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AN ISSUES PAPER
Contributed by the Energy Study Group of the Goals, Processes, and Indicators of Development Project, United Nations University

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CONTENTS

This paper by the GPID Energy Study Group is an outcome of the Study Group meetings held in June 1979 and May 1980, with Dag Poleszynski as co-ordinator and rapporteur.

Geneva, February 1981 Johan Galtung

It is being circulated in a pre-publication form to elicit comments from readers and generate dialogue on the subject at this stage of the research.

INTRODUCTION

Since the quadrupling of world market oil prices during 1973/74, energy issues have been raised with great fervour all over the world. Energy is being discussed in mass media, by experts and lay persons, by young and old, in rich and poor countries. Is the energy problématique that important? We believe it is and have put together this issues paper in order to come one step further in the energy debate, by sorting out some issues which we believe are important and which need further debate in order to come to agreement on at least some central points in the debate which to many seems confusing and contradictory.

The several hundred millions of poor and starving people in this world are not interested in energy as such. They desperately need more and better food, decent housing, clean water and air, medical attention, better transportation and communication, increased levels of education, meaningful work and a good cultural and social environment. However, the availability of suitable energy forms is a prerequisite for such needs satisfaction ever to take place. And as we shall discuss in this paper, no physical constraints seem to be able to exist which could prevent everybody on earth to enjoy a decent way of life. There is enough energy for all, but there are too many institutional and organizational constraints, too much abuse of power, too skewed a distribution of incomes and too low a level of knowledge for energy to be used in such a way that urgent needs are met for those most in need.

I. ENERGY AND HUMAN AND SOCIAL DEVELOPMENT

A central idea of the GPID Programme is that development is something which takes place in people, ie. that human and social development should be put in the centre of development thinking instead of economic growth or growth in energy availability. The development process hinges upon the progressive satisfaction of human needs, with priority given to those most in need, whose needs provision as much as possible should be carried out in a self-reliant, participatory manner, on the basis of local resources. Energy systems, conversely, should be simple enough to assure mass participation and be based on renewable, non-polluting or even pollution-reducing resources. All exchanges of energy carriers between resource-rich and poorer regions should be done on an equal basis, with the goal of reducing such exchanges when the capacity to utilize local energy potentials is increased. In order to facilitate the transfer of surplus energy from one region to another, unnecessary energy use and waste of resources should be brought to an end. The high use of non-renewable energy sources (oil, gas, coal, uranium) in the industrialized countries should be scaled down and be replaced by improved energy efficiency, conservation measures and the use of alternative sources of energy (biomass, wind, waves, and solar energy).

In the GPID view, there is no such thing as energy sources and technologies fit for "developed" as opposed to technologies appropriate for "underdeveloped" countries. It is rather a question of adapting energy use patterns and technologies to human and social development everywhere. In this way, energy policies enacted in the industrialized world may be of use to the less and non-industrialized parts of the world and vice versa, provided they really serve human and social development.

The GPID energy view leads one to an image of a future world where energy is used sparingly and applied with simple technology, still amply covering human needs all over the world.

We do not foresee the need for a quadrupling or quintupling of world energy conversion by 2030 as implied by some international bodies of opinion.(1) We know that it is possible to obtain far more useful energy with less input of primary energy in almost any sector of society or process needed to provide human needs. Accordingly, there is no need for planning an increase in the average global per capita energy use, although some regions of the world clearly must make more energy available to provide for human needs. Given a possible doubling of global population by 2030, an upper range for total energy of twice the present level should more than suffice - from the approximately 8 TW global energy budget of today to a total of 16 TW.

Analysts in several industrialized countries have demonstrated that these countries in the foreseeable future can maintain industrial growth even if energy growth rates turn negative. With a sharp rise in energy efficiency and an increased emphasis on non-material aspects of development, a world average of 2 kW per capita should be ample to cover our material needs for the future. 2 kW per capita is about 10 times higher than the commercial energy supply in poor Afro-Asian countries today, or some 4 times higher than per capita conversion rates in all less industrialized countries (total supplies).

The energy problématique should not centre on how to achieve world-wide growth of large-scale technologies, whether solar or non-solar, but rather on how human needs best may be covered with a minimum amount of renewable sources of energy. Such a strategy would aim for an all-renewable energy system for as many regions of the world as possible. It would argue for a substantial reduction in per capita energy use in some countries, zero growth in many others, and a significant per capita increase only in areas of human poverty and deprivation. Only in this way will it be possible to reach some kind of global parity of energy use, a necessary, but not sufficient, condition for an equitable, socially just world in ecological balance. Thus, the achievement of human and social development is contingent upon energy policies formulated to achieve such goals, and vice versa.

Since energy use involves most aspects of the whole development problématique, many issues remain unsolved, even if one may put up, in program form, an alternative view of what the energy problem is really all about. An essential issue is to agree on the terminology used in the energy debate, a point which is discussed below.

II. LANGUAGE AND INSTITUTIONS

The energy debate worldwide is bedevilled by fundamentally inaccurate and tendentious language. The word "energy" is used indiscriminately with a variety of meanings which are frequently mutually incompatible. Oil and other fuels, electricity, ambient energy like sunlight, and energy-conversion hardware like power stations or solar panels are all referred to casually as "energy." The usage is, of course, physically wrong. It also tends to blur the distinction between the different meanings. It suggests that one of these forms of "energy" is equivalent to another and can be easily substituted. In practice, such substitutions usually involve a substantial change in the entire energy-use infrastructure: for example, a change from the use of oil to the use of electricity.

