BIO-ENERGY PERSPECTIVES VERSUS BIO-ENVIRONMENTAL CONCERNS

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Energy availability is fundamental to the prosperity of modern society and necessary for global economic development. Energy demand, particularly in the form electricity, is increasing and will continue to increase as long as the world population increases and nations struggle for social and economic development. However, as energy consumption rises, a great threat to the environment, stemming from intense energy use, is becoming apparent. Concern for the environment began because of pollution phenomena and climatic changes resulting from the greenhouse effect. Smog, originating from excessive emissions of CO2, CO, and SO2 as a result of solid and liquid fuel combustion, may have important climatic consequences.

There are no unique, or easy, solutions to environmental problems. Energy conservation is considered a fundamental target with a great many possibilities and is a basic factor for reducing atmospheric pollution. It is of vital importance to obtain the optimal balance between economic development, use of energy and environmental preservation. This is not a matter of choice, because all three are necessary. The world must use technology and make energy choices, that will ensure a sufficient and reliable supply of economically and environmentally clean energy for the future. In order to satisfy these requirements, a variety of energy choices will be necessary and the following issues will play a key role:

- energy conservation and more efficient use
- renewable energy sources (wind, photovoltaic waves and ocean energy)
- nuclear energy
- improved use of mineral fuels (co-generation, clean combustion)
- transnational transfer of technology

