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Gerd Ganteför

A Provocative Thesis: Oil, Gas, Coal and Uranium Are Indispensable Energy Sources for the Poor Countries*

Abstract: An integrated approach of the topics 'population', 'energy' and 'climate' results in conclusions contrary to public opinion. Population growth will lead to disaster ten times faster than global warming. 2.5 billion people in the poor countries account for a population growth of one billion every 12 years. Fertility rates decrease with increasing gross domestic products (GDPs). Increasing GDPs correlate with increasing energy consumption. Wind power and solar energy are too expensive for the poor countries. Low-price energy can only be produced with coal, gas, oil and uranium. Therefore, many more coal-fired power stations and nuclear reactors need to be built and hopefully population growth will slow down. Once population is stabilized environmental issues can be addressed.

1. Introduction

Many people believe that regenerative 'green' energies are the only means to fight global warming. They propose to stop consuming oil, gas and coal immediately and switch over to clean energies such as wind power and solar energy. Germany claims to be the leading country in the development of clean energy technologies. Consequently, the public believes that Germany depends less on fossil fuels than other industrialized countries. But public opinion is mistaken. The share of fossil energy in the total consumption of primary energy is the same in Germany as in the rest of the world and is about 80 percent. And public opinion is mistaken concerning an even more fundamental issue. The priorities have not been set right. Climate change is not an impending catastrophe and it would be disastrous to subordinate all measures to the urge of reducing carbon dioxide emissions. Such a single priority dominating all decisions is an exaggeration and it could have harmful consequences (Lomborg 2007).

In reality, the more urgent problem is population growth. Every 12 years the world population increases by one billion people (UN 2009). This is the same number of people as there are living in Africa today. A comparison of

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the dangers of global warming and of population growth is possible based on the claim that the protection of human life must have the highest priority. The main threats of global warming are sea level rise, storms and droughts. The main threats of population growth are famines, epidemics and civil wars. In the following it will be illustrated that the consequences of population growth threaten human lives on a ten times faster time scale than the ones of global warming. Global warming might even have some advantages. An elaborate analysis of the predictions of the climatologists is beyond the scope of the present contribution and is presented elsewhere (Gantefӧr 2010). Here, the sea level rise predicted by the Intergovernmental Panel on Climate Change (IPCC) is taken as one example of the threats of climate change.

Global warming and population growth are interrelated. Already today, the increase of carbon dioxide emissions is no longer driven by the economies of the developed countries but by the population growth in the less and least developed countries. More people burn more fossil fuels. Already in 1972 the Club of Rome pointed out the dangers of the population explosion in the well-known book *The Limits to Growth* by Meadows et al. (1972). Today population growth is driven by the high total fertilities rates in the least developed countries. The total fertility rate is the average number of children that are born to a woman over her lifetime. These rates need to be reduced. In the following, two important relationships will be pointed out: 1. If a country develops economically, the fertility rate decreases. 2. The availability of affordable energy is a precondition for economic growth in poor countries. Mass consumption of coal, natural gas, crude oil and uranium accompanies economic growth and this hopefully stalls population growth. A maximum global population of 10 billion might be able to live on earth peacefully and at a reasonable standard of life. After world population is stabilized, there is still time to tackle the problem of global warming and other environmental issues.

For this integrated study of population, energy and climate considerable simplifications were necessary and many details have been omitted. The present contribution cannot provide a full analysis of the three problem areas. Instead, it emphasizes that a re-consideration of the almost neglected problem of population growth could result in an inversion of the baselines of future energy politics. A view restricted to global warming and environmental issues could have disastrous consequences.

2. The Initial Position

The consumption of primary energy is the sum of all energies used by a nation such as crude oil imports and nuclear power generation. Electricity is only a fraction of the total energy turnover and the greater share is directly consumed, e.g., for heating and combustion. The largest amounts are needed for heat supply and for mobility purposes (Bundesministerium für Wirtschaft und Technologie 2009). Fig. 1 displays the contribution of the different sources of primary energy to total consumption in the USA, Germany and the world.[1] In this figure, the contributions from the fossil energies crude oil, natural gas and coal have been summed up and marked black. 'Others' contain heat from combustion of waste and sludge (important in Germany), biofuels (important in the US) and peat and wood (considerable contributions to the world energy consumption).

