Energy as a Limiting Factor for Sustainable Development

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The title of the present talk, only a few years ago, might constitute a shocking statement as to the prevalent and or dominant socioeconomic development theories.

In fact. bearing in mind the most elementary definition of energy, as the capacity of producing work, up to recently it was obvious that the material and social progress of mankind was considered to directly result from the increasing intensity of energy use - starting from the muscular (human and animal), wind water and, later on, of thermal energies from , successively, biomass and fossil fuels.

The whole fabric and structure of human society did, in fact, bear testimony to the million fold increase in the energy intensity of the primary energy sources -starting from around a few hundredths of electron volts, characteristic of the aforementioned mechanical sources, passing by a few electron volts that are typical of chemical energy (combustion), to reach the hundreds and so million electron volts associated with uranium fission.

Perhaps a short cut for what will be made explicit bellow should immediately state that it is the combination of four factors:

1. uneven geographic and hence geopolitical distribution in energy consumption;

2. population growth;

3. acceleration in the intensity of energy utilization, and finally;

4. the steady 2 or 3% growth in energy use. prevalent in the last 120 years (Figures 1 and 2), which, despite considerable and sometimes even spectacular increase in the efficiency of energy production and use, set the limits to sustainable development spelled out in the title of this paper.

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** José Israel Vargas was the Ministry of Science and Technology of Brazil at the time of the seminar.

Figure 1 – 120 YEARS OF WORLD ENERGY USE

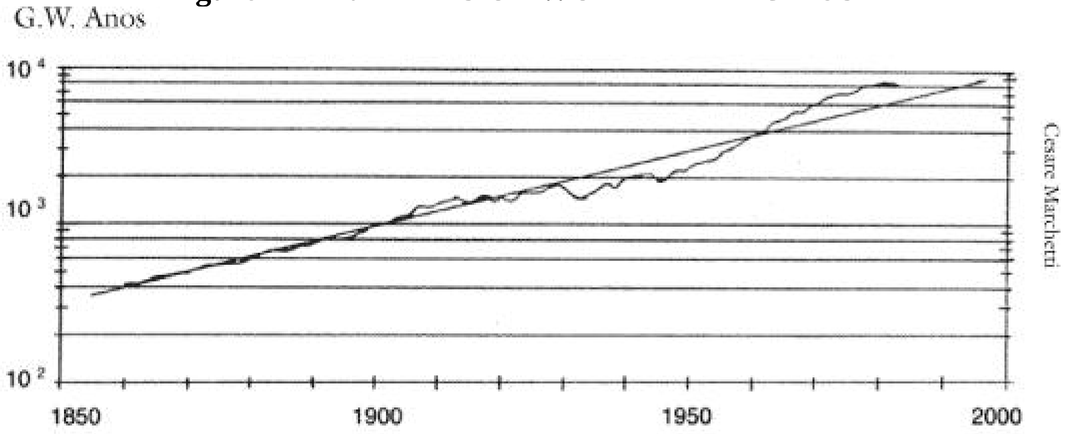
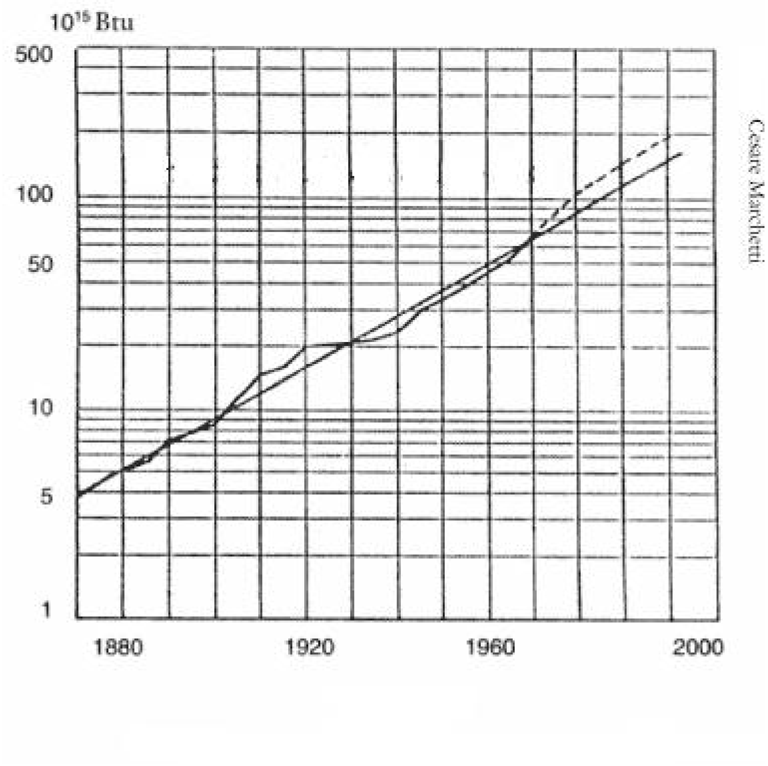