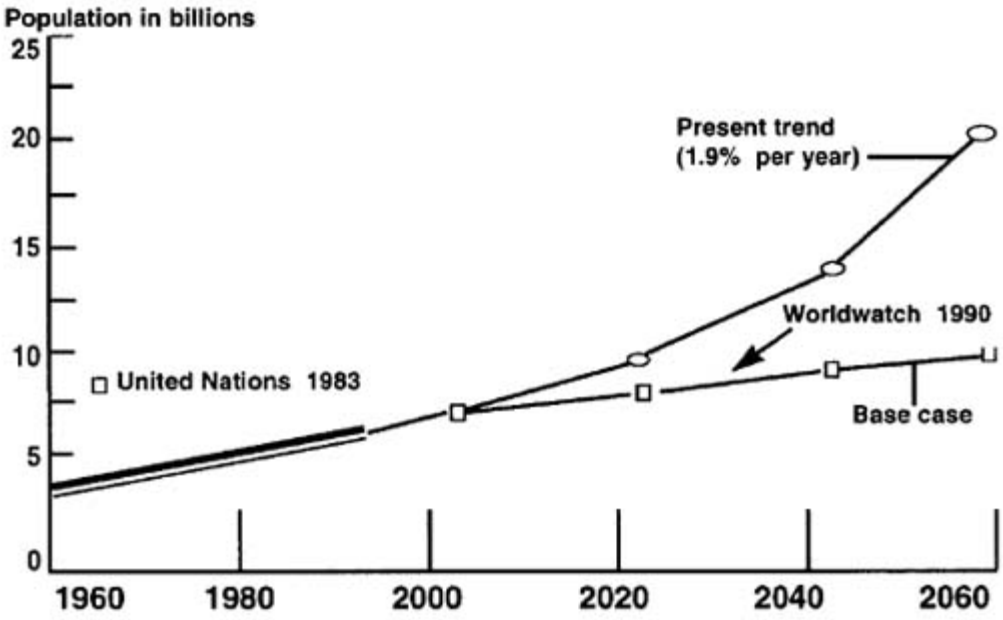

Figure 1. World population, 1960-2060

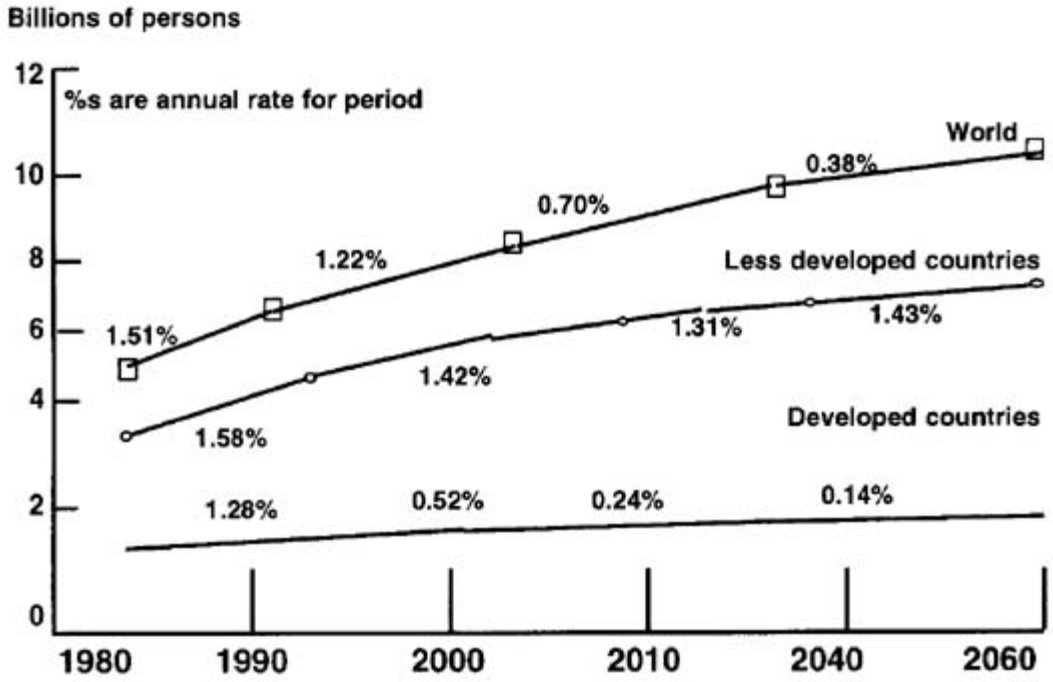

Figure 2. World and regional population, 1986-2060

Global Evolution of Electric Energy Supply and Demand

The increasing demand for energy, and particularly electrical energy, is directly dependent on economic and population development. The key parameter is world population, which will continue to increase during the next century. Figure 1 shows the predictions which arise from a combination of World Bank and United Nations data. Figure 2 makes a distinction between the developed and less-developed countries, showing that the less developed countries have a large share of the population increase, although the total rate of increase is being reduced overall.

Based on historical data, of per capita energy consumption, an accepted annual increase rate for long-term forecasts is 1.1% for energy, in general, and 1.75% for electrical energy. At these rates, the prediction for electrical energy demand for the year 2060 is shown in Table 1. This table gives the per capita demand separately for less-developed countries (LDC's) and developed countries (DC's), as well as the demand in the year 2060 for zero-increase and full energy conservation. The latter assumption is optimistic, but it is a requirement, since the development of technology might be dangerous for the economic development of nations.

Table 1. Electricity demand in the year 2060 (as compared to 1986)

	1986	Trend	Full Conservation	Zero per capita Growth
Electricity (KWh/capita)				
LDC's	500	3,590	2,390	500
DC's	6,850	24,730	16,480	6,850
World*	2,010	7,240	4,830	1,600
Total KWh (trillions)				
LDC's	2	29	19	4
DC's	8	41	28	12
World*	10	70	47	16

**Population weighted average of less developed countries (LDC's) and developed countries (DC's)*

Table 2 shows two probable scenarios (a and b). For various reasons, it has been assumed that, on a world-scale, the proportionality of mineral combustibles (coal, oil, and natural gas), will not change essentially. It has also been assumed that, by the year 2060, renewable energy sources (photo-voltaic, aeolic, geo-thermal and biomass) will have been developed commercially and will contribute to a certain extent. However, the aeolic and geo-thermal contribution has been considered a very small one. Nevertheless, solar energy and biomass contribute, although with a degree of uncertainty, because of cost and availability. Based on the above assumptions, 1986 data and full energy conservation, we arrive to the conclusion that the total demand for electrical energy in 2060 will be 47 trillion KWh, distributed according to two scenarios: (a) with

mineral fuels and hydro-electricity remaining at the 1986 level, in which case the participation of nuclear generation will be greatly increased and (b), with an increase in conventional combustibles from 8 trillion KWh to 15 trillion KWh, in which case the nuclears are reduced from 22 trillion KWh to 15 trillion KWh. Thus, mineral combustibles, such as coal, oil and gas, would remain a basic source of energy for many years, because of their abundance and relatively low cost. Their combustion is, however, accompanied by CO2 emissions and contributions to the formation of acid rain and an increase in atmospheric temperature.

Table 2. World electricity supply in the year 2060 (1000 trillion KWh)
(full conservation case - limited fossil and hydro, maximum solar and biomass)

Year	Electricity	Fossil and Hydro	Solar	Biomass	Nuclear
1986	10.0	8.4			1.6
2060 (a)	47.0	8.0	6.0	11.0	22.0
2060 (b)	47.0	15.0	6.0	11.0	15.0

Considering the very probable outcome, that of only partial conservation of energy and use of renewable energy sources, we should expect at least a doubling of annual CO2 emissions in the atmosphere. A rise in the annual increase rate of CO2, which is today approximately 1% to 2%, will reduce the doubling period of emitted CO2 from 70 to 35 years.

The climatic significance of such an increase might be very severe, although our present knowledge is insufficient for a safe prediction of the dynamic biosphere processes. However, definite measures should be taken from now on toward a drastic reduction of coal emissions. An obvious measure is the promotion of a more efficient use of mineral combustibles, with suitable courses of action and methodologies.

The technology, which is developing toward reducing the combustion effects on the environment is that of co-generation, which utilises the remaining energy left during the generation process of electrical energy. Another investigation, which is also encouraging, is the development of clean-coal technologies, as a result of which, emissions related to the formation of acid rain might be limited.

Many other technologies can still be effective, such as, for example, electric vehicles. The use of electric cars for urban transportation will very probably be commonplace in a few decades and, if the electricity were to be generated from non-mineral sources, the reduction of CO2 emissions into the atmosphere would be dramatic. In any case, the generation of electricity from clean energy sources such as solar, aeolic, geo-thermal, hydro-electric and nuclear, should be encouraged and continuously promoted. Even though each of them has problems and limitations, the technology to solve these problems is making steady progress.

