# Market Exchange Rates or Purchasing Power Parity: Does the Choice Make a Difference to the Climate Debate?[a]

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**In the year 2000, the Intergovernmental Program on Climate Change (IPCC) published its Special Report on Emission Scenarios (SRES).[1] The scenarios were defined by alternative assumptions concerning the demographic, economic, and technological driving forces, which, in large part, determine greenhouse gas (GHG) and sulfur emissions. The full set of scenarios produced a higher range of global mean temperature change over the 21st century than were contained in previous IPCC assessments.[2] Recently, the validity of the SRES Scenarios has been questioned. Critics have expressed concern about the way that economic indicators, such as gross domestic product (GDP), are converted from domestic currencies into a common currency such as dollars.[3] In short, they charge that the use of market exchange rates (MER), rather than purchasing power parity (PPP), has led to an upward bias in emission projections. This, in turn, has resulted in unrealistically high temperature projections. In this note, we estimate the differences in key climate-related variables that might result from choosing one approach over the other. Whereas the use of PPP for dealing with the volatility of exchange rates has been the subject of debate among economists and others for some time, we find that the choice of conversion factor makes only a small difference when projecting future temperature change.**

Policy makers often turn to GDP as a welfare measure for gauging the implications of a specific policy initiative. This has certainly been the case when examining the costs of policies to limit greenhouse gas emissions.[4] This raises the issue of how to compare GDP across countries. Traditionally, modelers have used market exchange rates (MER) for making the necessary conversions. However, some have argued that purchasing power parity (PPP) offers a better approach.[5] With PPP, a specific basket of goods and services is identified and is assumed to represent an equivalent value in every nation. The ratios of the prices of the goods and services are then used to make the conversion to a common currency. An extreme form of this approach would be to compare all currencies through the relative cost of a "Big Mac" hamburger in each country. Such a measure is published in the *Economist* on a regular basis.

Critics of PPP suggest that it has serious limitations for exchange rate conversions.[6] Among the criticisms are that: 1) the market basket of goods and services includes non-traded goods, and this precludes arbitrage; 2) there are significant transaction costs for

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traded goods; and, 3) the composition of the market basket is likely to differ across countries. Samuelson expressed his skepticism of PPP noting, "unless very sophisticated indeed, PPP is a misleading pretentious doctrine, promising what is rare in economics, detailed numerical precision."[7] For a discussion of the problems of using PPP in the context of projecting future carbon emissions, see ref. 8.

Rather than revisit the extensive literature on the choice of conversion factors, we ask a different question: *does the choice make a difference when it comes to projecting future temperature change?* To address this issue, we employ an intertemporal general equilibrium model that has been used to explore a variety of questions in the greenhouse debate.

The analysis is based on MERGE (a **m**odel for **e**valuating **r**egional and **g**lobal **e**ffects of greenhouse gas reductions). The model integrates submodels that provide a reduced-form description of the energy sector, the economy, emissions, concentrations, temperature change, and damages. In MERGE, the globe is partitioned into nine geopolitical regions: 1) USA, 2) WEUR (Western Europe), 3) Japan, 4) CANZ (Canada, Australia, and New Zealand), 5) EEFSU (Eastern Europe and the Former Soviet Union), 6) China, 7) India, 8) MOPEC (Mexico and OPEC), and, 9) ROW (the rest of the world). Note that the OECD (regions 1 through 4) together with EEFSU constitute Annex I of the UN Framework Convention on Climate Change. Regions 6-9 comprise the non-Annex I "developing" countries.

MERGE accounts for both price and nonprice-induced reductions in energy demand. Nonprice efficiency improvements may be brought about by deliberate changes in public policy, such as mandatory efficiency standards. Energy consumption may also decline as a result of shifts in the basic economic mix away from manufactured goods and toward more services. The autonomous energy efficiency improvement (AEEI) rate summarizes such nonprice-induced sources of energy intensity reduction. The annual AEEI rate is assumed to be proportional to the per capita GDP growth rate. The faster the economy grows, the greater the opportunity for efficiency improvements.