Figure 2 – U.S. TOTAL ENERGY CONCUMPTION
(TREND LINE 3% PER YEAR)



In fact, it would be worth recalling that, according to World Energy Council,[1] the World's energy consumption has attained, in 1990, 8.7 Gigatons of oil equivalent, which is anticipated to reach between 11.2 and 17.2 Gigatons, in 202,. depending:

- on the role of a greater influence of environmental concerns and pertinent policies;
- on the evolution in efficiency of energy production and utilization;
- and. of course, on the observed rate of economic development, worldwide.

The major share of this anticipated demand shall be due to the developing countries, which shall increase from the 2.9 Gigatons in 1990 to reach between 6.3 to 10.3 gigatons in 2020. This extraordinary evolution in the developing countries demand (of 110 to 250%) would largely originate in the anticipated population expansion, which. according to the United Nations projections should reach about 8.3 billion persons in 30 years, as compared to the 1990, 5.3 billion inhabitants of our planet. It is also known that 90% of this population growth shall be concentrated in the developing countries. According to the Council, the consumption in the industrialized world should level off at the present level or even undergo a 10% reduction by the year 2020.

Thus, in the next 30 years, the situation in the poorer countries may become critical on account of. both. the probable cost and difficulties in the access to either to conventional, or to more appropriate or environmentally more benign sources.

A special study by the World Bank[2] of energy efficiency and conservation in the developing world further aggravates this picture, pointing out that, for these countries: the energy efficiency in the industrial sector's consumption is about 2/3 or 50% smaller than that of the industrialized countries.

In fact, the evolution on the efficiency of energy transformation and use in the latter countries, shown in Figures 3 and 4 has avoided much earlier initiation of the energy induced global environmental disruption, despite their much larger enemy use.

[1] WORLD ENERGY COUNCIL: **Energy for Tomorrow's World**. St. Martin's Press Inc.. New York, 1993.
[2] BANCO MUNDIAL: **Energia: Eficiencia y Conservación en el Mundo en Desarrollo**. Banco Mundial. Washington, 1993