The common meaning of the word "energy" is commercial fuel and electricity. Energy-conversion systems themselves are left implicit, even though policy decisions in practice are almost always directed to revisions of conversion systems. The terminology makes it particularly difficult to deal with the choice of options as between ambient energy and its conversion hardware, and fuel energy and its conversion hardware. Present terminology strongly favours fuel energy conversion simply by implication.

To speak of "consumption" is, of course, physically wrong, and tendentious, as is the term energy "production." Fuel can be produced and consumed; energy cannot, according to what ought to be a well-known law of nature (the first law of thermodynamics). The language is utterly inappropriate to ambient energy and its conversion.

"Supply" and "demand" are similarly loaded words in this context. It is not necessary to supply sunlight. "Demand" likewise relates only to fuel and electricity and arises because the energy-conversion infrastructure in place requires fuel or electricity to run it. The language does not allow for the replacement of the energy-conversion infrastructure with new structures requiring no fuel or electricity, as in the context of buildings, perhaps the single most important sector of the energy economy in northern countries. If the subject at issue is fuel and electricity, then the language should refer to fuel and electricity as such, not to "energy." It would be better still to keep the three energy factors separate and explicit: ambient energy, fuel energy and energy-conversion systems. In that way the policy discussion could deal coherently and symmetrically with all the various available technical, economic and political combinations of these various factors, and recognize existing constraints, including institutional constraints. The way in which the energy language is used in dominant institutions conceals the true range of possibilities available to society.

The question then arises as to how this basic energy language can be revised in practice. No easy answers suggest themselves.

The form of energy conversion under human control which developed gradually through history eventually prefigured the present-day way of thinking and acting about energy. A century ago, fuel energy was used in simple conversion hardware(such as the steam engine or wood-burning stoves); a combination of fuel and hardware imposed few constraints on either. The establishment of the electricity supply in the 1980s created a new type of energy-conversion system, integrated from supplier to user and involving a sequence of conversions of the original fuel energy through specialized hardware. This type of system also constituted a natural monopoly, as did the gas and, to a large extent, the oil-supply systems. Electricity suppliers had to meet particularly stringent criteria for planning and expansion of their systems to meet the demand of the customers - especially since electricity as such cannot be stored in useful quantities, but must be generated precisely as required by the total of all the customers involved. The monopoly characteristic of the supply system also brought into being legislative and regulatory institutions and a framework for central planning and central implementation of such plans.

The users, of course, were diverse, numerous and decentralized; so the concept of planning focussed on the acquisition of the necessary fuel and the establishment of the intermediate conversion infrastructure to deliver the fuel to the final users. It did not, however, encompass the final users themselves. In subsequent decades, the increase of scale and integration of fuel and electricity supply systems and the increasing specificity of fuel and conversion hardware for each particular end-use application established a procedure and a tradition for planning of the future evolution of the fuel and electricity-supply systems. Users themselves, however, whether individuals or organizations, were not usually called upon to think in terms of energy plans. This economic structure of fuel and electricity supply and its consequent necessity for planning were important factors in determining the linguistic usages discussed above.(2)

History has created a powerful constituency of interests on behalf of fuel and electricity supply. The existence of a large-scale energy-conversion infrastructure reinforces the power of this constituency, since the alternative to further fuel and electricity is replacement of the infrastructure, of necessity both diverse and gradual. Now, in 1980 in industrial societies, energy planning in a meaningful sense is done centrally: by government departments and agencies, and by public and private fuel and electricity suppliers. These central authorities and organizations have their own staffs of energy analysts and planners. The background of such analysts and planners is almost invariably in engineering and in economics, not in physics or in biology. Their understanding of the real physical nature of energy usually seems to be very limited. Their preoccupation with planning for extraction of fuel and for the installation of intermediate energy-conversion systems - power stations, refineries and the like - starts from the premise that the final uses of fuel and electricity are not susceptible to planning. Indeed, statements to this effect are regularly made.

In practice, of course, a great deal of influence is already exerted to ensure that the fuel and electricity available for use is indeed used. Pricing policies, tariff structures, and official financial support for the fuel and electricity suppliers all constitute powerful and asymmetrical influences in favour of the extension of the supply of fuel and electricity in preference to the replacement of the conversion infrastructure to require less fuel and electricity. The central planners use the language and concepts described above, both among themselves and in public. This ensures that options which might eventually reduce the importance of fuel and electricity remain unstated and even unrecognized in policy discussions. Through recent years there has nevertheless developed a substantial body of evidence suggesting that a major shift of resources and effort away from fuel and electricity supply to up-grading of the energy-conversion infrastructure is a policy option worthy of consideration. The reaction of central planners to such a suggestion was initially to claim that such innovative measures, making more use of ambient energy and using more efficient end-use conversion systems, were not technically feasible. This was comparatively easy to declare when innovative strategies laid great stress on technologies like solar photovoltaics, still in the research and development stage. The proclaimed lack of technical feasibility became less plausible when innovative energy strategies were suggested which relied entirely on familiar conversion technologies like combined heat and power, heat-recovery systems and heat pumps, as well as high levels of thermal insulation and cascading of energy conversion from high quality to low. Central planners gradually retreated from their initial position, acknowledging that alternatives might be technically feasible. However, the central planners claimed that such technical innovations would not be economically justifiable. Once again, this claim was easier to sustain about innovative policies relying on comparatively exotic conversion technologies. Again, however, the claim became less credible about strategies involving the familiar conversion technologies afore-mentioned. Indeed, the economic status of thermal insulation and high-efficiency conversion systems was much better established than that of nuclear electricity, fast breeder reactors and synthetic fuel plants, all of which figured prominently in the strategy of central planners.(3) Once again the central planners were gradually forced to concede that innovative strategy propopals were not only technically feasible, but economically justifiable.(4)

