy consumption is not just a pipe dream but based on the fact that the battle for more energy efficient processes and technologies and the most important energy modesty has just begun.

A final word of caution. Depending on which international data source is used, these indicators differ. It is not uncommon to see a difference of more than 50% due to the fact that the PPP of a country is difficult to establish. Furthermore, the total primary energy consumption of countries such as India, Nepal and China include a large percentage of non-commercial biomass fuels. Consumption figures of these fuels are somewhat speculative and considered very rough estimates.