Although Germany has been subsidizing regenerative energies for decades, the contribution of solar energy, wind power and hydropower to the total primary energy consumption is smaller than in the US. This is surprising, but there is a simple reason. Usually, the largest contribution to the green energies 'water, wind and sun' comes from hydropower. It is the oldest technology of electricity generation and has been developed up to its full potential in all industrialized countries including Germany and the US. At low population density, hydropower might be able to provide 100% of electricity as it is the case in Norway. With increasing population density more and more additional sources of energy are needed. In Germany, population density is high (230 people/km^2) and in the US it is much lower (30 people/km^2). This explains why hydropower can make such a large contribution to the energy supply of the US. In general, it is easier to switch over to regenerative energies at low population density.

Of the heavily subsidized new energies only wind power generates a noticeable amount of energy in Germany (6.4% of electricity generation in 2008).[2] The contribution of solar energy is an order of magnitude smaller. It is important to mention that in some diagrams the green energies appear to contribute with higher percentages. Quite often in such publications the so-called 'installed power' is displayed. The comparison of the 'installed power' with the power of conventional power stations would only be meaningful if the sun was shining 24 hours a day and the wind blew all year long. In Fig. 1 the truly produced energy amounts are compared and this gives smaller percentages for wind and solar power. Both energies are far from making a perceptible contribution to the global primary energy consumption. In 2004 wind power and solar energy provided 0.06% and 0.03% of the global primary energy, respectively (Bundesanstalt für Geowissenschaften und Rohstoffe 2009).

The US, Germany and the world produce roughly 80% of their primary energy by combustion of fossil fuels. Germany differs from the world by its larger share of nuclear energy. There are other small differences: In the US the largest contribution to the segment 'Others' is biofuels, in Germany it is heat from waste and sludge and in the world it is wood and peat. But beside such details, the three diagrams prove that the world, Germany and the US heavily depend on the supply of fossil energies.

The goal of the Kyoto Protocol is the reduction of the global carbon dioxide emissions. Germany and several other industrialized countries will meet the limits defined by the protocol. This will be achieved partly by a reduction of primary energy consumption and partly by the replacement of coal and crude oil by natural gas (Bundesministerium für Wirtschaft und Technologie 2009). Given

[1] See Energy Information Administration 2009; Bundesministerium für Wirtschaft und Technologie 2009 and International Energy Agency 2009.

[2] See Bundesministerium für Wirtschaft und Technologie 2009.

a certain amount of generated heat the combustion of natural gas results in 20–40% less carbon dioxide emissions than the combustion of oil and coal. However, the Kyoto Protocol has no recognizable effect on global carbon dioxide emissions. These increased dramatically since 1990 (Fig. 2) with no visible attenuation. Several of the developing countries, namely China, invest heavily into energy production and this is mostly based on coal, because it is the cheapest source of energy (Küffner 2007). Here, public perception and reality diverge again. While most citizens think the Kyoto protocol is working it has no effect in reality. Carbon dioxide emissions increase every year driven by the energy demand of the growing population.

3. Population Growth

150 years ago the industrial revolution changed societies and the enormous exponential growth of the global population started (US Census Bureau 2009). Exponential growth means that the numbers double in constant time intervals. In the prime time of population explosion the number of people on earth doubled every 40 years. Obviously, this cannot continue forever (Meadows et al. 1972). There are several attempts to calculate the maximum number of human beings which the earth is able to carry. This number is called the 'carrying capacity'. The estimates produced various results ranging from 10 billions to 30 billions (Weiss 2004). Most calculations are based on the amount of food which can be produced on the available farm land. If people limited their daily food consumption to a minimum, today 35 billion people could survive on earth (Gantefór 2010). But then population density would be everywhere as high as in Japan. Such a scenario seems rather unrealistic. An extensive study of the Word Wildlife Fund for Nature (2008) predicts that at a maximum 5 billion people can live on earth with a long-term perspective. In this study not only the need for food but also the consumption of other resources such as water and energy and the production of waste are taken into account. Other studies support these results (Daily/Ehrlich 1992). Today, 6.7 billion people live on earth and according to the WWF study, they consume more resources than the earth is able to provide. Hence, they live on the 'savings' of the earth. For example, in dry countries more groundwater is used than can be replaced by natural processes. At some time in the future the stock of groundwater will run out there. Such considerations illustrate the threat to human life caused by excessive population growth. In a not too far future, the amount of food and water provided by the land will no longer be sufficient for the growing population. People in overpopulated areas will suffer or even starve to death. And they will start to fight for survival.