Central planners then retreated to a third line of defence, much more impregnable. They claimed that, despite their technical and economic plausibility, innovative strategies would not be politically or socially acceptable. Given the existing institutional infrastructure for fuel, electricity supply and energy planning in medium or highly industrialized countries, this claim carries considerable weight; but it should be correctly understood. The people to whom innovative strategies would be institutionally unacceptable are the central suppliers of fuel and electricity, and their government overseers. The central planners have developed the habit of referring to "coercion" that might be necessary to bring about the diversified decentralized improvements of efficiency entailed in many innovative energy strategies. They fail to point out that present centralized supply of fuel and electricity has coercion built into it as an inherent assumption: the unilateral setting of prices, the sanction of disconnection of supply, and of course, the whole centralized mechanism for planning, financing and constructing new supply facilities like power stations.(5) Innovative energy analysts now accordingly direct considerable attention to the institutional structure involved in decision-making: criteria, procedures and the mechanisms for implementation of energy decisions. It is recognized that the legislative, statutory and regulatory context of energy use may require substantial alteration if society is to choose an optimal long-term strategy, free of preconceptions and asymmetrical constraints.

The official arguments put forward by central planners purport to be objective, rational analyses, and deductions therefrom. The central planners contrast their own views with the "emotional," "naive" "wishful thinking" of the unofficial analysts and commentators. Official planners assume that unofficial analyses are unsound. Official planners also miss no opportunity to attempt to discredit unofficial analyses. Official planners forecast a substantial increase in the use of fuel and electricity - which of course they call "energy." They then claim that the so-called "renewables" cannot contribute more than a modest proportion of this eventual requirement. They usually fail to note that oil and nuclear electricity will be at least as hard-pressed to accomplish the expansion official strategy entails. Official planners address considerable attention to the "motivation" of unofficial energy analysts and commentators, the implication being that these unofficial participants have narrow axes to grind. No reference is made to the "motivation" of the central planners themselves, whose public statements are presented as though, unlike unofficial participants, the official planners had absolutely no axe to grind. Precisely the reverse is usually the case. Official planners are concerned primarily with the investment programmes of fuel and electricity supply - often only with such investment programmes. Unofficial planners are not subject to such constraints of self-interest. It should also be noted that official planners, while deploring the alleged "emotional" nature of unofficial commentary, do not themselves hesitate to suggest that unofficial strategies would lead society "back to the stone age" and to "freezing in the dark."

It need hardly be added that official descriptions of unofficial analyses leave a great deal to be desired. Official misrepresentation even of the factual basis of unofficial analyses is endemic. It is essential to understand the psychology of the official planners. They have a long record to defend. A complex of previous assumptions and programmes gradually put in place the present energy systems of society, both technical and institutional. Even in cases where decisions were patently misconceived or badly executed,it is difficult for official planners to concede error; indeed the bigger the error, the bigger the vested interests to defend. It is thus henceforth necessary to stress in energy discussion the non-quantifiable aspect of energy issues. It is these aspects which determine policies and strategies. The outpourings of numbers mostly represent post hoc rationalization of policies determined by non-numerical criteria.

The present energy establishment, so-called, is really the fuel and electricity-supply establishment. It is powerful and deeply entrenched and has a relentless momentum behind it; but it does not follow that the views of the fuel and electricity-supply establishment will necessarily prevail. Technical failures, economic stresses, and political tensions have been accumulating for a decade or more. The present system is interconnected, inflexible and brittle, precariously vulnerable to misjudgment, mishap and misrepresentation. There is an urgent need to confront the fuel and electricity-supply establishment and insist that their interests be subordinated to the broader interests of society as a whole, both in industrial countries and in the third world. Such confrontation must begin with the very definition of the energy problem.(6)

III. ON DISAGGREGATION OF THE ENERGY PROBLEMATIQUE

In the standard approach to energy assessment, the energy-supply side is split on different energy sources, such as coal, oil, nuclear, hydro and wood ("primary energy"). Similarly, the demand side is divided in sectors such as industry, agriculture, transportation, commerce, households and the public sector. The sectorial demands are often worked out in terms of delivered heat, electricity and portable fuels (energy forms), and only losses in central conversion (heat and electric utilities, town gas plants, etc.) and transmission are counted. Taking these losses into account, the sectorial demands are translated into primary energy requirements, and possible mixes of energy-supply sources can then be assessed and economically evaluated.

In later years, more emphasis has been placed on the way in which the "delivered energy" is utilized. The amount of heat to be delivered for space heating uses depends on insulation standards and building types. The amounts of electric power to be delivered for lighting and electric equipment depends on the technology used, eg. glow or fluorescent light bulbs, the amount of insulation on freezers, and controlled regulation of motors and other industrial machinery. The amount of fuel to be delivered for various vehicles depends on motor construction, gearbox exchange ratios, aerodynamic shape, tyre type, driving habits and so on. Considerations of efficient energy use have led to increased emphasis on multiple energy use, such as "cascading" energy by queueing industrial processes according to temperature requirements, so that the process heat supplied to the highest temperature process will be successively reused for other processes at lower temperatures. Co-generation and other "waste-heat" uses fall into the same category. Generally speaking, one should consider the actual task to be performed, and then choose a method which achieves the task with a small energy input. Both input of energy into manufacturing of equipment and into operating it over the expected life should be counted, so considerations of running energy supply should be supplemented by considerations on equipment choice and durability of components.

