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Climate negotiation: The Case of Per Capita CO2 Targets

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Global Energy Economics and Climate Protection

The per-capita CO_2 emission value is not a suitable general target for short- and medium-term efforts because it does not take account of countries' differing development states. It makes sense as a long-term goal and 1 t CO_2 per capita and year is certainly worth having as a long-term target.

A better grip on the problem results if the benchmark or guideline value is not the CO_2 emissions per capita but a value relative to an indicator that is a good representation of the development state of the country. The only quantity that is collected world-wide and meets this requirement to some extent is the gross domestic product (GDP), at purchasing-power parity (World Bank, IMF [2]), despite the shortcomings associated with this quantity as an indicator of prosperity. Finding and establishing a better one would be a task for the Guild of Economists.

In 2007, the CO_2 emissions value expressed in g CO_2/$ purchasing-power-parity GDP was worldwide 435 g CO_2/$ (dollars of the year 2007). This indicator can be determined as the product of two factors: the *energy intensity of the GD*P(ppp) and the *CO_2 intensity of the energy*. The first one characterises the *efficiency of the use of energy*, and the second one the *CO_2 sustainability of the energy employed*. These factors are of equal significance and fundamental for climate protection.

The trend of increasing CO_2 emissions can only be broken by influencing both of its causes. The important number is the product of the two factors *energy intensity* ε and *CO_2 intensity k, used as CO_2 –sustainability indicator* η that must be kept as low as possible for effective climate protection.

$$\eta\left[\frac{t\,CO_2}{10'000\$}\right] = k\left[\frac{t\,CO_2}{kWa}\right] \cdot \varepsilon\left[\frac{kWa}{10'000\$}\right],$$

The world-wide value of this CO_2 indicator in 2007 was 4.35 t CO_2/\$10 000 (US Dollars of 2007) or, written more concisely and understandably, 435 g CO_2/\$. This number, together with its components, is significant for comparisons between countries regarding sustainability of their energy economics and the effectiveness of measures for climate protection. It is therefore suitable as a basis for discussion and a starting point for negotiations. What value must it reach in 2030 or 2050 if the goals of climate protection are to be achieved?

The resulting per-capita indicators are also of interest: *e* for energy and α for CO_2 emissions

$$e\left[\frac{kW}{capita}\right] = \varepsilon\left[\frac{kWa}{10'000\$}\right] \cdot y\left[\frac{10'000\$}{a,\ capita}\right]$$

$$\alpha\left[\frac{tCO_2}{a,capita}\right] = \eta\left[\frac{tCO_2}{10'000\$}\right] \cdot y\left[\frac{10'000\$}{a,capita}\right] = k\left[\frac{t\,CO_2}{kWa}\right] \cdot \varepsilon\left[\frac{kWa}{10'000\$}\right] \cdot y\left[\frac{10'000\$}{a,capita}\right]$$

in which *y* indicates the gross domestic product at purchasing power parity GDP(ppp) per capita. The indicator α is decisive for climate warming since the population trend is the most predictable and it is entirely sensible long-term as a target quantity, but is not particularly suited to current-day comparisons and therefore as a basis for short- and medium-term negotiations.

Target values and international cooperation

For effective climate protection (temperature rise not over 2°C, stabilisation of CO_2 emissions by 2030 relative to 2004 and halving by 2050) the following world-wide target values are necessary ([1], main report and annex):

- 3.3 t CO2/capita by 2030, giving about 200 g CO2/$,
- 1.5 t CO2/capita by 2050, giving about 60 g CO2/$.

The worldwide target values in g CO_2 per purchasing-power equivalent GDP (year-2007 $) depend on the expected increase in the worldwide GDP and are therefore more difficult to determine than those for CO_2 emissions per capita. Nevertheless they are more informative for comparisons since they take into account the development state of the country concerned. Each country should therefore accept them as a guideline and make an effort to achieve them, regardless of the state of development.