But there is good news. Today population no longer grows exponentially but increases by one billion every 12 years (UN 2009). This is still a huge amount, but exponential growth has slowed down to a linear increase. If the exponential growth had continued, the time interval needed for a one billion rise would have become shorter and shorter, and this is unimaginable. The attenuation is caused by the decrease of total fertility rates in almost all countries of the world (UN

2009). For several selected countries and the world, Fig. 3 displays the variation of total fertility rates between the years 1950 and 2050. Up to the year 2007 these are measured data and reflect a true development, while the numbers for the future are based on an optimistic prediction of the UN. Already today there are hints that in some of the least developed countries the trend might reverse because of increasing poverty (Askew et al. 2009). It is possible that the growth rate starts increasing again, which would be disastrous. Today the global mean value of the total fertility rate is 2.6. For a stable population, the value should be between 2.1 and 2.3 to account for accidents and diseases.

4. The Correlation between Total Fertility Rate and Gross Domestic Product

There are several reasons for the decrease of the total fertility rates depending on the specific economic and cultural situation in a certain country. Simple reasons are access to means of family planning and access to education especially for women. An example of a more complex reason is the transition from an agricultural society to a service economy, in which education determines the social position. All these reasons correlate strongly with the standard of living, which itself correlates with the gross domestic product (GDP). As a result, there is a strong connection between total fertility rates and GDP. Fig. 4 displays the GDPs and the fertility rates for 157 countries, for which these data were available. Each dot represents one country with its fertility rate (UN 2009) and GDP.[3] Wherever different sources provided different numbers the average value has been taken. The pronounced correlation is indicated by the grey line and most data points are close to this line. For the moment, this is just a statistical correlation and it alone provides no information about causal relation. It is necessary to carry out further studies to reveal the underlying mechanisms causing the correlation. There are several publications[4] indicating a causality running from a higher level of development to the reduction of the total fertility rate. The level of development is tied to GDP and because of that, economic growth is a means to reduce population growth.

Countries with high total fertility rates have low GDPs of less than 1500 US$ per capita and per year. This means that many people must live from annual incomes of less than ~1000 Euros. Today, this applies to 59 countries with a total of 2.5 billion people and this is roughly a third of mankind. Table I provides a list of these countries.

[3] See Central Intelligence Agency 2008; International Monetary Fund 2007 and World Bank 2007.

[4] See Deutsche Stiftung für Weltbevölkerung 2008; National Wildlife Federation 2008 and University of Michigan's Global Change Curriculum 2009.

5. The Correlation between GDP and Energy Consumption

Similar to the correlation between GDPs and total fertility rates there is a correlation between GDP per capita and energy consumption per capita. Several organizations[5] collect data on primary energy consumption per capita and per year. In Fig. 5, energy consumption per capita and per year is plotted against the corresponding GDP value. Obviously, there is a correlation between the two parameters and most data points are located close to the grey line representing the average of all data points. At low values, energy consumption increases strongly with increasing GDP. At higher values the curve flattens and a further growth of GDP is accompanied by a less steep increase of energy consumption. Accordingly, for the least developed countries a growth of the economy is accompanied by a strong relative increase of energy consumption. For the industrialized countries, a further increase of GDP does not necessarily result in a strong increase of energy demand. A higher energy efficiency using modern technologies can dampen energy consumption. This effect can be illustrated by an example: In the less developed countries houses with no insulation need much energy for heating, while high-tech low-energy homes need almost no energy for heating. Such homes can only be built by the developed countries. For the least developed countries, energy efficiency is low and a strong increase of energy consumption is a precondition for rising standard of living.

Fig. 5 proves that a higher degree of prosperity is accompanied by higher primary energy consumption. As in the case of Fig. 4, this is just a statistical correlation and provides no information about causal relations. Studies about a possible causality between GDPs and energy consumption have been carried out by several researchers. However, the specialists did not come to an agreement and produced contradictory results. Some publications prove that there is no causal connection. But there are other studies that focussed on the situation in the least developed countries and several of them[6] claim that they found a causality. It may run either way: higher energy consumption causes economic growth or vice versa. Looking at these data, a reasonable conclusion could be that energy is a precondition for economic growth. This conclusion would be justified if there were any causal connection and it might be valid only for the least developed countries. Although there is an ongoing debate on this issue, Fig. 5 provides strong support to the conclusion. Energy consumption and economic growth are closely interrelated and this is especially true for the least developed countries. If a country reaches a certain level of development, energy supply might not be that critical any more. Other parameters such as the type of the political system and the degrees of corruption and bureaucracy have a stronger impact on economic development.

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[5] See Energy Information Administration 2009; International Energy Agency 2009; Bundesministerium für Wirtschaft und Technologie 2009 and World Energy Council 2008.