Most energy planning has been at a national level. This has obvious advantages, due to the administrative uniformity and common legal basis. However, larger geographical regions in some cases have to be considered as entities, in order to achieve the optimal planning, eg. the shortest utility transmission lines may not respect national borders, and exchange of primary or secondary energy between the individual nations may lead to stable energy-supply systems organized in ways different from the organization resulting from individual assessment of each country. Such technical considerations cannot, of course, give all the answers to better planning; they must go hand in hand with strategies for overcoming political and social constraints to reaching such ends.

The administrative aspect in energy planning can, of course, be carried to smaller subunits in the prevailing administrative system. In this way, energy planning on a country or commune level has recently been encouraged in a number of countries, with the purpose of filling in a detailed local strategy within the general framework set by the national energy planning, which in itself may then only contain general trends and prescriptions of a principal nature. Although a global, regional or national level analysis may be useful to give a rough overview, it prejudges the issue. It is not at all obvious that what works at the global/regional/national level will work at the local level, particularly not in times of crises when transfer lines of various kinds are broken. What is obvious is only that centralized energy provision becomes a power resource in both senses of that term, for the central elite: a provision that makes them look like (good) providers, a resource that can be cut off in order to exercise influence over those who depend on it.

A basic point when a problem is to be analyzed with a view to finding solutions is not to prejudge the issue in the choice of units and variables and conceptual schemes for the analysis. Hence, both from a physical and a social perspective it would be better to base the analysis on the local level as a planning unit and ask: given its endowment, how can any local unit become self-reliant - meaning by that a capacity for self-sufficiency in times of crises, and equitable exchange with others in normal periods. Ultimately this type of localization of the energy analysis would go down to the individual household. The advantage of this type of planning is not only that the sum total of local balances is global balance (and not vice versa), but that the local level is where most people live so that their creativity can be utilized - higher levels of analysis would only draw on experts. The role of experts for local level analysis would be to make people aware of options, particularly of using ambient energy, and to convey experiences from other places. And as usual, the best results are probably obtained by combining global, regional, national and local level planning.

Again it is to be argued that some aspects of energy planning are not evaluated best within the administrative framework. Physical and social classifications may be of extreme importance, if energy planning should reflect an approach to the general goals of a society. One promising approach is to work upon a classification according to habitat, eg. farms, villages, towns, cities, metro- and megalopolis, that offer distinct, different problems and solutions, particularly if the guiding norm as a point of departure is a move towards self-reliance.

The activities and hence structure of energy use if often greatly different in these different types of settlements, and the separate treatment thus helps in understanding the dynamics of the development within the different habitat-sectors.

Another approach would be a distinction between social classes, again with the purpose of following the development in each class separately, eg. concentrating the constrained energy-use policy to the upper classes, who can best afford investments in high conversion efficiency, and conversely following a strategy for increased energy usage in the lower classes, if the development goals so demand. Furthermore, the sectors requiring subsidies in order to adopt efficient energy-use habits are also best identified in a class-stratified classification. Drawbacks include the negative connotations to openly stated class divisions in societies which aim at diminishing - or claim to have eliminated - class differences.

However, one guiding principle could be formulated with the purpose of ensuring a balance between the aspects of individual citizens and those of society as a whole. This would be to start the analysis at the bottom end, with methods of satisfying the needs of each individual, and then to work one's way upward to larger units or sectors, in order to identify the structures which give the most acceptable system as seen from society as a whole, in terms of economy and other factors of importance. This "bottom-up" approach ensures that only strategies satisfying the more basic needs for all individuals in society are given attention, and that the choice according to the different rules taking a more prominent position in different societies is made between alternatives which are all consistent with the basic needs goal, no matter which different criteria are used at the more aggregate levels of the analysis.

Then, there is the problem of the conceptual framework implicit in the cutting of the energy problématique into a supply side and a demand side. To many this looks so obvious: there is a demand from various sectors of the society, there is a supply, or at least a potential supply; the problem is how to make the supply meet the demand within such logics as the market, or the centrally planned economies. Put differently: there is a production side producing the supply and a consumption side consuming the demand - the link is the distribution. Without denying that this way of looking at it may be in the interest of producers and consumers, what is absolutely certain is that it is in the interest of those controlling the distribution. The cut between supply and demand makes it possible for the market and/or the state to enter, in other words corporate and/or bureaucratic interests - energy corporations and/or the national department/ministry of energy. What is needed would be a less dichotomous conceptualization, more in terms of energy cycles, less in terms of an exchange relation between two parties (and one intermediary).

However, if the market metaphor is to be retained, some minimum requirements should be placed on the disaggregation of the supply side and the demand side:

as to the supply side:	the supply should be disaggregated along a hard/soft dimension, spelling out clearly what kind of choices, which costs and benefits have been made;
as to the demand side:	the demand should be disaggregated along a basic/non-basic dimension, spelling out clearly what kind of need this and that end use serves directly or indirectly.

The net effect of such analyses could be a higher level of consciousness as to the human and social costs involved, and the priorities implicit in the energy-use allocation.

