Global Inequality in Energy Consumption: Insights from Statistical Physics

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About 10 years ago, we proposed a mathematical analogy between the probability distribution of money among economic agents and the probability distribution of energy among molecules in a gas in statistical physics[1]. The analogy is based on treatment of both money and energy as a limited resource partitioned and redistributed among the participants using the principle of maximal entropy. Subsequent quantitative studies have found that, indeed, the probability distributions of wealth and income for different countries are often given by the Boltzmann-Gibbs exponential distribution for the majority of population: see review[2]. In the recent study[3], we applied these ideas to the global distribution of energy consumption per capita for different countries around world using the data from the Word Resources Institute[4]. We found that this distribution is also approximately described by the exponential function. We argue that the global energy production is another limited resource, so the same partitioning principle can be applied, as described above. Comparing the data for 1990 and 2005, we find that the latter distribution is closer to the exponential, and the boundary between developed and developing countries in terms of energy consumption is less pronounced. We attribute this change to the effect of globalization, which, however, does not lead to the energy consumption equality, but rather to the exponential distribution with a high degree of inequality. Given the experience from statistical physics, we argue that this highly unequal distribution is very robust and difficult to change, because it maximizes entropy. These conclusions have important consequences for strategies aimed at reduction of fossil fuel consumption and CO2 production. It is not likely that the same strategies would be effective for both high and low ends of the distribution because of the inherent and very stable global inequality in energy consumption.

[1] A. Dragulescu and V. M. Yakovenko, 'Statistical mechanics of money', The European Physical Journal B 17 (2000) 723.

[2] V. M. Yakovenko and J. B. Rosser, Jr., 'Colloquium: Statistical Mechanics of Money, Wealth, and Income', Reviews of Modern Physics 81 (2009) 1703.

[3] A. Banerjee and V. M. Yakovenko, \'Universal patterns of inequality\', New Journal of Physics 12 (2010) 075032.

[4] World Resource Institute data, http://earthtrends.wri.org.