[6] See Chontanawat 2008 and Odularu/Okonkwo 2009.

6. Energy Prices

According to the above considerations, the least developed countries need large amounts of affordable energy to enable economic growth and to pass the threshold of poverty defined in Fig. 4. Based on the correlation displayed in Fig. 5 it is even possible to estimate the amount of energy needed. The poverty limit defined in Fig. 4 is a GDP of 1500 US$ per capita per year and it is marked in Fig. 5 by a vertical line. This vertical line crosses the correlation at a point that corresponds to an energy consumption of 4000 kWh per capita per year. Therefore, the poverty limit can also be defined by an energy value. On average, people with primary energy consumption of less than 4000 kWh per capita per year are very poor and most likely belong to the countries with high total fertility rates. For a rough estimate of a reasonable energy price we assume that an average family in such a country has to live on a yearly income of 1000 Euros. Many have less and several might have more, but for now this number is taken as a standard. People can spend only part of their income for energy. In the developed countries this is about 10%, which is needed for fuel, heat and electricity. If we assume a constant percentage of income spent for energy in the least developed countries, this amounts to 100 Euros per year. Accordingly, the 4000 kWhs which are necessary to overcome the poverty limit must cost no more than 100 Euros, which translates into to a maximum energy price of 2.5 Euro cents per kWh. Of course, the true price limit may depend on many more factors and it is certainly different for different countries. But the above consideration gives the correct order of magnitude. The least developed countries can pay only a few cents per kWh. In other words: Poor countries cannot afford expensive energies.

The total amount of energy needed for the least developed countries can be estimated based on Figs. 4 and 5, too. There are 2.5 billion people living in these countries and they need at least 4000 kWh per capita and per year to pass the threshold. For 2.5 billion people this adds up to 10,000 Terawatt hours per year, which equals the energy production of 2000 regular 1-Gigawatt power stations. Only part of this energy needs to be electricity. More than half of it can be provided directly by primary energies such as coal or crude oil.

Fig. 6 displays a list of the production costs for heat or electricity. Most 'classical' energies such as coal and crude oil are inexpensive and the production costs are below 5 Euro cents per kWh. The prices vary with time, the most prominent example being the crude oil price. It peaked in the summer of 2008 at 140 US$ per barrel and dropped 9 months later to 50 US$. Hence, the numbers given in Fig. 6 can provide a snapshot of the prices only. Besides these market induced fluctuations, different references provide different numbers for the costs of regenerative energies. The data displayed in Fig. 6 are based on an elaborate review of existing wind farms and solar energy power stations (Ganteför 2010) and take investment costs and expected lifetimes into consideration. The calculated costs are not future projections but give a picture of the energy costs today. Other studies predicting lower costs for wind power and solar energy may include an anticipated price reduction due to future technological developments.

All prices given in Fig. 6 refer to one kilowatt hour of generated heat or electricity. For electricity, this covers the costs for the fuel, the interest rate of the investment, the amortization and the operating costs of a power station. The price of nuclear power includes the anticipated costs for permanent disposal of nuclear waste. The final consumer prices will be considerably higher, because taxes and profits have to be added. The figure points out that wind power and solar energy are too expensive for the least developed countries (Voß 2007). In contrast, coal used for the generation of heat is the least expensive source of primary energy and the prices of natural gas and crude oil are only a little bit higher. Low price electricity can be generated from coal, natural gas, uranium and hydropower. Accordingly, the demand for coal, gas and uranium will increase dramatically and this will certainly have an effect on the prices.

It is difficult to predict energy prices, but it is possible to estimate the amount of natural gas, coal and uranium available on earth. Most experts agree that the supply of crude oil will last another 10–20 years and then it will become increasingly scarce and expensive. Crude oil and natural gas are of similar origin, but the gas can withstand much higher temperatures, which prevail at great depths. Accordingly, large deposits of natural gas might exist at depths far below the oil fields. Experts estimate that there should be at least three times more natural gas than crude oil and the gas resources are still almost untouched. They might last for more than 100 years. Coal is abundant and there might be enough coal on earth even for 1000 years. Finally, uranium is a metal such as lead and silver and earth's crust contains 3 gram/ton of uranium on average, which is much more than, e.g., its content of silver (0.12 gram/ton). Hence, uranium will last much longer than coal. The assumption seems reasonable that the prices for natural gas, coal and uranium will stay low because there are plentiful deposits for at least another 100 years (Gantefór 2010).