IV. UNDERLYING ASSUMPTIONS

There is a considerable number of energy projection studies now available from high-income (OECD) countries, with projection horizons typically in the range of 10-50 years, ie. from the near to the more distant future. Typically, the reports would have a supply side by energy source and a demand side by social sector. Assuming that there is a supply/demand balance today (or that there was one before the OPEC 1973 action), assuming further that the supply may be decreasing because the conventional sources (oil, gas) are dwindling (because they are being exhausted, are too expensive to exploit or no longer available because of new control patterns), there is obviously a *problem*, sometimes referred to as a *crisis*. One approach would be to decrease the demand side through *saving*, another to increase the supply side by introducing new sources - if the status quo cannot be maintained through a reversion to old control patterns (eg. through military coup or intervention). How all of this is done in the various government reports will not be discussed here, as that belongs to the explicit part of energy analysis. It is the implicit part, the underlying paradigm, the unstated assumptions, that constitute the issue to be discussed here. As an example will serve one particular article,(7) selected here as typical of a certain type of analysis, and for its explicitness, which means that what is not stated is equally explicit, through its absence. Actually, one of the usually implicit assumptions is made explicit and immediately seems to invalidate the whole exercise:

> The two scenarios for demographic development and economic growth for world regions are not predictions but rather conceptualizations of the future world status. Thus, they determine a range of conceivable evolutions of the techno-economic domain, *assuming a world free of major disruptions and catastrophes*.(8)

Being located in the midst of a historical process characterized by the decline and fall or at least modification of Western imperialism on a world scale and the rise of not only new power centres but indeed of other "conceptualizations of the future world status", this is a peculiar assumption indeed. A more realistic one would be a continuity of discontinuities. But as a base-line scenario, one among many, one may of course also admit the intellectual value in something based on that assumption as long as it is seen precisely as a conceptualization and not a prediction.

Over and above this the following implicit assumptions merit attention:

H_1: Economic growth, as measured by GDP, will continue to make sense. As GDP essentially measures monetized, market value added, through processing of goods and services (including bads and disservices) this of course requires energy conversion as industry (for processing) and transport (for marketing) are involved. Statements linking long-term GDP growth to energy demand growth, hence, are nearly tautologous. Accordingly, the real message beyond tautology is not about energy, but economic growth as normal; business as usual.

H_2: H_1 is valid all over the world. In treating seven regions qualitatively exactly alike, only with variations in population growth and in economic growth, an image of world homogeneity is created, implicitly conveying an image of a conceptually manageable world.

H_3: No structural reorganization of society is needed to obtain energy balance. In modern urban, industrialized society, human-controlled energy is typically controlled technocratically, ie. through a complex of bureaucratic, corporate and intelligentsia components, in a centralized fashion. When such arrangements are not seen as variables, changes in them are seen as parts neither of the problem, nor of the solution - as a conclusion the (hidden) message is that no changes are foreseen. Power as usual.

H_4: H_3 is valid all over the world. Again, the non-mentioning of such factors for seven regions of the world carries a message to those who wield technocratic power: here is a scenario, a "conceptualization of the future world status" that will in no way erode their power basis; it may even strengthen it.

H_5: National estimates presuppose intra-national transfers. Energy budgets for a nation presuppose transfer systems within the country, as there is no built-in assumption of local self-reliance. This adds more detail to H_3 above, implicitly:

- there will be a national power grid
- there will be a centre coordinating that grid
- in periods of deficit the centre can justify saving by rationing energy evenly, equitably
- in the periods of surplus the centre can justify spending it by spending for "common purposes" (national defence, big industry - both of these by balancing trade budgets, etc.).

H_6: Global estimates presuppose global inter-national transfers. Energy budgets for a whole world presuppose transfer systems, called trade between countries,eg. exchanging energy raw materials for energy-conversion facilities. As these are asymmetrically distributed,the hidden message is a continuation of division of labour rather than national self-reliance - in other words,maintenance of basic aspects of the global structure.

In short, the sum total of these axioms is status quo, and the message (as also the assignment) is to solve the energy problem within the framework of the status quo. The accusation of conservatism in this connection may be countered by saying that a set of axioms indicative of change would also be a set of political value assumptions. But the accusation of lack of realism is more important - both in the sense that global processes will prove the axioms to be invalid, and in the sense that if they were valid, a world based on those axioms is precisely the world that will continue to generate "energy problems" ad infinitum, as it did in 1973. In short, a self-defeating scenario.

V. HARD VERSUS SOFT ENERGY SYSTEMS

Nobody will have or should have any monopoly on how to define this strategic dimension in the theory and practice of energy politics. But two main schools of thinking can be identified: those who try to define it in terms of one single variable (eg.,centralized vs. decentralized systems), and those who try to define it in terms of a cluster of variables. We prefer the second approach; it is richer, calls the attention to more aspects of the total problématique, and also makes for a less absolutist approach. Thus, if one agrees on five dichotomies of the hard vs. soft type, then any system could be rated in terms of its softness score, say from 0 to 5, assuming equal weight to the variables - "5" meaning soft on all variables, "0" hard on all of them. All 32 possible types (2^5)might be of some interest, although the preference in this issues paper, of course, and indeed, is in the direction of the soft end of the spectrum.

The problem is which variables to choose. Here are some candidates; all of them applying to the total energy cycle, including the cycles for the production of energy-conversion hardware:

(1) Structure 1: Centralization vs. decentralization, meaning roughly the extent to which the parts (of a country) are energy self-sufficient.

(2) Structure 2: National vs. local control of energy surplus, meaning, roughly, the extent to which the local level is free to decide itself how a possible energy surplus is to be used and is in a position, for instance, to withold it from "national" causes (arms manufacturing).

(3) Structure 3: Non-distributive vs. distributive, meaning, roughly, the extent to which energy is transformed in such a way that it is available within reasonable differentials to all groups of the population, both in terms of costs and benefits derived from the total cycle.