To date, MERGE has been based upon market exchange rates for cross-country comparisons. GDP projections through 2020 have been taken directly from the Energy Information Agency's *International Energy Outlook, 2001*.[9] Potential GDP growth beyond 2020 depends upon both population and productivity trends. In MERGE, it is assumed that per capita income differences remain sizeable in 2100, but that per capita income will eventually converge in all regions. This "limit to growth" is not binding, however, within the time horizon of the model. For a detailed description of MERGE and its key assumptions, see our website:

http://www.stanford.edu/group/MERGE/

For purposes of converting GDP expressed in MER to GDP expressed in PPP, we have fitted the following relation to the cross-country comparison data for the year 2000.[10] (See

Figure 1.) The parameter 1.25 is chosen so that the curve will reproduce the world ratio of MER to GDP at the mean level of per capita income (expressed in thousands of dollars).

Equation 1: PPP/MER = 1 + (1.25/per capita income)

For incomes in the neighborhood of $5 thousand per capita, the PPP-MER difference approaches only 20% and is still lower thereafter. On Figure 1, for example, compare the point for China with the one for Western Europe (WEUR). This difference has been reported by a number of analysts. See, e.g. ref. 11.

In order to examine the impacts of the choice of exchange rates on projections of future temperature change, MERGE is run in two modes. In one, we use the standard MER approach. In the other, we rewrite the "potential GDP" so as to be consistent with equation 1. This means that we raise the GDP of the initial year, 2000. By equation (1), the growth rates are lowered during the subsequent years.

Figure 2 compares carbon emissions over the $21^{st}$ century using the two alternative approaches. From a global perspective, emission projections are lower when GDP is expressed in PPP than in MER. From Figure 3, however, we see that virtually the entire emissions decline occurs in the non-Annex I countries.

Why does this occur? First, from Figure 4, note that with the exception of the countries of Eastern Europe and the Former Soviet Union (EEFSU), the initial per capita income in Annex I countries is well above $5000 per capita. Hence, it makes little difference whether the GDP calculations are based on MER or PPP. With the developing countries, however, the story is quite different. Here, the use of PPP makes a sizeable difference in the early decades of the century.

Second, the base year assumptions regarding energy intensity are a critical determinant of future energy use. Figure 5 shows how energy per unit of output changes with the choice of exchange rate. In the case of the OECD regions, the exchange rate makes little difference. However, for low-income regions, energy intensity is considerably lower when output is expressed in PPP rather than MER. Indeed, in the case of India, energy intensity falls below that of the US in the base year.

Finally, in the case of non-OECD countries, not only is base year energy intensity lower with PPP, but so is per capita income growth. This has two countervailing effects. On the one hand, emissions will grow at a slower rate. On the other hand, the rate of energy efficiency improvements will fall. Recall that the AEEI is proportional to the per capita GDP growth rate.

Table 1 summarizes our estimates of the impact on temperature change for the reference case of MERGE.[a] Although the choice of conversion rates has a marked impact on carbon emissions at the regional level, the effect is relatively small at the global level. As a result, the impact on CO2 concentrations and temperature change is even smaller.

Table 1. Change in key variables in 2100 – base case

| | Carbon Emissions (Billion tons of C) | CO2 Concentrations (PPMV) | Temperature Change Over the 21st Century (Degrees C) |
|---|---|---|---|
| MER | 21.0 | 731 | 2.52 |
| PPP | 18.0 | 678 | 2.38 |
| **Reduction from MER** | **14%** | **7%** | **5.5%** |

We have also conducted some limited sensitivity analysis to explore the robustness of these results. In one case, we assume that, in 2100, per capita GDP in non-OECD countries will be half that of the base case. In the second case, we assume that per capita GDP will be twice that of the base case. Table 2 summarizes our results.