The above considerations explain the situation in China today. The famous Three Gorges Dam has attracted a lot of attention. Its huge turbines create 18 Gigawatts of electrical power replacing the same number of big conventional power stations. In addition, in 2007 every few days a new coal-fired power station went into operation (Küffner 2007) and China plans to build whole fleets of nuclear reactors (Tagesanzeiger 2007). The investments in hydropower, coal and uranium are quite understandable looking at Fig. 6. These are exactly the energies with the lowest prices.

7. The Top Priority: Global Warming or Population Growth?

Bangladesh is a persuasive example for the urgency of the problem of population growth. The country is half the size of Germany, but has twice the number of people. Population growth amounts to ~2% per year at a total number of 150 million people. Accordingly, the population grows by three million per year. Actually, Bangladesh must build a city about the size of Berlin each year to accommodate the growing population. At this growth rate, in 100 years there are more people in Bangladesh than there are in Africa today (= 1 billion). Of course this is impossible. Long before that the country will subside into devastation and desperation. Population growth can be viewed as a loss of area available for each individual. If population grows by 2%, each citizen loses 2% of space per year. After 10 years each inhabitant has 20% less space at his disposal. Fig. 7 shows a simplified map of Bangladesh. The areas close to the Bay of Bengal (marked grey) will be flooded when the sea level rises by 1m, which is predicted to occur in ~200 years. It corresponds to a loss of 20% of the area (World Bank 2000). This illustrates that the problem of population growth is ten times more urgent than the problem of sea level rise.

The case of Bangladesh is an extreme example and the reader might think that the factor of ten deduced from the losses of area per capita by population growth and sea level rise might hold for this case only. But there are other examples. In the Netherlands there is no population growth and there are 100 years of time to find measures against the sea level rise of 0.5m. Nigeria, the most heavily populated country in Africa, will lose only a small part of its area by sea level rise. Here, population grows by an annual rate of 2.8% corresponding to 4.2 million newly born human beings each year. Already today, the country is struggling to feed its population. The country is running out of usable farmland and there is not much time left to throttle back the population explosion. The comparison of the Netherlands threatened by global warming and Nigeria fighting population growth might give a number even higher than the factor of ten deduced from the example of Bangladesh.

Here, sea level rise is taken as one example of the threats caused by global warming. A careful analysis of the publications of climatologists and paleoclimatologists shows that other consequences such as droughts and storms are by far less disastrous than announced by the media (Ganteför 2010). E.g., global mean temperature showed no correlation with the number and violence of hurricanes during the past 3000 years. And climatologists agree upon an increase of global precipitation, which makes predictions of an expansion of deserts rather implausible. Hence, even if all consequences of climate change are taken into account, climate change might cause serious problems on a time scale of 100 years, while overpopulation is a problem in the least developed countries already today and gets worse on a time scale of decades.

8. Conclusion

Population growth is a much more urgent problem than global warming. Measures to reduce population growth must have first priority, because otherwise famines, epidemics and civil wars will lead large regions of the planet into disaster. The total fertility rates decrease if GDP increases above a certain threshold. A precondition for the necessary economic growth is the availability of sufficient amounts of affordable energy. Sufficient amounts of low-price energy can only be produced from coal, crude oil, natural gas and uranium. These primary energy sources are indispensable as long as there are many countries with gross domestic products of less than 1500 US$ per capita and per year and as long as there are many countries with total fertility rates above 2.5 children per woman. Wind power and solar energy are too expensive for these parts of the world. The less and least developed countries will heavily invest into low-price energy sources such as coal and this will result in a further increase of carbon dioxide emissions. Many new nuclear power plants will be built. This development is going to happen independently of what the industrialized countries may decide or demand.

If developed countries such as Germany reduce their CO_2 emissions, this will have almost no effect on the global CO_2 balance. Instead, the use of high-efficiency coal-fired power stations would reduce global CO_2 emissions by numbers far greater than the total CO_2 emissions of a small country such as Germany. Hence, with the export of modern coal-fired power stations Germany can save much more CO_2 than by the generation of a few Gigawatts of solar energy. A similar consideration can be made for nuclear energy. If the industrialized countries stop building nuclear power plants, this will increase the probability of another Chernobyl. The less developed countries will buy nuclear technology from countries with lower safety standards, if this technology is not available from the highly developed countries. As a result, the number of dangerous nuclear power plants in operation will increase dramatically. Export of safe nuclear reactor technology is a better way of avoiding another Chernobyl disaster than shutting down nuclear reactors at home. Finally, research and development are needed for those new techniques of energy generation which meet the requirements of the least developed countries. Energies with a high future potential are wind power, geothermal energy and fusion (Gantefőr 2010).