Figure 3 – HISTORICAL TRENDS IN EFFICIENCY

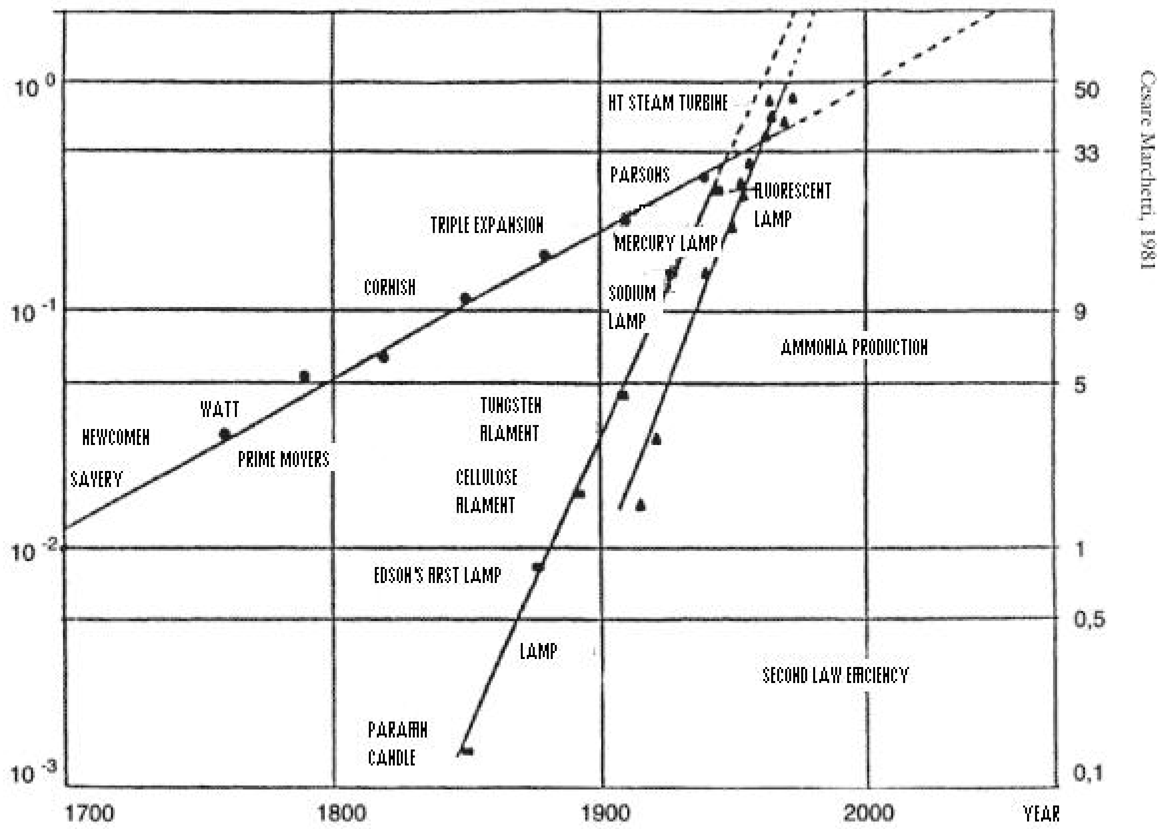
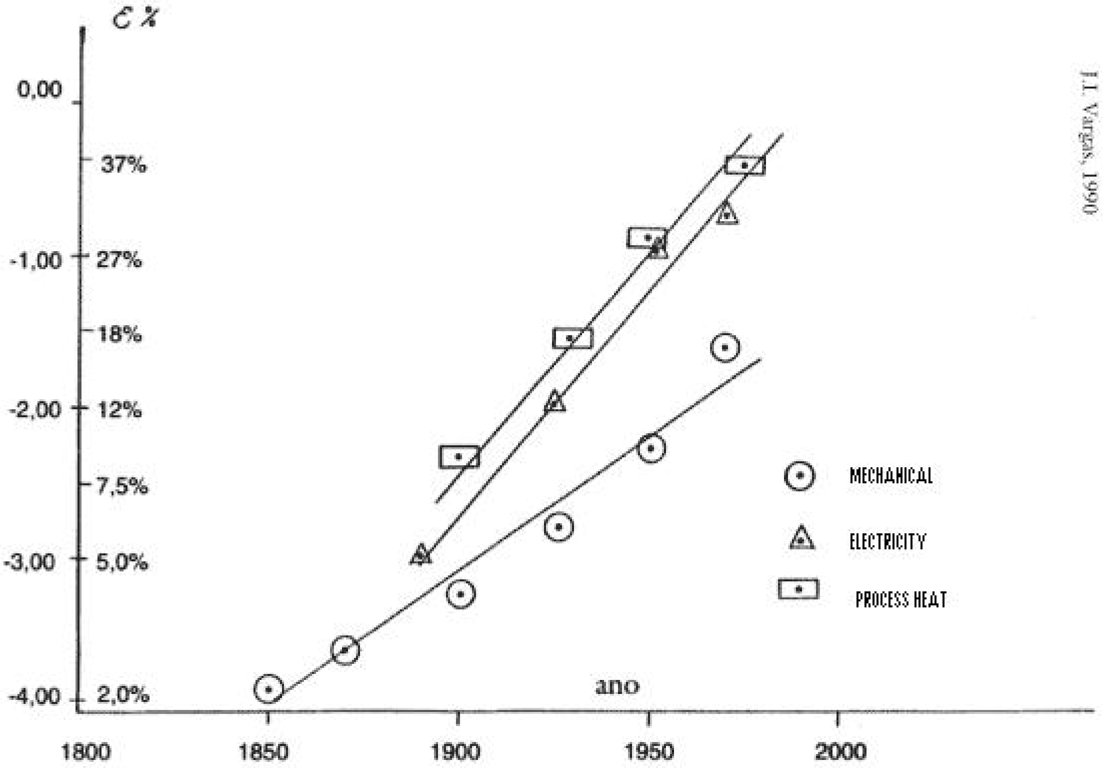


Figure 4 – EVOLUTION OF THE EFFICIENCY OF ENERGY TRANSFORMATION



The conclusion reached at by the large extent of information gathered in recent years indicates that only efforts for equity sake, to promote a higher access of energy to the developing world, coupled with profound changes in the life styles in the industrialized countries leading forth to a drastic immediate reduction of the rate of energy use, with some kind of leveling off in the next few decades shall invert the deleterious and, possibly, catastrophic environmental impacts, that shall impair the very possibility of sustainable development. Sustainability consisting, basically, in the observation, by society as a whole, of a life style of such restraint as to preserve the diversity of life sustaining systems, conducive to guarantee the continued operation of the multifarious evolutionary process.