(4) Nature 1: Polluting vs. non-polluting, meaning, roughly, the extent to which the total cycle of pollution output is low, below an agreed-upon threshold (determined by those affected).

(5) Nature 2: Depleting vs. non-depleting, meaning, roughly, the extent to which the energy sources are renewable.

We are not arguing for one of the extremes in the given dichotomies, but rather for a better balance between centralized and decentralized, national vs. local control, etc. And for most countries the time now certainly has come to achieve a better mix of energy cycles in the direction of more decentralized, locally controlled, distributive, non-polluting and non-depleting systems - in short, more in the direction of a "soft energy path."

VI. COMFORT AND ENERGY USE

The relation between energy use and "quality of life", almost regardless of how it is defined, is problematic. No simplistic assumption of a linear relationship, positive or negative, seems warranted, even if we focus on physical aspects of quality of life only. At the most basic level this takes the form of satisfaction of basic needs, for food, shelter and clothing, medical care and schooling, for transportation and communication. There is no argument that energy should not be made available for these purposes - what else should be the purpose of man-made energy-conversion systems if not to protect human beings against the acute pain and discomfort of hunger, extreme temperatures, disease, exclusion from the human community because of insufficient command of language or because of geographical isolation? But at the next level, provision of material comfort, it becomes more problematic - partly because this concept is difficult to define, partly because there seems to be no end, no stop signal to the provision for material comfort once initiated, and mainly because the need for comfort, when over-provided for, quickly leads to a sense of discomfort although of a subtle kind.

Material comfort,then, is seen as located in the interface between man and nature; both in the way nature has an impact on man and in the way man impacts on nature. Nature can be pleasant to our senses, but it can also be brutal. One definition of material comfort would be to provide people with an environment making a pleasant impression on their senses: a low level of noises or mostly pleasant ones (bird twitter, music); absence of foul smells or the presence of pleasant ones (the smell of flowers, perfumes); no bad tastes or only pleasant ones (fresh fruits available, soothing drinks); control over light and darkness and no unpleasant sensations impacting on the skin (temperature, moisture within acceptable ranges, mild winds, light rain, soft snow; no avalanches, tsunamis, etc.). Modern urban, bourgeois dwellings in industrial societies provide much of this for many people; so did slave and feudal societies for their elites. The energy costs in controlling temperature and moisture through air conditioning may sometimes be considerable: among the social costs is a society that produces noise and foul smells and tastes, the energy costs of isolating human beings from this (noise and toxic pollution, much of it not registered by our senses so that artificial warning signals are needed), and so on and so forth. No doubt, there is a lower limit for human comfort where needs are not satisfied, but there is also an upper limit, less precisely defined, beyond which it is illusory to talk about comfort. Thus, much of what has been hinted at above is tantamount to the creation of an artificial nature replacing natural nature, partly through control of variables within a constant range, partly through isolation, and partly through the introduction of artificial compounds (for instance, "fresh smell" on spray bottles). The fuel impact of this introduction of non-natural elements (new compounds, electro-magnetic waves, etc.) is far from known, but what we know already is more than enough to serve as a warning.

That the creation of artificial nature, ie. our removal from natural nature, requires energy conversion is clear, but the problem of the upper limit to material comfort merits discussion regardless of whether there is an "energy squeeze" or not. If we assume that there is an optimum range of material comfort beyond that of merely satisfying basic material needs, then there is both under- and overconsumption relative to this optimum range in the world today. To what extent savings from those who want a less fuel and electricity-intensive way of life - protecting themselves against the second kind of material discomfort - compensate for the energy demands by those who want more material comfort remains to be seen. Intra-nationally they live side by side, and the rich man who goes in for a smaller car and less speed may liberate fuel (or other energy forms) for use by others. Internationally, they do not live so closely together, but it looks as if the underconsumers have at least potential control over so much of the energy sources that it might also even out in the longer run.

Some of the same may be said about the way in which people have an impact on nature: through work. There are at least two ways in which work may lead to material discomfort: by being heavy (a strain on the body, possibly leading to poor health or pain), and by being dirty (a general term covering the toxic and non-toxic, such as unpleasant smells, touch, tastes - one may even add eye-sores and ear-sores). Labour-saving devices are particularly aimed at making work less heavy; to make it less dirty all kinds of protection are used. Nobody, particularly not those whose task it never is to have to do heavy and dirty work, should argue against this. There is a bottom line of tolerance, although varying from culture to culture. But there is also an upper line: there can be too little strain on the body, too little exercise and too much protection, which essentially means a too artificial surrounding. If this comes in addition to too much artificiality in daily life outside work, the guess would be that the negative impact could be considerable.

Consequently, slogans to the effect that lower rates of energy conversion would mean lowering of the quality of life are as wrong as the opposite slogan: it all depends on where, for whom, and how. The plea, hence, is for a less simplistic debate.

