Economy – Energy – Entropy

A Europhysics Study Conference on energy and the environment was organized by the EPS Action Committee for Physics and Society at CERN, Geneva, on 10-13 May 1996.

E. Worrell speaking during the roundtable discussion.

Economists, engineers and physicists met at CERN on 10-13 May to analyze the economic, social and physics aspects that must be taken into account when considering energy production and consumption and their related environmental problems.

Beat Bürgenmeier (University of Geneva) opened the discussion with a talk on *Economic approaches to environmental protection* that explained why policies to protect the environment require not only traditional economic incentives but also direct controls to change the institutional structure of the debate between science, economics, politics and ethics (see insert).

Other topics presented were:
The economical system and environment (B. Trezza, University of Rome)
Energy concept future of the HEW: renewable energies and demand site management (W. von Braunmühl, Hamburger Electricitäts Werke - HEW)
Options and policies to improve the efficiency of energy consumption (E. Worrell, University of Utrecht)
MARKAL-Macro: model structure and climate change issues (S. Kypreos, Paul Scherrer Institute, Villigen)
Energy policies in the developing world (M. Munasinghe, Colombo University)
Status and prospects of renewable energy sources (H.J.M. Beurskens, ECN, Petten);
New perspectives in energy from nuclei: the energy amplifier (C. Rubbia, CERN)
Self-consistent nuclear energy systems (Y. Korovin, Obninsk, Russia)
Technical and economic competition of advanced energy technologies (H.-C., Groscurth, European Institute for Economic Research, Mannheim)
Energy - entropy - economy - environment - ecology (K. Rebane, Tartu).

In opening the round-table discussion, Horst Wachsmuth from CERN, the conference chairman, reviewed the question marks surrounding so-called "facts" about the relation between global atmospheric CO_2 levels and global temperatures (see insert). His remarks prompted a lively debate which led to a press release articulating the need to invest now in new energy systems with reduced impact on the environment (see insert). Socrates Kypreos (Paul Scherrer Institute, Villigen) demonstrated in his presentation of least-regret hedging strategies (see insert) that the investment risk is affordable.

Institutional Change Needed

According to Beat Bürgenmeier (Geneva University), market-based incentives to protect the environment use taxes and subsidies since they view protection as one aspect of an economic policy that analyses the scarcity and allocation of resources. Such strategies are currently favoured because they work (in contrast to regulation-based approaches): one simply decides on the relative prices for goods by comparing costs of pollution with the utility of keeping the environment intact for future generations.

However, pollution is fundamentally a consequence of our way of life. Changing environmental policies therefore involves many different institutions, value systems and power balances. Economic policies must recognize the need for a combination of different strategies based on extremely varied viewpoints by broadening the analysis to include other disciplines. Economics must also come to terms with the fact that it is not an exact science with immutable laws, but a social science that has to reconcile all aspects of society's development. This overlooked feature has its roots in the notion that one cannot continue to assume capital and labour will substitute for natural resources *ad infinitum*. For the system is exhausting itself in much the same way as a system's entropy increases (order decreases) when its energy is used.

A socio-economic approach to environmental policy is essentially based on a sociological concept of society and not on an economic concept of trade. Economics must therefore replace its strict rationality with the notion of the bounded rationality of human behaviour - man wants to be rational but is imperfectly so, with individual preferences largely depending on the social context.

Transactions extend beyond market forces to information flow within society. However, the flow is increasing since incentives and technical advances that make workers more cost effective are tending to make people more individualistic. So it is costing more to ensure that the democratic rules governing collective decision making prevail, and developing environmental policies involves higher consensus costs. To handle these cost increases, governments have allied themselves with pressure groups. But as the number and variety of groups increase, they are finding it increasingly difficult to give each group something in return. So they now surround environmental decisions with precautionary measures such as impact studies and expert reports, and the lack of clear information and transparency results in hostile consumers.