A natural scientist's conception of sustainability has been rather thoroughly discussed recently by Hans Peter Dürr[3] and shall not be further elaborated on here.

The prevention of the anticipated effects of present day and future inconsiderate energy use implies in:

1. increased use of renewable energies - from the present 0.2 gigatons in 1990 to 1.5 gigatons in 2020, increasing their participation in the world energy matrix from the present 2.5% to 13%;

2. energy conservation;

3. greater energy efficiency.

In any case, these studies also indicate that probably, and unfortunately, in the next 30 years, 63 to 75% of the world energy market shall still be supplied by fossil fuels, in slight variation from the present 77% offer.

Other scenarios have been proposed to deal with this important question and have been discussed by Goldemberg[4] and colleagues, and which shall certainly be up-dated in his presentation in this meeting.

The failure in implementation of the profound modifications which are called for, have been discussed by many studies and do constitute serious obstacles to sustainable development.

Fossil fuels are by now sufficiently recognized as being responsible for global alterations in the life sustaining systems. the time scale of their possibly irreversible damage - if the present rate of energy utilization is maintained - being, however, still the object of many discussions.

These stem mainly from lack of more quantitative information as to the extension and importance of CO2 and of other antropogenic green house gases sinks, as well as to uncertainties on the working mechanisms - linear or non-linear -bearing on the complex interactions resulting from human actions. particularly in energy use. which do not still allow for the formulation of reasonably precise predictive models.

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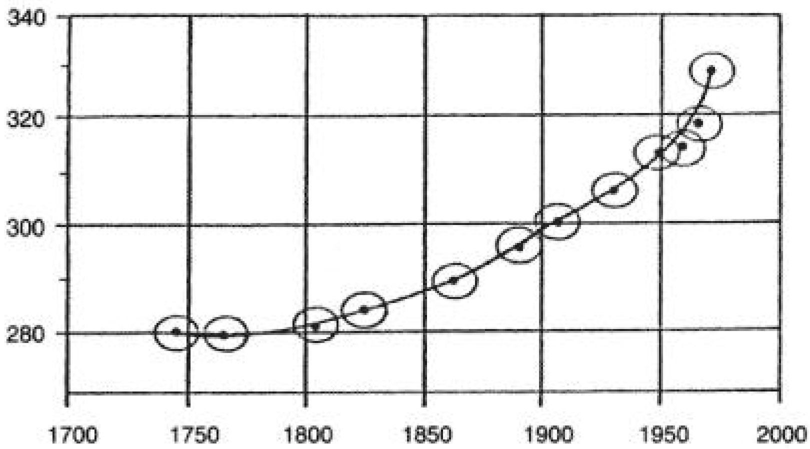
[3] DÜRR. Hans Peter: **Ecology - Challenge to Economy from the Natural Science Perspective**. Communication to the Annual Meeting of the Brazilian Association for Advancement of Sciences (SBPC). Recife, July, 1993.

[4] GOLDEMBERG, José. **Potential Global Climate Change - the Realities**. Communication to the World Energy Council – 15th Congress, Madrid, September 1992.

The quantification of CO/ emission variations in the atmosphere is feasible for periods covering the last 100.000 years, via the measuring of the composition of air bubbles trapped in glaciers (Figure 5) or through 14C analysis of tree rings (Figure 6). Both show increasing values for CO2 in the atmosphere, but emissions really resulting from fossil fuels burning became dominant only in the last five decades.