The International and European Energy Situation

The energy policy which has been applied in recent years, particularly in developed countries, has led to an improvement in energy efficiency and the reduction of oil demand. In practice, the European Union, in a decade, has achieved a reduction to half of its oil imports. Although, more specifically, in 1973 oil accounted for 62% of the total energy needs of the Community, while in 1985 that percentage had been reduced to 31%. However, in spite of the progress achieved in recent years, the European Union still remains very vulnerable with regard to the energy issue. This dependence is evident from the fact that the supply to the Union of energy (oil and other forms) from foreign countries was, in 1985, more than 44% of its total energy needs, whereas in the same period the respective dependence of the USA on foreign countries was only 12%. Consequently, efforts in that direction must be continued. In the European Union the energy objectives, as defined in 1986 for 1995, are in general still valid:

- improvement of energy efficiency by 20%
- reduction of the oil share in the energy balance of the CEC by 40%
- preservation of oil imports at below 33% of total energy consumption
- preservation of the percentage proportion of natural gas
- increased use of solid fuels with parallel improvement in their efficiency
- input of oil in electricity generation at below 15%
- substantial increase in renewable energy sources

The main targets of the Hellenic Energy Policy coincide with those of the European Union and include:

- reduction of dependence on oil
- introduction of natural gas into the energy system
- maximum possible use of local energy sources, with parallel research for new fossil fuels
- energy conservation

- development of renewable energy sources
- application of a policy for the preservation of the environment

The degree of public concern over environmental issues reflects the degree of public awareness and maturity about the health and security problems which have been caused, and the need to direct industry and production accordingly. Of course, this depends on the sensitivity which has been developed in each country about the quality of the environment and the significance given to related problems. The greenhouse effect and acid rain, which at one time were of only academic interest, appear today as considerable areas of public interest and concern. The global CO2 emissions, which are responsible for half of the greenhouse effect, have more than tripled between 1950 and 1980. About one quarter of the world emissions of CO2 comes from the combustion of solid fuels in the USA, where the generation of electricity is responsible for 7.5% of total world CO2 emissions. Although our knowledge of the influence of human activities on the earth's climate is still limited, protective laws have already been established, such as the World Climate Convention of 1987, and the Montreal Protocol on the ozone layer. Using today's data, gas emissions in the atmosphere and the greenhouse effect could lead to an increase in the earth's temperature, with the probable consequence of climate instability. In the year 2015 a global temperature rise of almost 1°C can be expected, an effect which would also considerably increase requirements for additional electrical energy.

Environmental constraints directly affect the electricity industry. Standards of environmental protection influence the site, design and operation of almost all units for the generation of electrical energy, and have considerably increased the cost of installed capacity, as well as construction time. Consequently, they cumulatively affect the total generation and delivery costs of electrical energy, for example KWh rates.

Electrical and Magnetic Fields (EMF)

In recent years there has been increasing public concern about the unfavourable influence of electrical and magnetic fields, produced by the transmission and distribution lines of high-voltage networks. Such electrical fields are also produced by all conductors and cables of medium and low voltage, from industrial and domestic electrical installations and apparatuses.

The wide-spread suspicion that these electrical and magnetic fields contribute to an increased risk of cancer development, is not definitive and carries important uncertainties. As a result, investigations are still continuing in many countries. It is generally accepted that electrical and magnetic fields do not promote cancer initiation. The current hypothesis is that EMF contributes to the development of cancer cells in humans where the cancer process has already been initiated or, who are on the initiation threshold.

A great deal of epidemiological research has been carried out over the last ten years, the results and conclusions of which present considerable differences and deviations, as far as targets, breadth of investigation and conditions examined are concerned. They differ on the magnitude of risk and on the type of cancer that is probably related to EMF exposure. The International Radiation Protection Association (IRPA), and other experts conclude that the evidence, up to now, on the carcinogenic influence of EMF is not persuasive. However, the problem is very important and requires constant research and attention. The World Health Organisation (WHO), the International Radiation Protection Association (IRPA) and the Office of Technology Assessment (OTA)are some of the authoritative international associations which have undertaken this task.

After such a survey, it is difficult to determine whether an optimistic or a pessimistic view is more appropriate, however, of the fate of our environment, one thing is certain and very important; the danger is already tangible and we need to urgently react to that danger.

Professor **Basil C. Papadias** has been Professor of the Chair of Electric Energy Systems at the National Technical University of Athens since 1975. His M.A. and Doctorate in engineering, were awarded by the Ransselear Polytechnic Institute, Troy, USA. His current research includes dynamic analysis of power systems, transient stability and renewable energy sources. He is author or co-author of numerous research papers and several text books; he has also participated in, and chaired, numerous international meetings and scientific conferences. Memberships include CIGRE (Conference Internationale des Grands Reseaux Electriques), Study Committee 13 CIGRE, and the Administrative Council of CIGRE. He is currently Chairman of the European IEEE Chapter Co-ordinating Committee.