The following chart **figure 1** shows, for the whole world, the annual changes in the indicators from 2004 to 2007 and the annual percent changes required until 2030 for protecting the climate (CO_2 indicator in g CO_2/ $ of 2007). Thus, the CO_2 indicator has, according to figure 1, reduced worldwide by about 2% annually from 2004 to 2007. However, for effective protection of the climate, this indicator must come down by 3.2% annually between 2004 and 2030. If the average growth of GDP(ppp) per capita exceeds the assumed value of just under 2.4%/a, an even greater decrease is required.

With the assumed growth rate of GDP(ppp) the indicators would evolve worldwide from 1971 to 2030 as shown in the following **figure 2**.

In the Report 2009 [1] the main indicators for all countries are presented and commented. This is together with the hope that critical debate with one's own energy economy and that of the world will give rise to discussion and lead to the understanding that, despite differing and, to some extent conflicting, interests, will enable a coming together of viewpoints in matters of climate protection. International cooperation is certainly required, and naturally both market-based means (CO_2 certificates) and promotional actions by the state can and must be employed.

Indicator values required for OECD- and non-OECD countries for 2030

To meet the stabilisation condition the world-wide emissions of CO_2 in the year 2030 must be below 27 000 Mt. With a GDP (ppp) of $135 000 bn ($ of 2007), in the alternative scenario of the IEA, this would give a necessary CO_2 sustainability indicator of $\eta = 2$ t CO_2/$10 000 (or 200 g CO_2/$). Switzerland, for example, has already gone below this value in 2007.

In the same scenario, the gross energy requirement would be 19.7 TWa (growth 1.1%/a). This corresponds to an energy intensity of $\varepsilon = 1.46$ kWa/$10 000. The formula $k = \eta/\varepsilon$ gives the mean CO_2 intensity $k = 1.37$ t CO_2/kWa required for climate protection. Comparing with the year-2007 value of 1.8 t CO_2/kWa, shows that CO_2 intensity must improve to 0.76 of that value. This improvement is not unrealistic and seems to be within reach if appropriate structural changes are expedited round the world in the energy sector, and above all in the generation of electricity. The world-wide indicators for energy and CO_2 emissions would then be $e = 2.43$ kW per capita at that time (increase of about 3% over the 2004 figure) and $\alpha = 3.33$ t CO_2 per capita (reduction of 20% below 2004).

The following graphs **figures 3, 4, 5 and 6** show, for the OECD, USA, non-OECD and China, the annual changes in the indicators from 2004 to 2007 and the annual percent changes required until 2030 for protecting the climate.

Indicator values required for 2050

The halving of CO_2 emissions in the next 20 years to 13 500 Mt CO_2 requires even greater efforts which, however, seem entirely possible, if the efficiency improvements and structural adjustments that have been successfully introduced up to 2030 are further pursued with determination. To estimate the indicator values, assume, for 2050, a world population of 9 bn and a GDP(ppp) of around $220 000 bn ($ of 2007), which corresponds to a world-wide growth of 2.5%/a from 2030. Assume that gross energy consumption still increases, but more slowly, to 22.5 TWa (growth 0.67%/a). The resulting worldwide indicators would then be: energy intensity $\varepsilon \approx 1$ kWa/$10 000 $ (efficiency improvement by a further 40%); CO_2 intensity $k \approx 0.6$ t CO_2/kWa (further strong improvement to 0.44 of the previous value); Sustainability indicator $\eta \approx 60$ g CO_2/$.