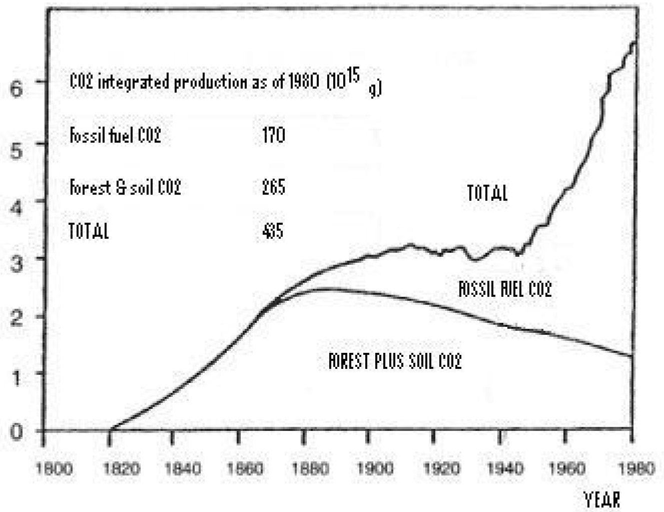
Figure 5 – CO2 MEASUREMENTS FROM GLACIER BUBBLES



Historical series of the concentration of CO2 in air can be produced today by looking at air bubbles trapped in glaciers. This methodology may permit to go back perhaps 100,000 years and compare CO2 levels with prevalent climatic situations that can be evaluated by various types of analyses of sediments (and tree rings for the last 1500 years). This reconstruction may help calibrating the climatic models over which much of the CO2 controversy is based.

FIGURE 6 – ANNUAL CO2 PRODUCTION

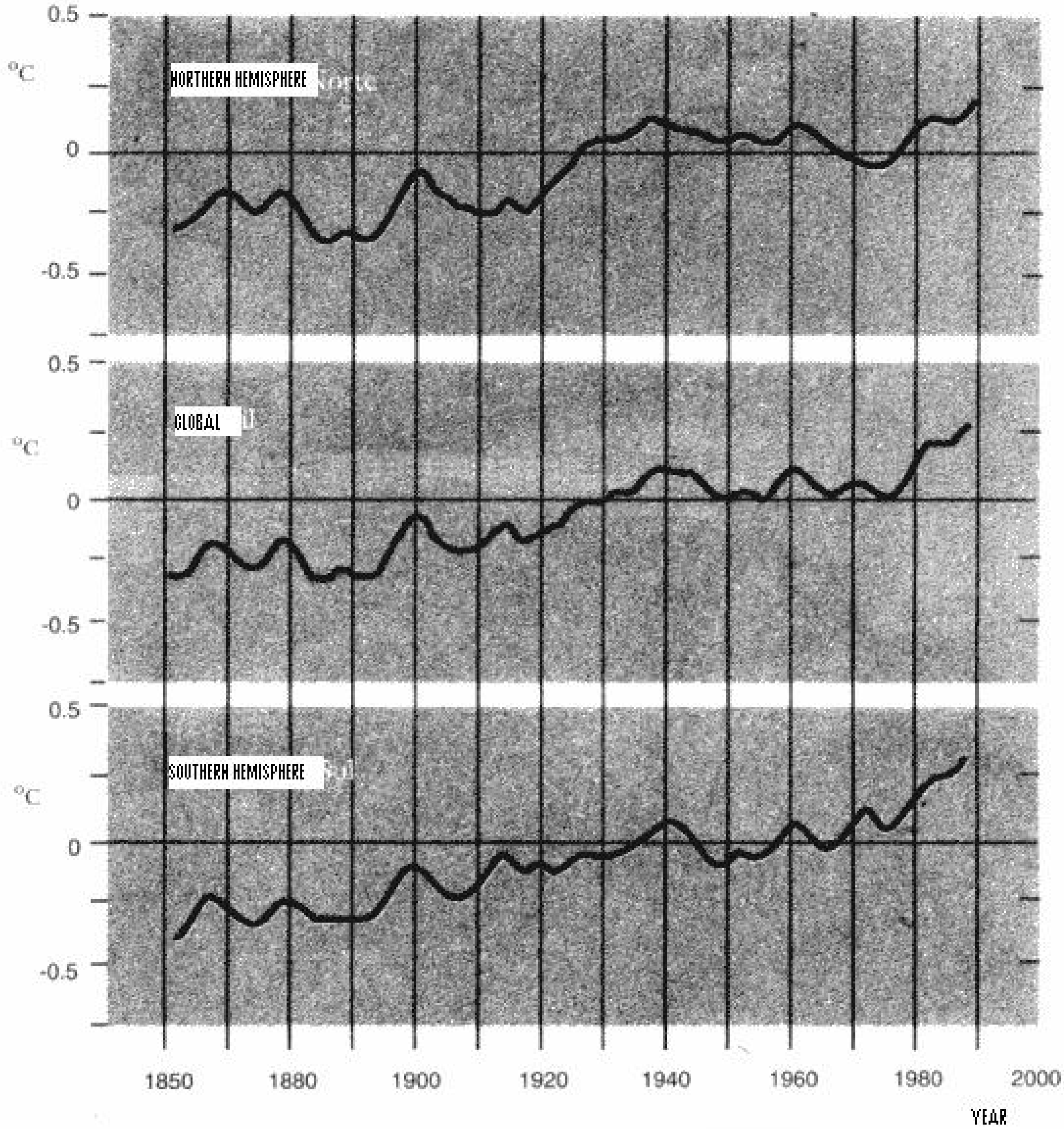
(10^9 TONS OF CO2)