VII. GEOGRAPHICAL DISTRIBUTION OF ENERGY RESOURCES

It is generally acknowledged that an uneven distribution of resources has a potential for creating conflicts, and that the uneven geographical distribution of fossil and fissile energy resources is a major factor in the political unrest presently surrounding these resources. Also the renewable energy resources, solar radiation, wind, hydro and wave energy as well as geothermal flows are unevenly distributed, and it may be of interest to ask questions such as the following:

Are there enough energy resources in every region to sustain essential energy uses? It is, of course, debatable which uses are essential, but for a given social organization, it is often possible to estimate a minimum energy supply below which serious disruptions or collapse of societal functions are likely to occur. It would thus be a basic policy to supply and control this minimum energy from indigenous sources, and to see to it that additional energy, if imported, does not create structural changes that would increase the region's minimum energy requirement and vulnerability in case of supply denial from the outside. Since the minimum supply depends on social organization and particularly on the structural framework (settlement patterns, industry types etc.), an assessment of indigenous controllable energy sources may have the outcome that the organization would have to be changed in order to obtain the desirable level of self-reliance, and, of course, it may point to inappropriate divisions between regions. The delineation of each regional unit is evidently a key factor, since very small regions are likely to be characterized by a lesser multiplicity of energy sources than larger regions. For small regions within a country, as well as for individual members of society, only the most basic of energy supply self-sufficiency may be achievable, whereas larger units, such as countries, may see it as feasible to obtain higher levels of energy independence. If trade of energy raw materials or of converted energy is necessary, a country may select its trade partners with care, in order that the potential for conflicts over energy is minimized.

As a first approach to the question, the energy flow per unit area may be estimated as a function of geographical location, adding the contributions of different energy sources. This should be done not only on a time-averaged basis, but also on time-scales allowing an assessment of suitability for use with different energy conversion systems, and especially the need for energy storage implied by the variations. A more detailed assessment has been attempted elsewhere.(9) Below will be given some average estimates of energy fluxes per square km for various geographical locations, averaged over the year.

For the sake of reference, the present average world population density is 27 people per km^2 (land surface), and the present average energy use is 2 kW/capita or 54 kW/km^2, excluding food (which would be 3.4 kW/km^2 based on an average 125W per capita).

The direct solar radiation flux at the surface of the earth ranges from about 95,000 kW/km^2 to about 500,000 kW/km^2. The biomass produced on 30% of the land at 1% conversion efficiency is thus 285 to 1,500 kW/km^2, which on average is seen to be generous enough for food to man and livestock, plus plenty of residues from which to derive biofuels. If 1% of the land area were set aside for solar collectors converting radiation into heat or electricity at a 10% conversion efficiency, the resulting output would be from 95 to 500 kW/m^2, thus exceeding the present average energy use.

The summed-up potential for indirect solar energy sources is more difficult to derive. The average energy flow into and out from the wind systems is 2,400 kW per km^2 of the earth's surface, and the similar exchange of energy with ocean wave motion perhaps 6 kW/km^2. Much of the wind energy is available at high altitudes above ground level, and practical wind energy conversion may be limited to an average 10-20 kW/km^2. Variation with geographical location is stronger than for solar radiation. This is also the case for hydro and geothermal energy, for which the average resource energy flows are 67 and 53 kW/km^2, respectively. Practical hydro power conversion is limited to an estimated 8-14 kW/km^2. Extractable geothermal heat may be of the same order of magnitude.

In summary, the average energy conversion considered possible on the basis of renewable energy flows by far exceeds the average energy use at present, and even the minimum direct solar energy conversion rate is sufficient to cover the average energy use. If instead the actual use is considered as a function of geographical position, there will, of course, be spots of high population density (cities,etc.), for which the estimate of renewable energy conversion on an area basis is insufficient. However, if regions large enough to comprise a typical mix of settlement types are considered, then the maximum population density can be limited to about 250 people per km^2(10) Most of the regions with extremely high population densities are in climates where space heating is not a major component in the energy usage, and therefore regions of maximum average energy use (presently of the order of 10 kW per capita, again assuming regions of a size which comprises several different types of activities) are not likely to be the same as the ones with maximum population density. Therefore, the maximum energy use on an area basis is today about 1000 kW/km^2, averaged over regions typically of a size above 1000 km^2, and in a few cases still larger (eg. for regions including the Ruhr-district or the Los Angeles Basin). How much of this is so basic that a supply cut could not be tolerated? The answer is debatable and depends on the effort made to adopt structures with minimum vulnerability. Most estimates will agree that every country could keep this basic energy need down to below 500 kW/km^2 (for the maximum average population density, otherwise correspondingly less), with at most minimal changes in the present structure. Since also none of the high-population regions is in the Arctic zones, this basic energy need is in all cases consistent with the estimate derived above for a possible rate of direct solar radiation conversion. In some regions, a mix of indirect solar sources would be more readily exploitable than direct solar conversion alone.

It thus seems that every region in the world has the potential for a basic energy supply which is inexhaustible and locally derived as well as indigenously controllable. Some regions even have a large surplus of such sources, as well as fuel resources for a limited period.

VIII. THE ROLE OF ENERGY STORAGE

Energy storage is used for maintaining a stable and dependable energy supply independent of variations in demand and in energy source input. Traditionally, energy storage has been in the form of fuel. After collection or extraction and refining a fuel-resource can usually be stored for any amount of time and with no (or very small) losses. Most fuels have high energy densities, so this kind of storage before conversion is extremely convenient, as evidenced by the considerable action radius of vehicles carrying their own fuel as only a minor fraction of their total weight. Energy systems based on renewable energy flows of varying strength are particularly in need of adequate energy storage facilities.