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Tables

AFRICA:	Sudan, Western Sahara, Benin, Burkina Faso, Ivory Coast, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Togo, Ethiopia, Burundi, Dschibuti, Eritrea, Kenya, Grande Comore, Madagascar, Malawi, Mayotte, Mozambique, Réunion, Rwanda, Zambia, Zimbabwe, Somalia, Tanzania, Uganda, Kameroon, Congo Zaire, Sao Tomé, Chad, Central African Republic, Lesotho.
AMERICA:	Nicaragua, Haiti, Guyana.
ASIA:	Yemen, Afghanistan, Bangladesh, India, Kyrgyzstan, Nepal, Pakistan, Tajikistan, Uzbekistan, Cambodia, Laos, East Timor, Vietnam, North Korea, Kiribati, Papua New Guinea.

Table 1: List of the 59 countries with a gross domestic product of less than 1500 US$ per year and per capita.

Figures

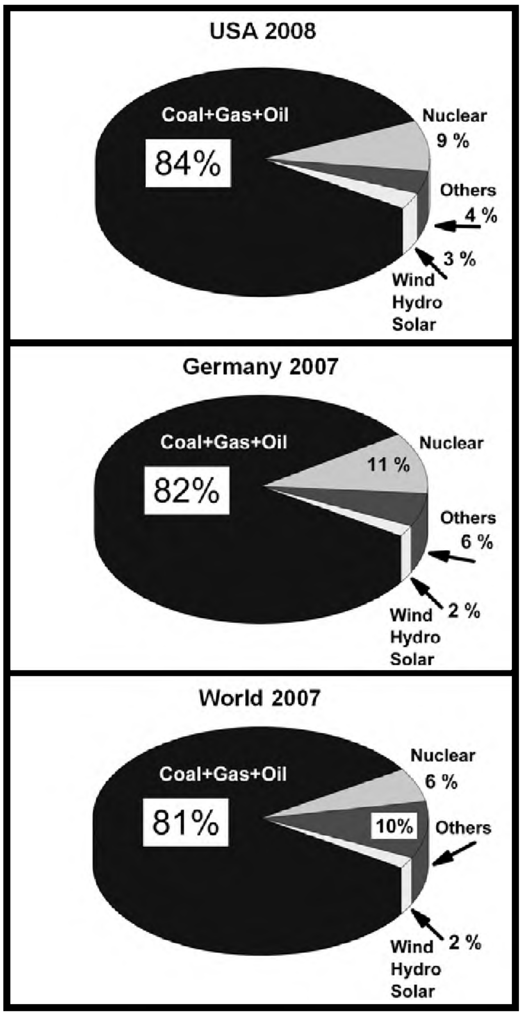

Figure 1: Main sources of primary energy of the USA, Germany and the World.*

* Data from Energy Information Administration 2009; Bundesministerium für Wirtschaft und Technologie 2009 and International Energy Agency 2009.

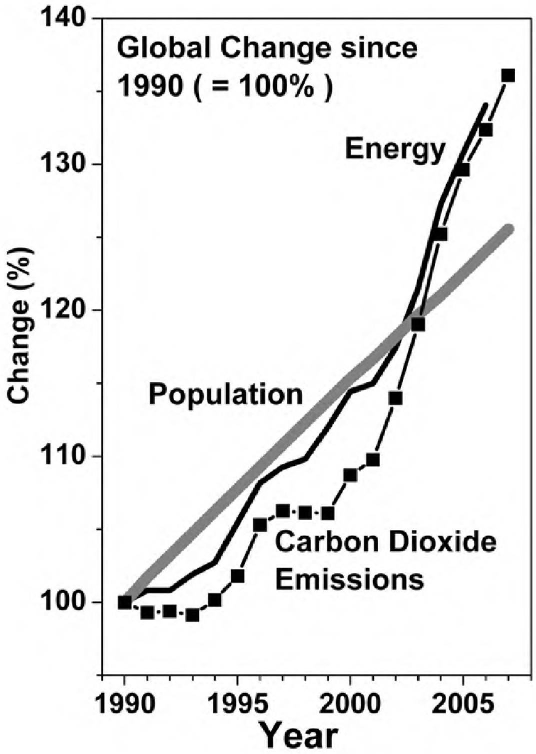

Figure 2: Change of global population (grey straight line), primary energy consumption (black line) and carbon dioxide emission (squares) with respect to 1990* (Ganteför 2010).