Knowledge of the fossil CO2 emissions and analysis of true rings for 14C and 13 C permits _ reasonable reconstruction of the amounts of CO2 put into the atmosphere by changes in the level of carbon storage in standing forests and soils. from these calculations, it appears as the integrated amount of CO2 that burdens CO2 levels in air, is due mostly yo activities related to agriculture and forests. Only after World War II emissions from fossil fuels have become dominant.

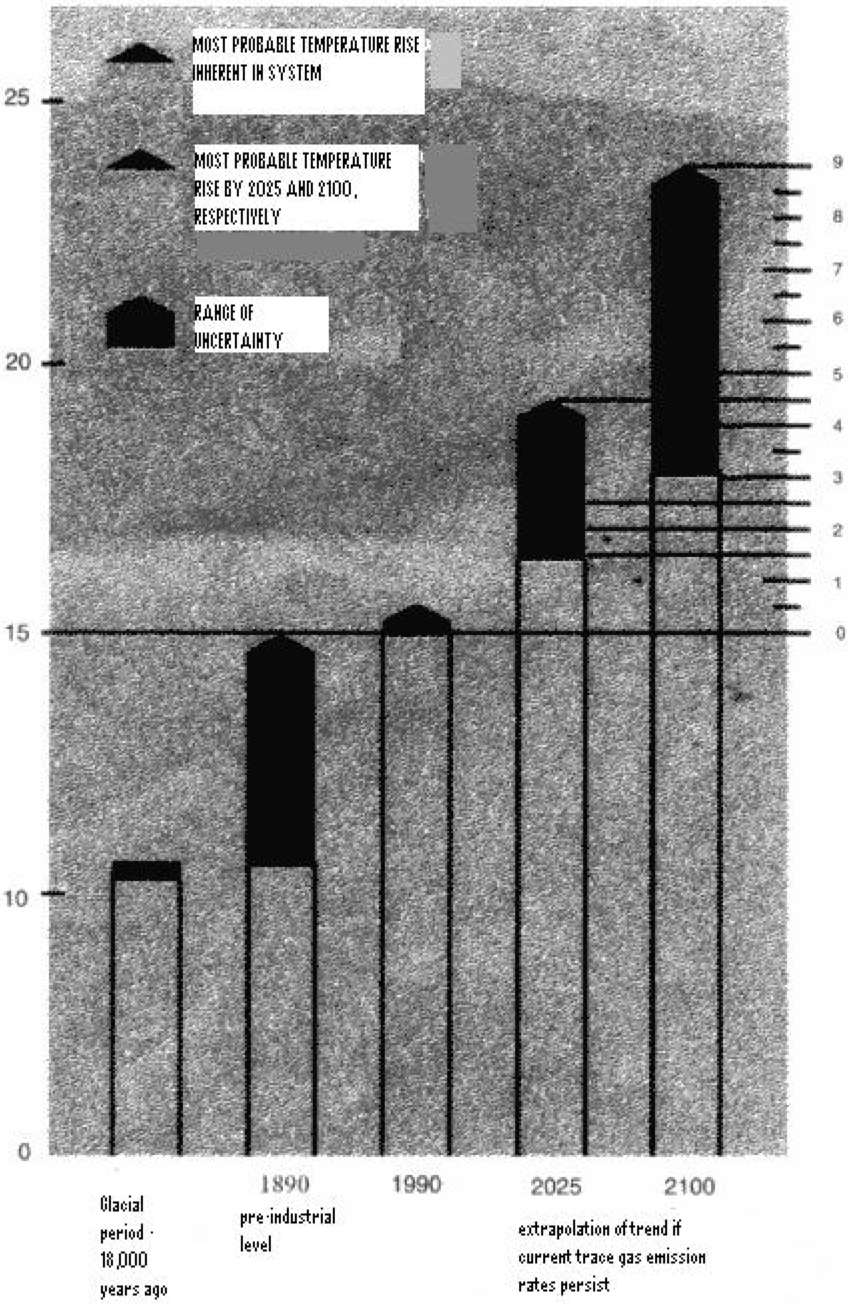
It is also possible to quantify the average earth temperatures increases, for long periods, as shown in Figures 7 and 8, but admittedly the range of uncertainties are still very high.