Table 2. Change in key variables in 2100 – sensitivity analysis

| | Low growth case | | | High growth case | | |
|---|---|---|---|---|---|---|
| | Carbon Emissions (Billion tons of C) | CO2 Concentrations (PPMV) | Temperature Change Over the 21st Century (Degrees C) | Carbon Emissions (Billion tons of C) | CO2 Concentrations (PPMV) | Temperature Change Over the 21st Century (Degrees C) |
| MER | 17.0 | 678 | 2.41 | 23.1 | 783 | 2.64 |
| PPP | 14.5 | 637 | 2.29 | 21.4 | 727 | 2.49 |
| **Reduction from MER** | **15%** | **6%** | **5.0%** | **7%** | **7%** | **5.6%** |

Returning to our initial question, does the choice of exchange rates make a difference when projecting future temperature? The answer appears to be yes, but it is only a minor difference. Hence, to a rough approximation, these calculations suggest that we may decouple the debate over the proper currency conversion rate from that over temperature change.

[a] For a description of how emissions are converted to atmospheric concentrations, and how atmospheric concentrations are converted to potential and actual temperature change, see the MERGE code that can be accessed through our website.

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*References*


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Figure 1.  PPP/MER vs. per capita income at MER in 2000
(9 MERGE regions)

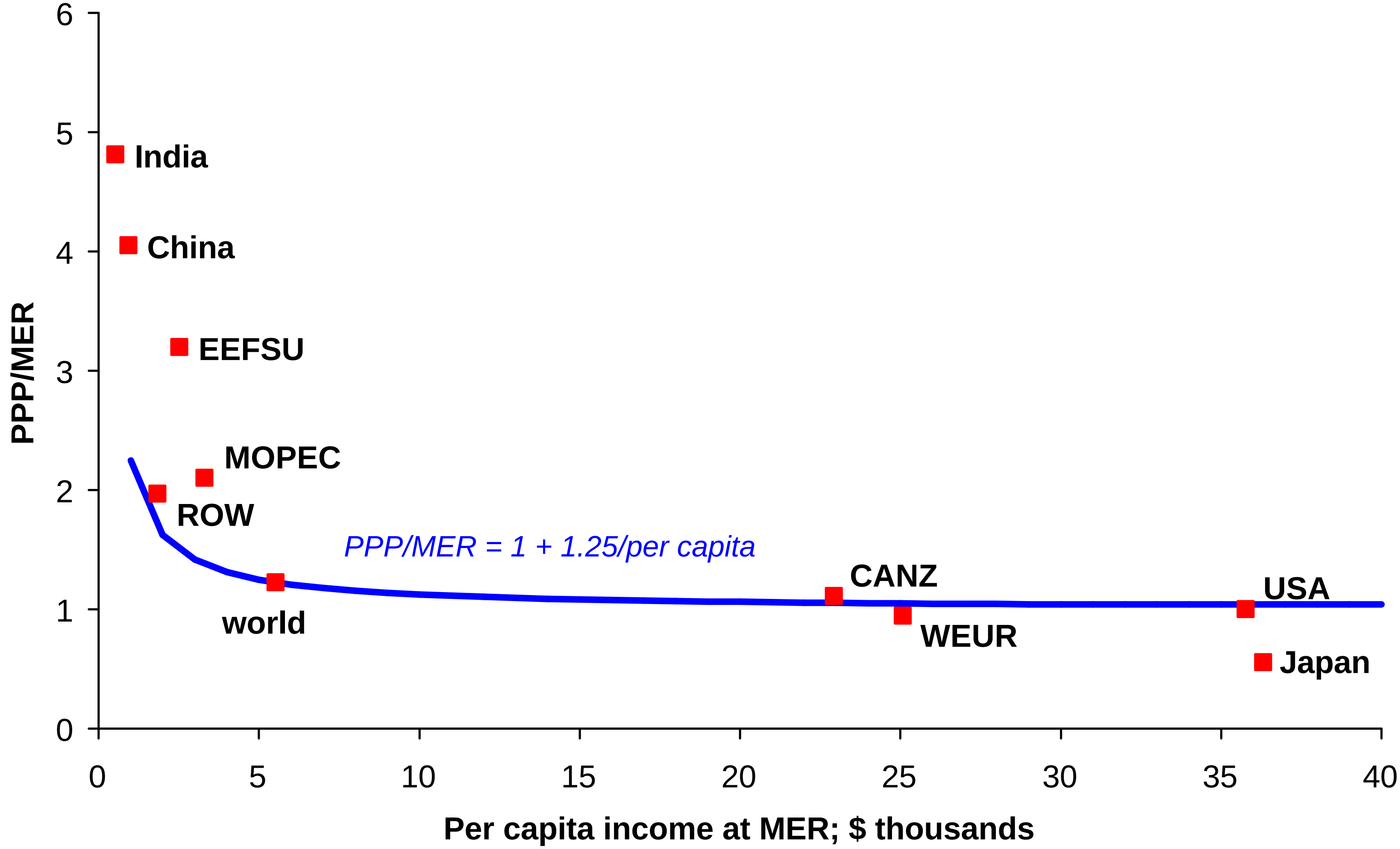