* Data from Bundesministerium für Wirtschaft und Technologie 2009 and International Energy Agency 2009.

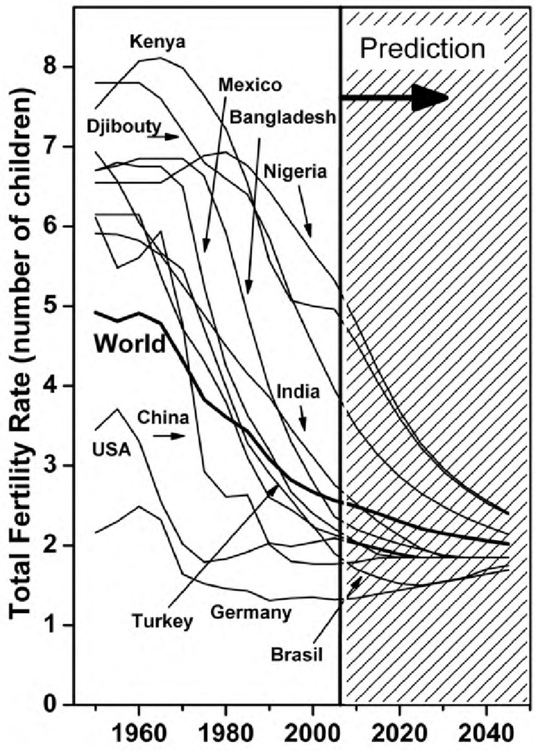

Figure 3: The variation of the total fertility rates of some selected countries and the world between 1950 and 2050 (UN 2009: Ganteför 2010).

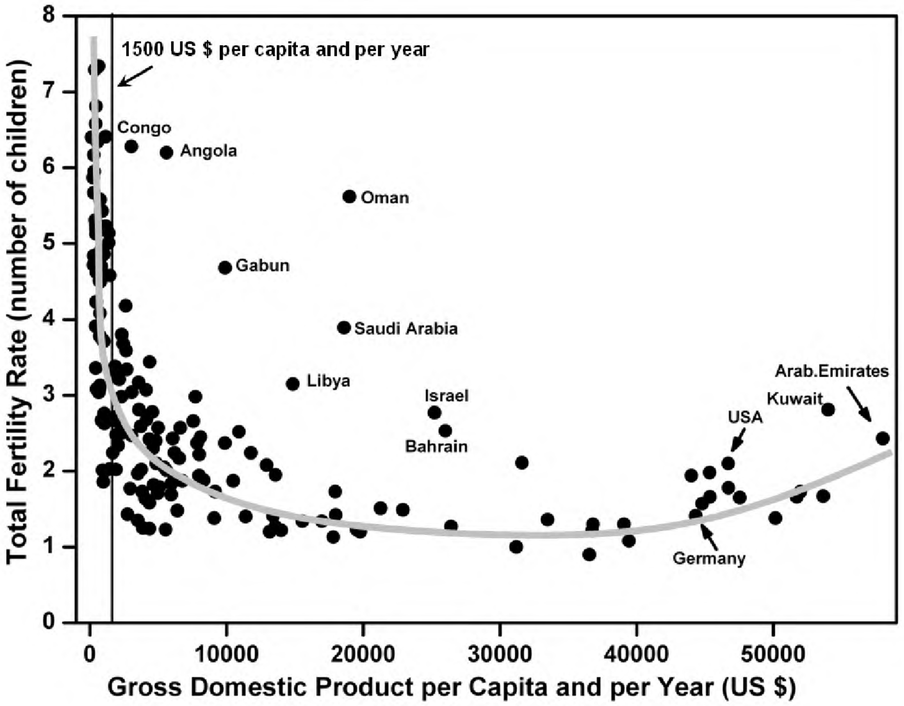

Figure 4: Total fertility rate (UN 2009) and gross domestic product GDP* (Ganteför 2010).

* Data from Central Intelligence Agency 2008; International Monetary Fund 2007 and World Bank 2007.