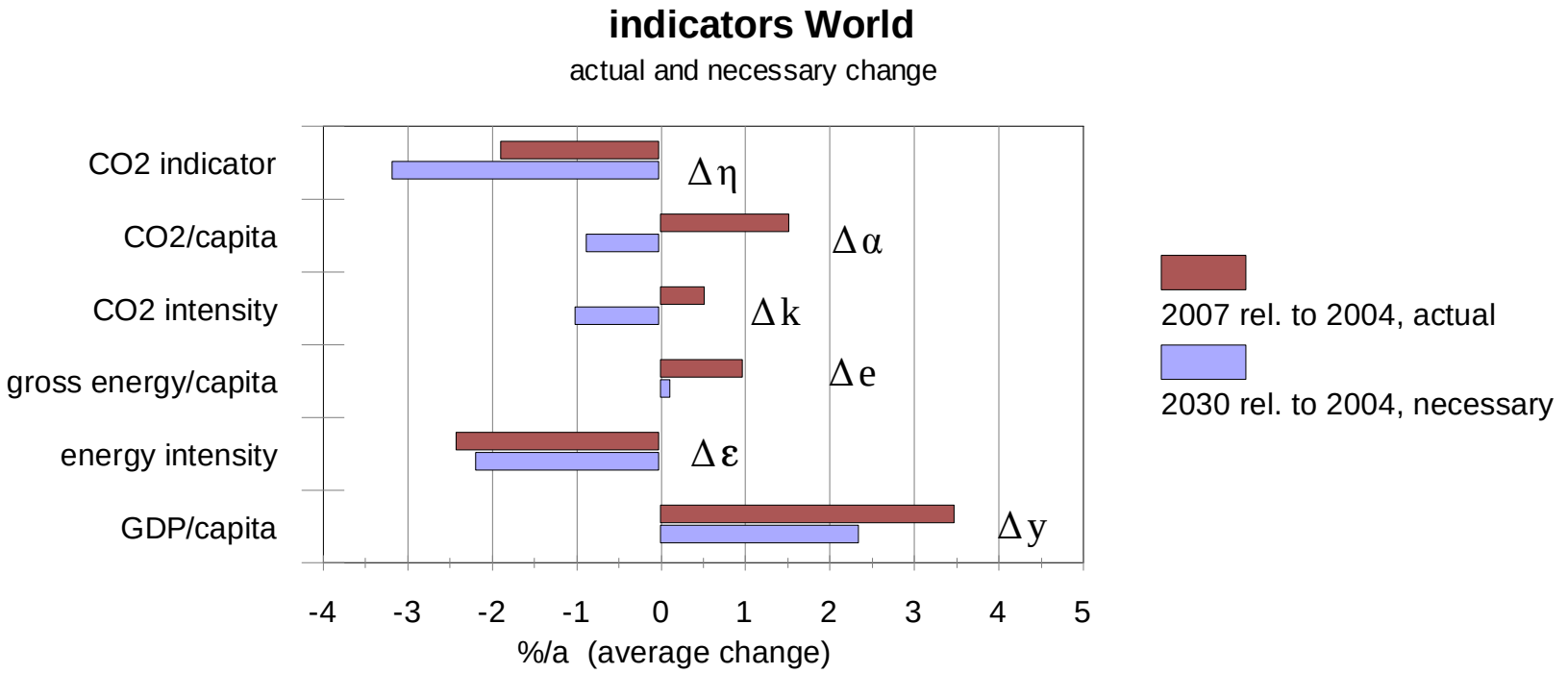

Figure 1. Indicators world: effective annual % change from 2004 to 2007 (red) and worldwide annual % change required until 2030 for climate protection for an assumed growth of GDP (PPP) (blue).
ε = energy intensity, k = CO_2 intensity, CO_2 indicator $\eta = k \cdot \varepsilon$, $\Delta\eta\% = \Delta k\% + \Delta\varepsilon\%$
y = GDP/capita (PPP), CO_2/capita $\alpha = \eta \cdot y$, $\Delta\alpha\% = \Delta\eta\% + \Delta y\%$
gross energy/capita $e = \varepsilon \cdot y$, $\Delta e\% = \Delta\varepsilon\% + \Delta y\%$