Figure 7 – ANOMALIES OF GLOBAL SURFACE TEMPERATURES (1861 – 1988)



Anomalies of global surface temperatures (1861 - 1988), taking into account continental and marine data (159).
The average for the period between 1951 and 1989 was chosen as zero line.

Figure 8 – TEMPERATURE RISE



Temperature rise since the last glacial period (18,000 years ago) and temperature increases to be expected as compared to pre-industrial levels, if the current trend in trace gas emission rates is extrapolated up to the years 2025 and 2100.

An overall discussion of these questions is contained both in a recent United Nations publications,[5] and more thoroughly in the well known report of the Enquete Commission Report of the Ilth German Bundestag, particularly in their *Status Report With Recommendations for a New Energy Policy* (Volume 1)[6] and *Protecting the Earth's Atmosphere - an International Challenge*.[7]

They concern with the prudent need to urgently reduce the currently exaggerate use of energy and particularly of fossil fuels by the adoption, by all countries concerned, of both technical regulations and severe legal restrictions, including forms of taxation which have been discussed prior to and during the Rio Conference, leading to the adopted Conventions on Biodiversity and on Climate Change and as related to developmental issues on the so called Agenda 21 recommendations.

I wish now to add to the discussion of the long list of the potentially detrimental impacts of anthropogenic green house gases heating of the earth, by inquiring on how the anticipated few degrees increase in temperature would, in some way affect our species mortality.

This investigation,[8] which was briefly cited on UNESCO's scientific meeting parallel to Rio 92 Conference, was motivated by an existing report on observations of effects on the unusual heat waves on human mortality.

In the present communication we shall examine quantitatively the data published by J.P. Besancenot in 1990, on the heat wave which struck Marseille in July - August 1983 that is presented in Figure 9. As may be observed, the daily mortality increased from 60 deaths per day on the 15th July, 1983 to about 100 deaths per day on the 25th July, finally decreasing to the normal rate (28 deaths per day) on August 13th. Statistical tests indicate the obvious correlation between the average temperature increase and mortality.