**Figure 2. Global Carbon Emissions**

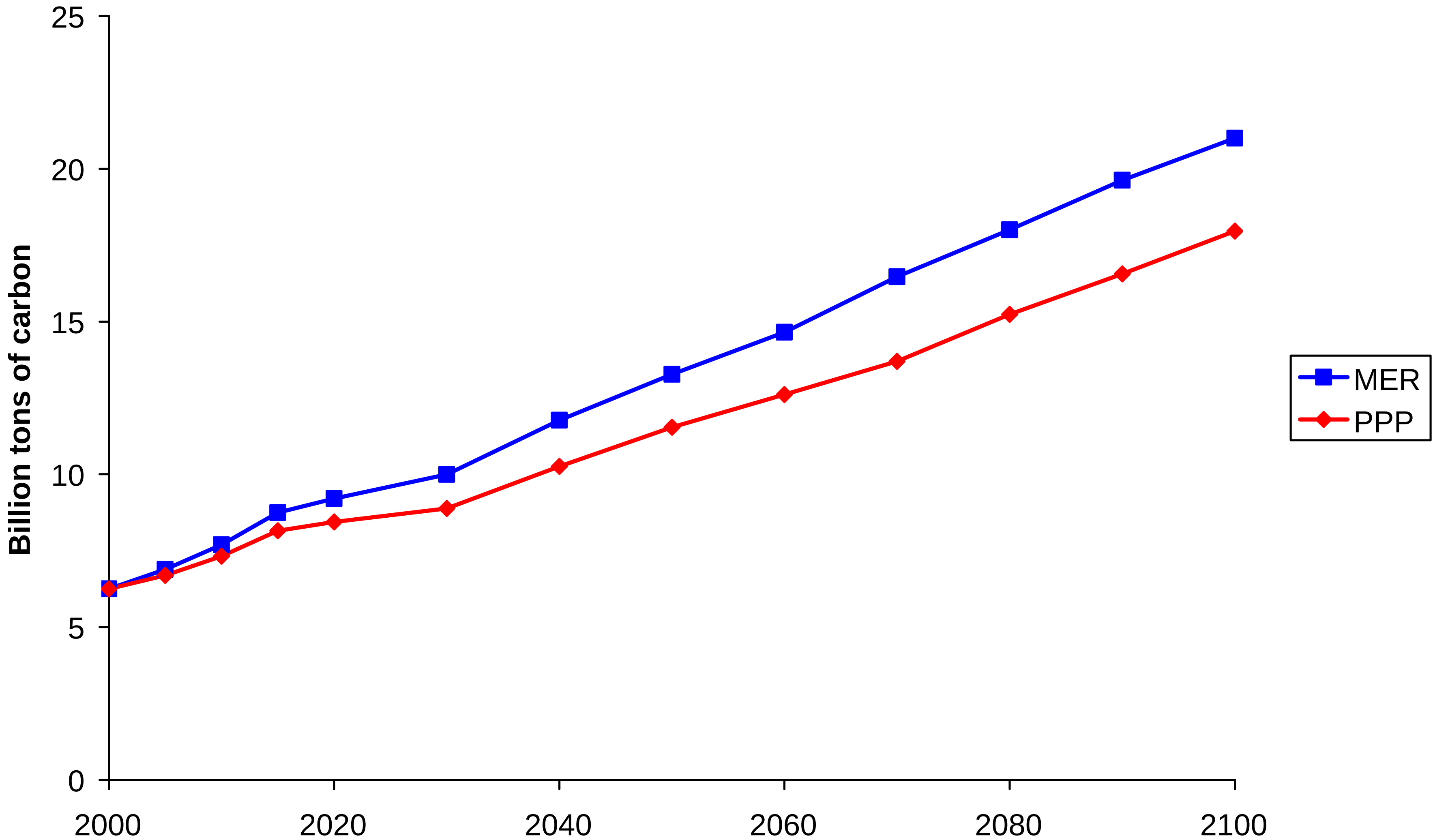


**Figure 3. Regional Carbon Emissions**

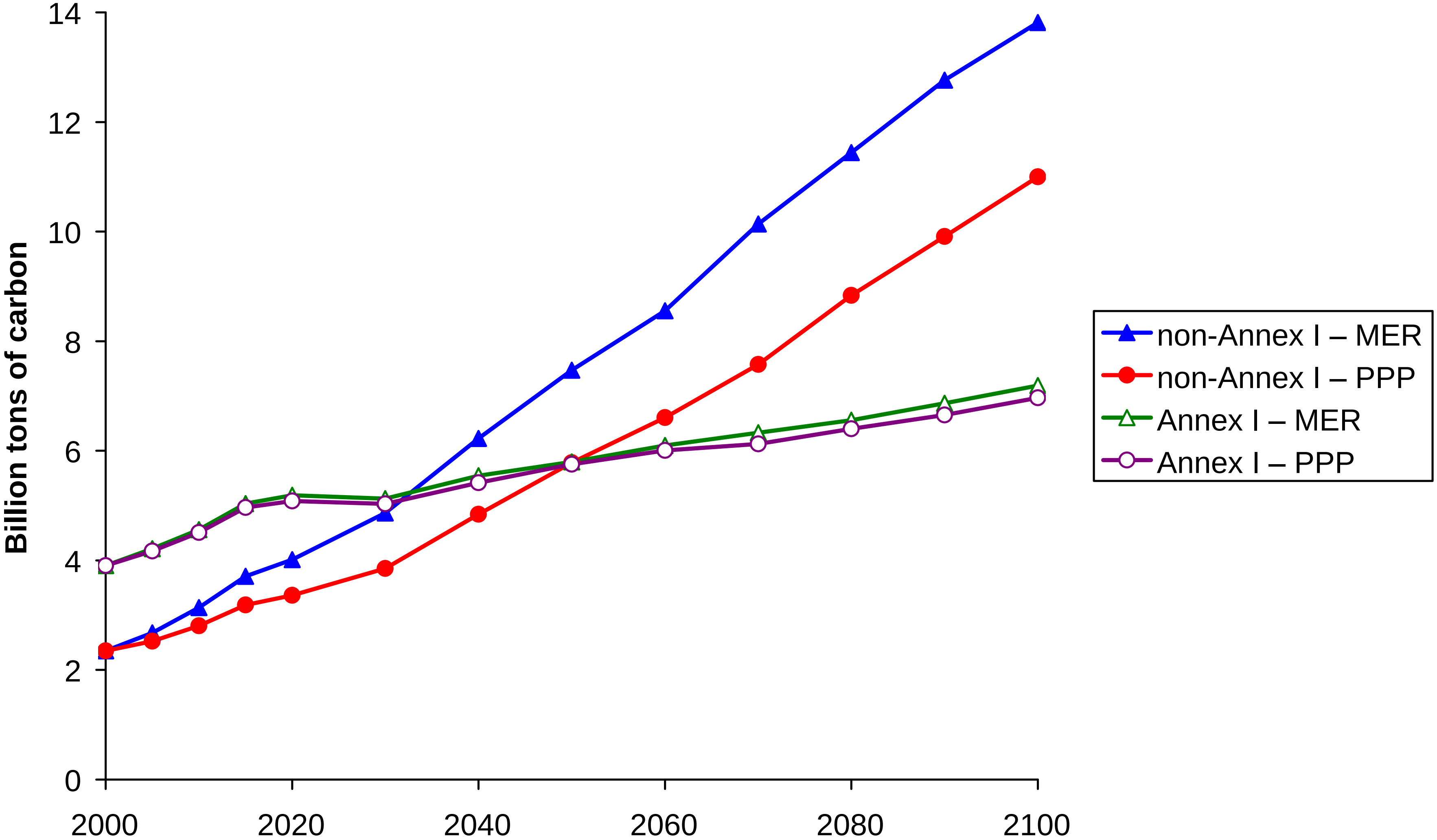


**Figure 4. Per Capita GDP at MER**

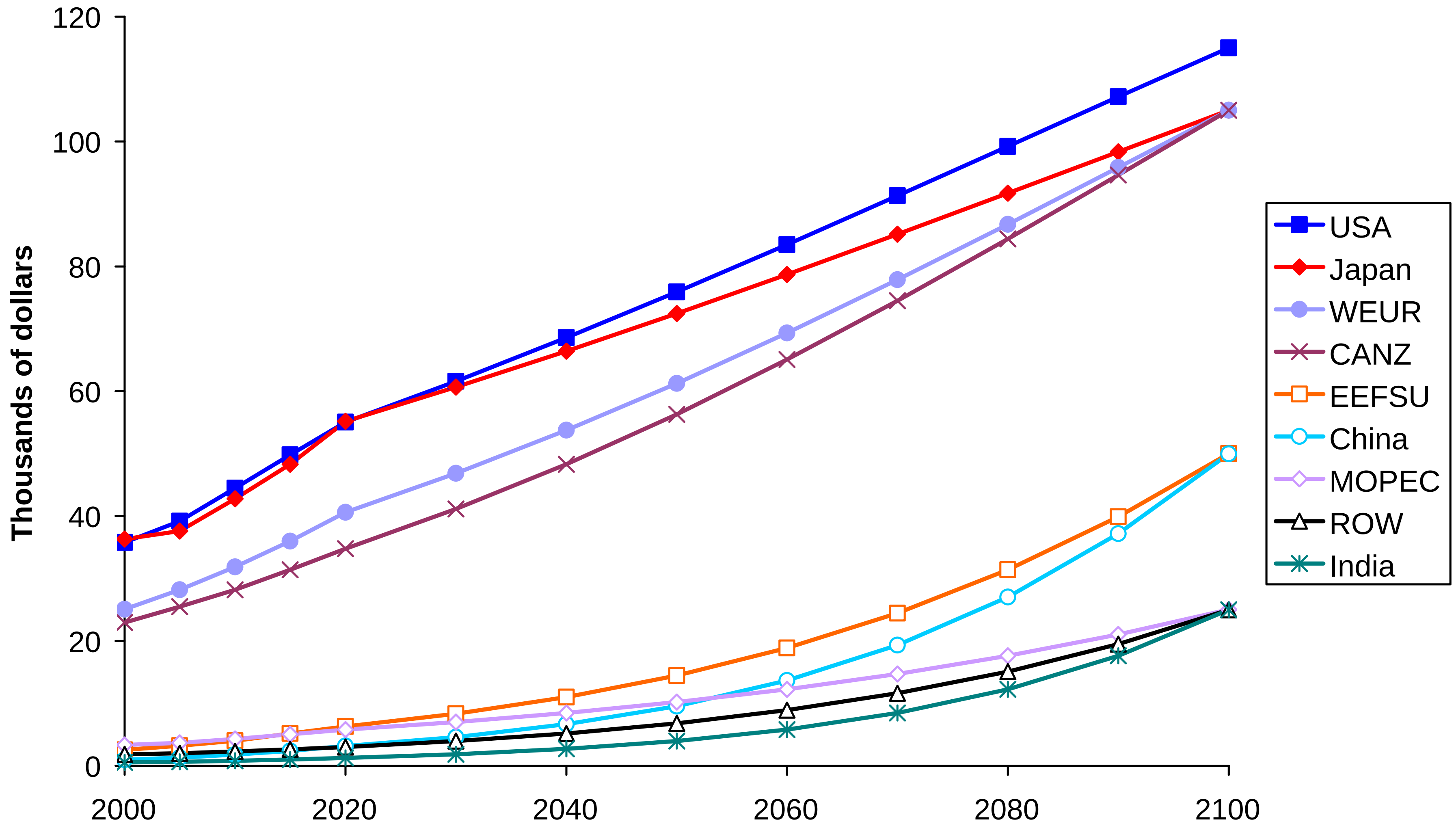
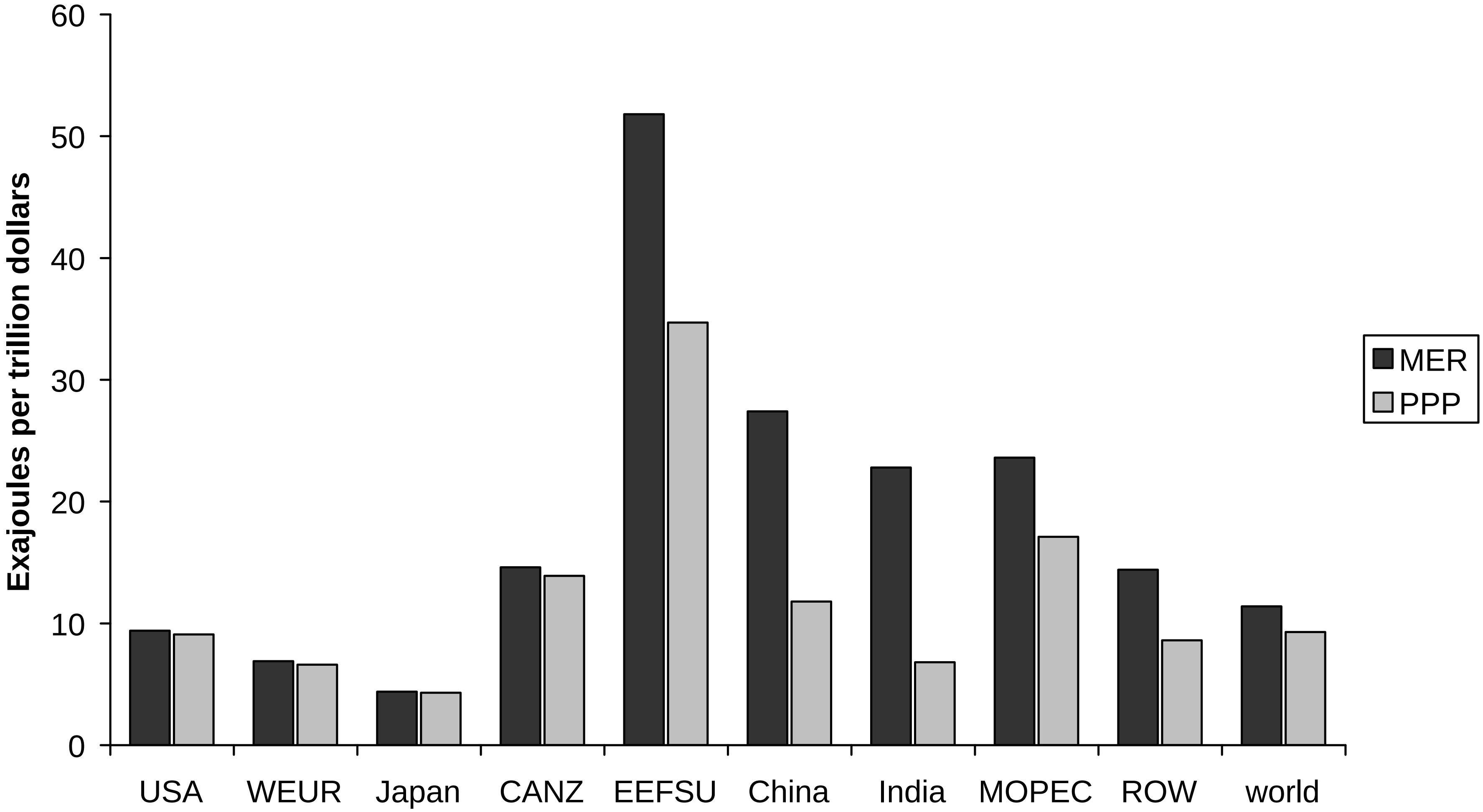


**Figure 5. Energy to GDP Ratios in Base Year (2000)***




**PPP converted to MER using equation 1.*