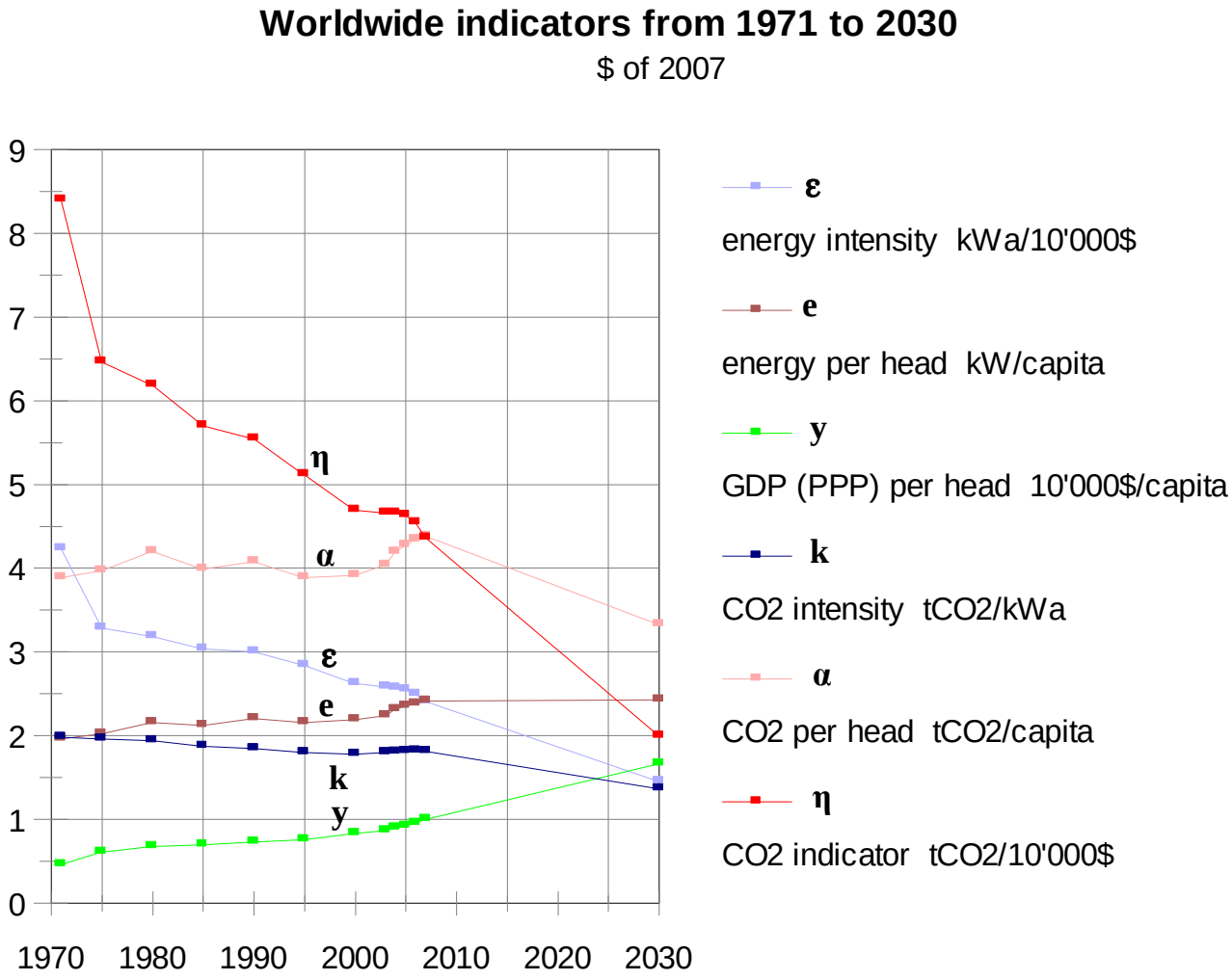

Figure 2. Worldwide indicators from 1971 to 2007 and necessary progress until 2030