One must therefore improve the flow of information and change the way pressure groups interact. In other words, institutional structures must change, and environmental policy must combine not only incentives which lead to modification of the relative prices of goods but also direct controls that produce this change.

B. Bürgenmeier is the Dean of Geneva University's economics faculty.

A Tolerable Investment Risk

The press release following the roundtable discussion stated that:

- The availability of energy is a prerequisite for satisfying basic human needs and for improving the quality of life, but with today's supply systems many people will continue to be unable to access an adequate amount of energy.
- In-depth discussion at the meeting confirmed that there exists great potential for energy systems which:
  - can provide secure, reliable and affordable energy now and for future generations in an efficient way;
  - have less impact on the environment than today's approaches;
  - help harmonize the world's unbalanced distribution of energy production and consumption.
- We must invest now in these intelligent technologies with
  - education
  - research
  - improved legal and financial frameworks

to enhance their potential to become future winners in the market for energy supply systems. For although they are not economically viable at present, it is clear that the opportunities for technical improvement are so large that the financial risk from starting investment too soon is tolerable.

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Europhysics Study Conference (CERN, 10-13 May).
The proceedings will be published by CERN and a report of the conference will be presented at the *Energy and the Environment Symposium* to be held at the EPS-10 General Conference *Trends in Physics* (Seville; 9-13 September 1996).

A Critical View

Horst Wachsmuth (CERN, Geneva), based on results reported by Z. Jaworowski *et al.* 1992, pointed out that while conserving fossil fuel for future generations is vital since it is offers irreplaceable non-energy resources such as materials, the impact of CO_2 emission from energy production on the Earth's atmosphere remains unclear.

Global atmospheric CO_2

• Pre-industrial level (**a**): data taken in the 19th and 20th centuries show wide scatter, with values approaching 1000 ppm. The much publicised estimate of 290 ppm was obtained by weighting data (circled points in **a**).

• Accelerating increase (**b**): the widely publicised curve showing an accelerating increase was obtained by shifting ice-core data by 90 years (**c**) in order to fit with more recent data obtained at Mauna Loa in Hawaii. Based on isotope data, the age difference has been found to be unreasonable.

• Correlation with fossil fuel CO_2 emissions: atmosphere measurements made at Mauna Loa do not correlate with global emissions.

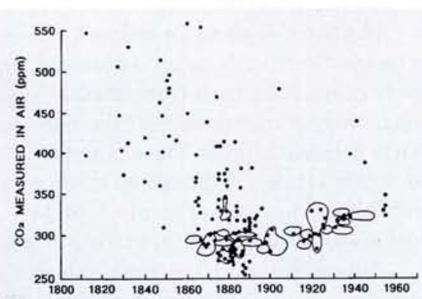
Global temperature

• Pre-1950 increase: larger before 1950 when little fossil fuel was burned.

• Correlation with solar activity (**d**): the measured difference from zero of the northern hemisphere's surface temperature correlate with the measured total solar irradience (reconstructed values also correlate up to 1840 when the measurements began). One-third of the observed global temperature increase can be attributed to solar activity.

• Correlation with global CO_2 levels (**e**): ice-core data for the atmospheric CO_2 concentration show marked some anticorrelations with the global temperature change.

H. Wachsmuth, on the right, with W. von Braunmühl.



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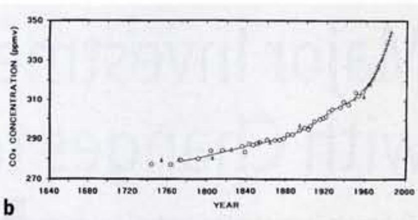

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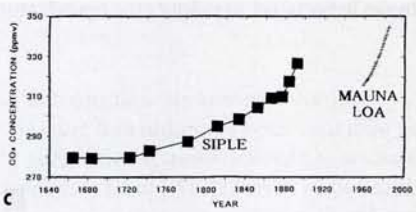