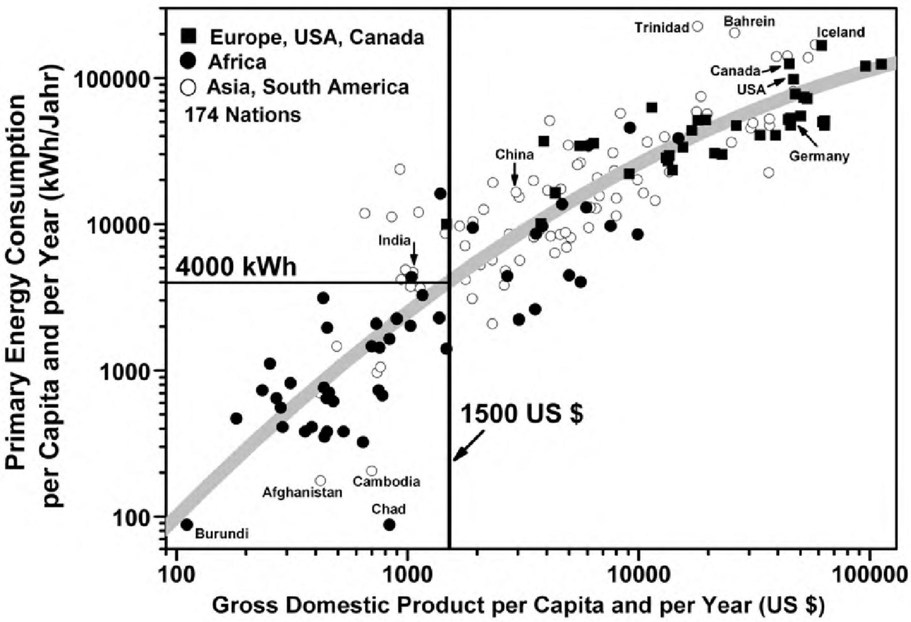

Figure 5: Correlation between energy consumption* per capita and per year and gross domestic product per capita and per year (Ganteför 2010).

* Data from Energy Information Administration 2009; International Energy Agency 2009; Bundesministerium für Wirtschaft und Technologie 2009 and World Energy Council 2008.

energy costs in Euro cents:

coal (100 US $ per ton, heat content 10 kWh / kg):
→ **0.7 cts / kWh**

crude oil (100 US $ per barrel, heat content 10 kWh / ltr):
→ **4 cts / kWh**

natural gas (100 - 300 US $ per 1000m^3, heat content 10 kWh / m^3):
→ **0.7 - 2 cts / kWh**

coal-fired power station (electricity production costs):
→ **4 - 5 cts / kWh**

nuclear power station (electricity production costs):
→ **3 - 5 cts / kWh**

photovoltaics (electricity production costs):
→ **35 cts / kWh**

wind power (electricity production costs):
→ **8 – 9 cts / kWh,**
→ offshore **15 cts / kWh**

hydropower (electricity production costs):
→ **2 - 4 cts / kWh**

Figure 6: Comparison of the energy prices (Gantefőr 2010; Voß 2007).

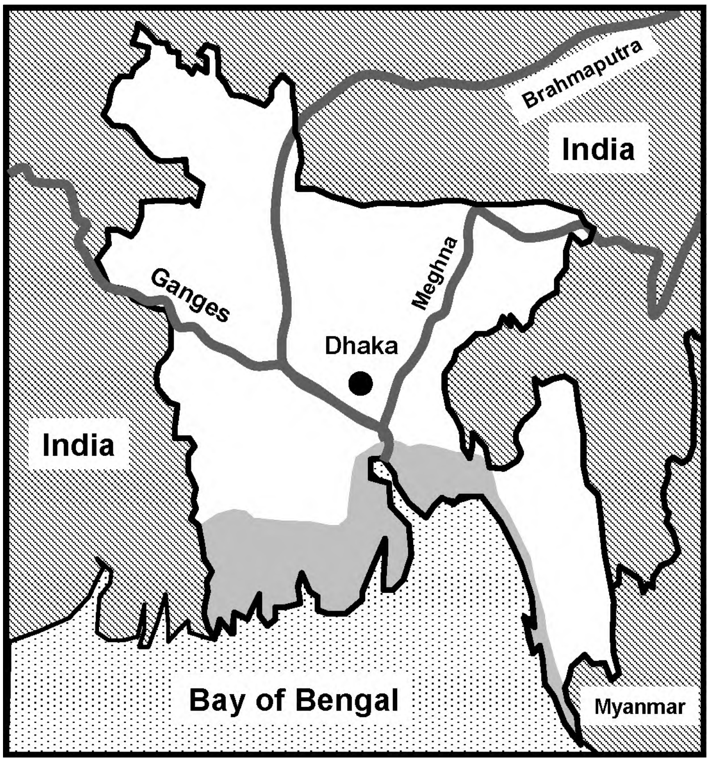

Figure 7: Simplified map of Bangladesh (Ganteför 2010; World Bank 2000).