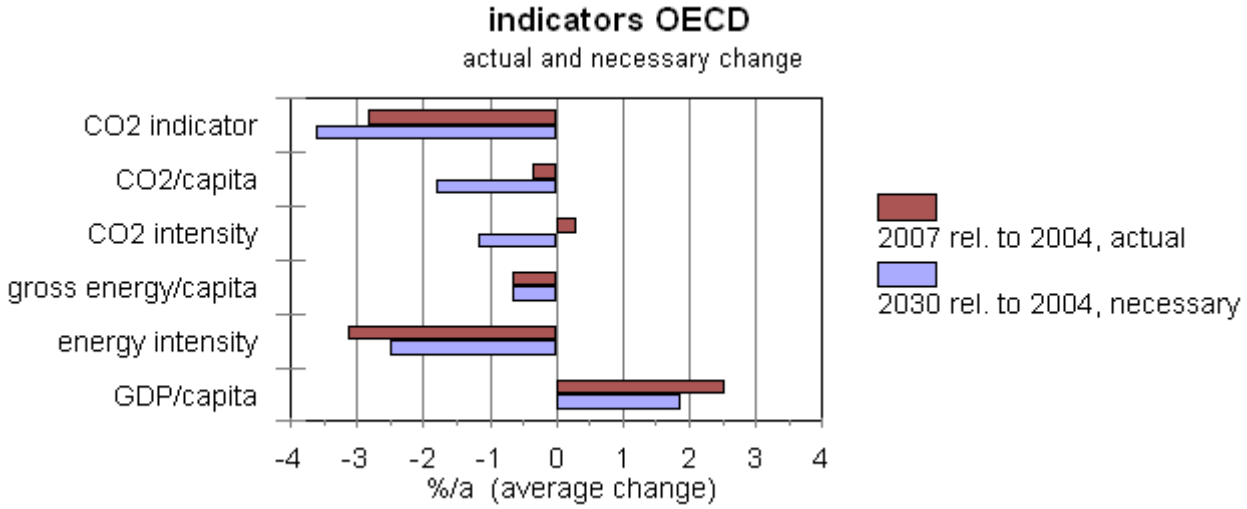

Figure 3. OECD indicators, effective change 2004-2007 (red) and required change until 2030 for climate protection for the stated GDP (PPP) change (blue)

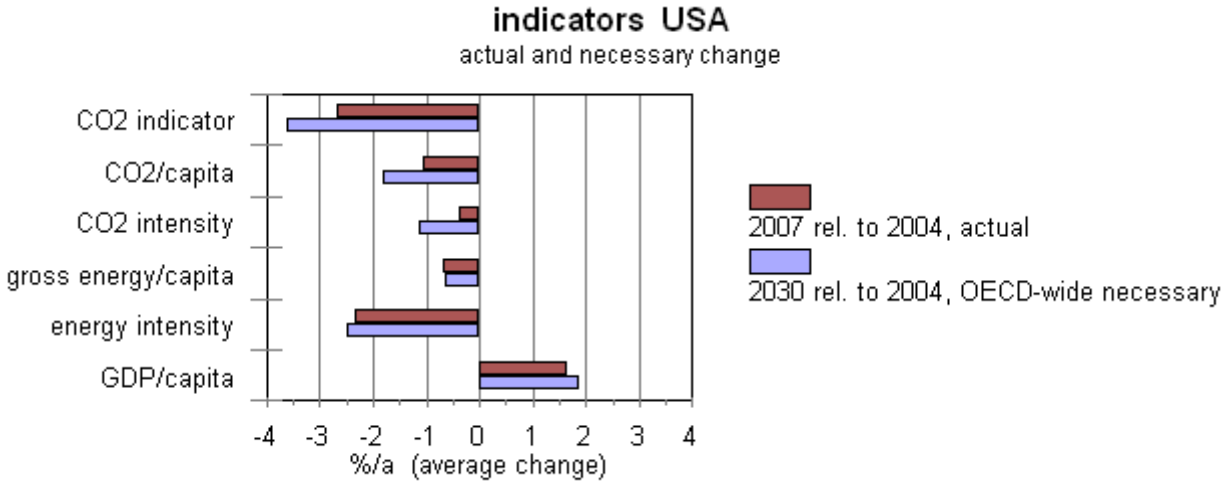

Figure 4. USA indicators, effective change 2004-2007 (red) and required change in the OECD until 2030 for climate protection for the stated GDP (PPP) change (blue)