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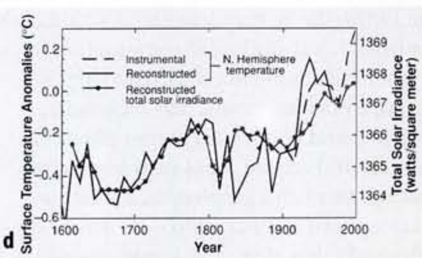

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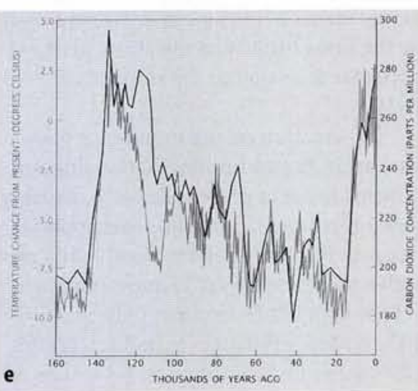

e

a: Average atmospheric CO_2 concentration measured in the 19th and 20th centuries. Encircled are the values used by Calendar 1938 [After Fonselius *at al.* 1956].
b: Atmospheric CO_2 increase in the past 250 years, as indicated by measurements of air trapped in Siple ice (squares; Neftel *et al.* 1985) and by direct measurements at Mauna Loa (crosses; Keeling *et al.* 1989) [From Siegenthaler & Oeschger 1987].
c: Same as (**b**) without assuming a 90-year age difference [Z. Jaworowski *et al.* 1992].
d: Northern hemisphere surface temperature anomalies (dashed line: measured; solid line: reconstructed) and the reconstructed total solar irradience [R.A. Kerr,1996].
e: Measured global temperature change from present and atmospheric CO_2 concentration as indicated by air trapped in ice [J.M. Barnola *et al.* 1987].

Least Regret is Acceptable

According to Socrates Kypreos (PSI, Villigen), most economists agree that a 50 % reduction in CO_2 emissions by 2050 (as demanded by the 1988 *World Conference on the Changing Atmosphere*) would have a drastic economic impact. In deciding what should be done, policy makers seek a single set of recommendations, such as a level of carbon tax. Using economic models, one can analyse different scenarios case-by-case.

PSI's MARKAL-Macro model (that combines an engineering model of the energy system with a macroeconomic model) predicts that for Switzerland, for example, very high and probably unacceptable carbon taxes are needed for a cumulative reduction of 30 % in the global CO_2 emission level by 2030.

However, CO2 emission is an uncertain threat and policy makers risk imposing premature and costly measures. A way to resolve the uncertainty uses multistage stochastic theory for a so-called "minimum-regret" short-term strategy, to gain time until 2005, followed by the full deterministic scenario-by-scenario strategy. One proposal is to have a low and reversible carbon tax to achieve by 2005 a CO_2 emission level mid-way between the levels that would be achieved if one simply set in motion policies for cumulative stabilisation and for a cumulative 20% reduction. If it turns out in 2005 that a 20 % reduction was necessary all along, one then applies the original deterministic strategy. According to MARKAL-Macro, this least-regret hedging strategy under all outcomes of uncertainty not only leads to sacrifices that are affordable for most people but costs less overall (15% lower marginal cost) than the deterministic strategy. It is also nearly as efficient in reducing the CO2 level (figure).

Buying greenhouse insurance with least-regret hedging. The fine lines give the CO_2 emission paths calculated using the MARKAL-Macro model for deterministic scenario-by-scenario cases with business as usual (upper curve: open squares), stabilisation (middle: open triangles) and a cumulative 20 % reduction (lower: open circles), relative to 1990. The thick lines are the corresponding paths with least-regret hedging to 2005 before applying the deterministic policies. Hedging gives only a slightly higher emission in 2025 if it turns out in 2005, when the uncertainty about CO_2 emission is resolved, that a 20% reduction was necessary all along.