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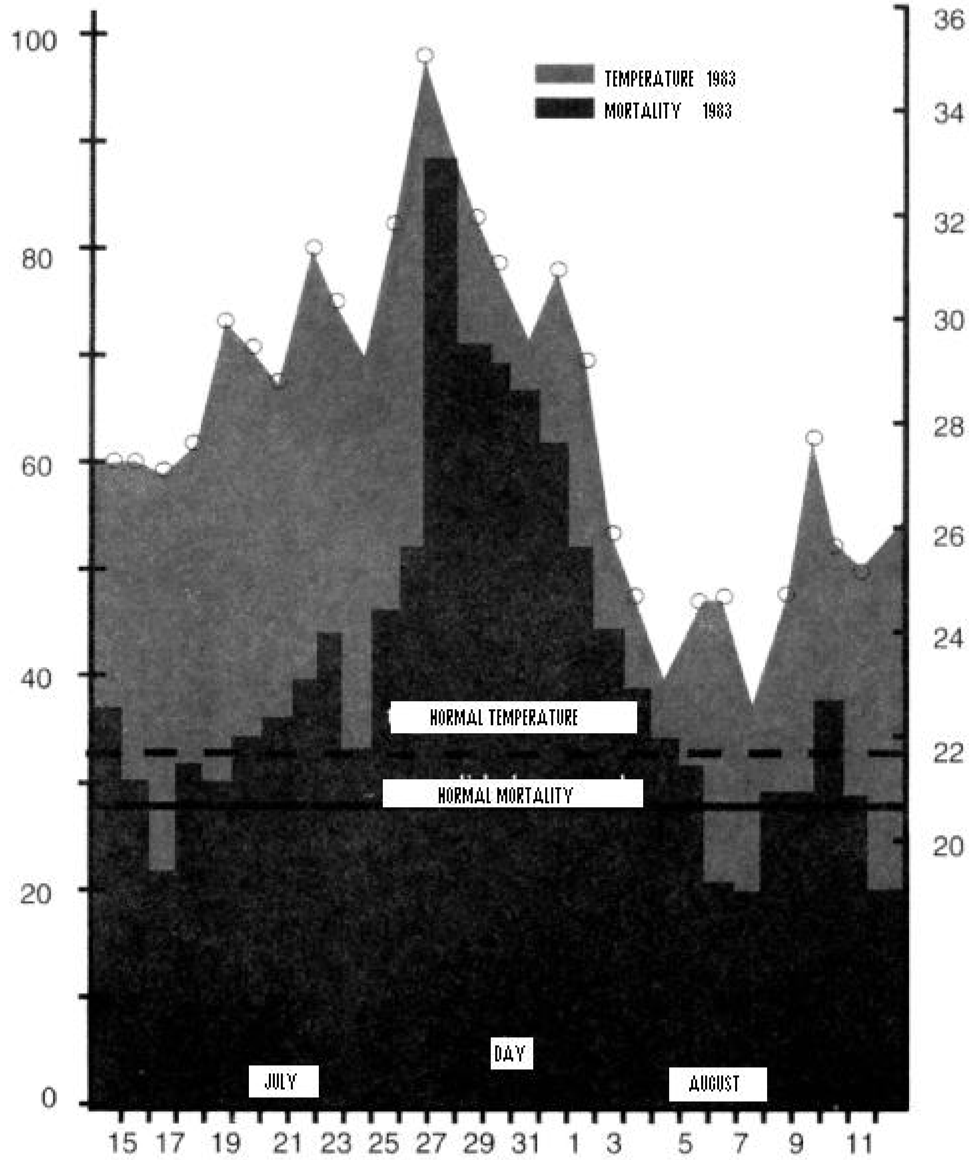
[5] UNITED NATIONS: *Energy Systems. Environment and Development – A Reader* in **Advanced Technology Assessment System**, Issue 6, Autumn 1991, UN, New York, 1991.

[6] GERMAN BUNDESTAG: **Protecting the Earth, a Status Report with Recommendations for a New Energy Policy** - Vol. 1. Deutscher Bundestag, Bonn, 1991.

[7] ________: **Protecting the Earth's Atmosphere: an International Challenge**. Deutscher Bundestag, Bonn, 1989.

[8] VARGAS. Jose Israel: **The Brazilian Energy Scenario and the Environment: an Overview**. CBPF, Rio

Figure 9 – TEMPERATURE X MORTALITY



de Janeiro, 1992.

The obvious approach to the problem would be to investigate whether the heat activated mortality, followed some quantitative law - which hopefully would allow for predictions to be made on similar fossil fuel burning induced green house heating. In particular, given that the heat activated mortality per unit time (obits/days) might be taken as a rate process, it would seem reasonable to surmise the obedience of Arrhenius relationship.

The results for Marseille are given in Figure 10. It shows nicely that, within the reported temperature range, the previous law is quantitatively obtained.

Presently, a number of other reports on heat waves which have affected the American Middle West, London and Greece are under scrutiny. The observed activation energies seem reasonably typical of biochemical processes, but, as yet. the lack of larger samples do not, at present, allow for the precision needed, for more quantitative estimates of the global effect on mortality of a given steady earth temperatures increase.

Reliable studies on thermal induced mortality of mammals are unfortunately unknown to the author: they would well serve as guiding models for further studies. In addition, most of the primary data on heat waves are almost always reported in terms of meteorological "comfort indexes", without explicit reference to actually measured temperature values observed during the occurrence of the phenomena.

Finally, as to the question of why the eventually higher temperatures prevailing in torrid zones should not induce evident increases in mortality, the answer seems to be the observation made by Besancenot himself, that it is the small thermal differential between night and day - rather then solely a steady rise in temperature - which explains the observed effects. Thus, while Carpentras, nearby Marseille, had also undergone, at the same occasion, exceptionally high temperatures, the higher observed differential, allowing for local cooler nights, caused an almost complete immunity of this town to anomalous mortality rates.

Figure 10 – HEAT WAVE AND MORTALITY IN MARSEILLE
(JULY –AUGUST 1983)