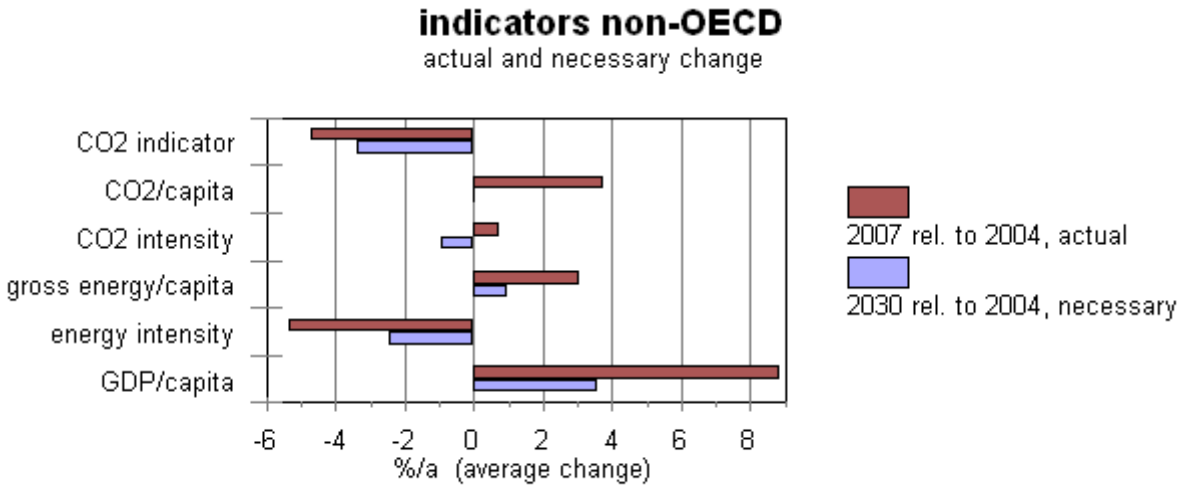

Figure 5. Indicators, non-OECD, effective change 2004-2007 (red) and required worldwide change by 2030 for climate protection with stated GDP(PPP) change (blue)

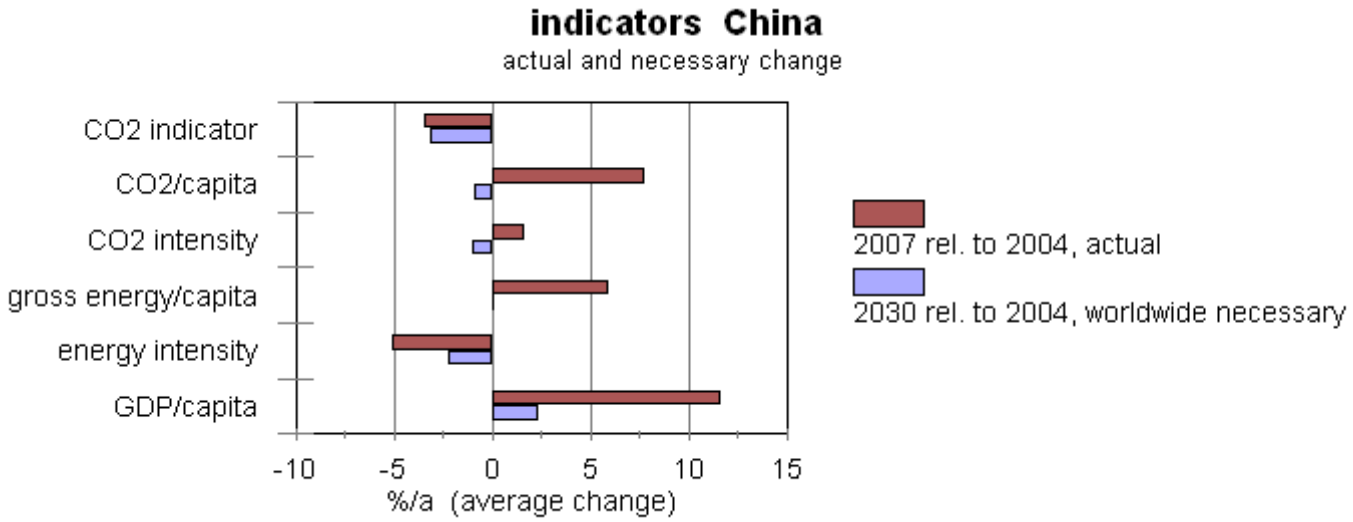

Figure 6. Indicators for China, effective change 2004-2007 (red) and worldwide required change until 2030 for climate protection with stated GDP(PPP) change (blue)

If the growth in GDP is greater than assumed, a correspondingly greater reduction of the CO_2 indicator is required