As fossil or fissile fuels constitute a declining fraction of a given energy system, there will be an increasing need for energy storage other than in terms of the fuels derived from such resources. One path would be to produce synthetic fuels, which can be used in a way similar to the present use of stored oil and coal products. Examples of synthetic fuels are hydrogen, methanol and ethanol. Hydrogen can be produced from wind energy, solar-electric or nuclear-electric converters (by electrolysis) or from high-temperature solar or nuclear heat-producing converters (by chemical conversion). Methanol can be produced from wood by chemical conversion, with the primary energy supplied by photosynthesis, or it can be produced non-biologically, using energy input eg. from nuclear reactors to direct the chemical processes (which may be via hydrogen). Ethanol (alcohol) may be produced by fermentation of biological material (non-wooden) or by non-biological chemical processes. Both methanol and ethanol formation is accompanied by a depletion of carbon dioxide from the atmosphere, balanced by the carbon dioxide release later at the energy-conversion stage. The use of these synthetic fuels would thus not be associated with the carbon dioxide problem of burning fossil fuels (where the assimilation and release of carbon dioxide are separated by millions of years).

Another path to energy storage would involve reversible physical or chemical processes, such as heating and cooling of water or rock, melting and freezing of a metal or in general any chemical phase change associated with latent energy release or absorption. The choice of materials and processes is dictated by considerations of temperature region, mass and volume restrictions, and of stability during a sufficient number of storage/extraction cycles. A special class of reversible chemical processes are those involved in electrochemical devices, such as batteries. They would be used for energy storage demanding electric input and output, whereas the previous examples are mostly interesting in connection with storage of heat energy.

Finally, there are the reversible physical processes using mechanical energy storage, such as pumped hydro setups, compressed gas storage and flywheels. Most of the concepts touched upon have been or are in use (some extensively), and attempts are made to improve the performance (batteries, phase-change chemical storage, synthetic fuels) and to use new methods (superconductive storage). Yet,the total R&D effort is surprisingly small compared to what goes into energy-conversion techniques, and the present experience with energy-storage techniques is not always relevant for future energy systems. For instance, much of the present battery use is in small systems (in portable radios, for automobile starter engines,etc.) with characteristics rather different from those of general energy-supply systems, and heat-storage systems such as hot water tanks are mostly for short-term storage, leaving unanswered the question of seasonal heat storage required at higher latitudes.

From the point of view of future energy systems the priorities would seem to be:

(a) portable storage systems for the transport sector;
(b) seasonal heat-storage systems for high-latitude buildings;
(c) storage systems capable of storing and regenerating electricity with high cycle efficiency, and perhaps
(d) high-temperature heat-storage systems for process industry.

The doubt about the necessity of the last item is due to reflections on the need for continuous industrial production. The work schedule could be arranged in such a way that the high-temperature demanding processes were performed when this form of energy would be available, and other activities were taken up in the remaining periods. Such arrangements, of course, could only be acceptable to the extent that they did not infringe upon the satisfaction of the needs of those very people the processes were intended to serve.

For the portable storage systems the main candidates at present appear to be synthetic fuels or batteries. Several years of advanced battery research have not led to the breakthrough hoped for, and general reservations towards a heavily electric future energy system may further discourage from this route. The production of synthetic fuels from biological wastes or energy crops is an activity in rapid expansion, but questions of an optimum balance between food and energy output remain open.

Dependable heat-storage systems operating at temperatures between 50 and 100° C are recently claimed to have become available (such as the Swedish "chemical heat pump" using the latent energy of crystal water in salts), but the practical experience is still limited. Hot-water systems are only marginally suited for seasonal storage, due to the heat losses from even a heavily insulated storage tank.

As far as electric energy storage is concerned, the only method proven at a large scale is pumped hydro storage, which on the other hand is limited to regions with access to suitable elevated reservoirs which can serve to store large amounts of water with tolerable environmental impacts. Since the distance between the location of such reservoirs and the load centres is important, transmission technology is a key factor in determining the regions for which pumped hydro is an option. Hybrid systems comprising hydro-power with reservoirs and another energy source may allow advantages of combined operation, without need for upwards pumping. Where hydro storage is not feasible, short-term storage using flywheels or batteries and long-term storage using hydrogen may be considered. However, all of these techniques need further improvements with respect to durability and cycle efficiency. For the hydrogen scheme a major problem is how one may store the hydrogen for extended periods.

IX. ENERGY EFFICIENCY

During recent years, a number of studies have convincingly shown that there are no technical obstacles to considerably lowering the primary energy use in a country,(11) and also that improvements in end-use efficiency in general are more economical than the further deployment of hard-energy-conversion hardware such as nuclear or coal power plants.(12) Also, there is nothing inherently extra-paradigmatic to present scientific thinking within the field of engineering or economics which should prevent industrialized countries to contemplate a significant lowering of fuels and electricity use during the next decade. Zero growth or even substantial negative growth rates can be had without sacrificing the <u>really</u> holy cow, economic growth, at least for several decades.(13) A not too unreasonable prediction, therefore, would be that efficiency-improving techniques which can be used without taking power away from experts and profits away from capitalists indeed will be used in the not-too-distant future. Institutional barriers, organizational obstacles and political prestige will slow down the implementation of such things as district heating from central power plants, the use of heat pumps and heat exchangers, of cascading of high-temperature process heat from high to low-temperature processes in industry, and of making more energy-efficient private automobiles. The trend is already there; all these things are coming. So should we not all be pleased?

The race for increased energy efficiency has begun, although very slowly so, by those people who already have the power to run the world. Do you think that energy experts will leave it to the grassroots to decide how to cascade heat from one industry to another, to decide what kind of thermal plant is best suited to what local community's district heating potential? They will not - high end-use efficiency will not automatically mean increased participation in local communities. A solar house can be made <u>too</u> clever, by using too sophisticated technology, even if the purpose is to make a low-energy or zero-energy house. Maybe a well-insulated house with well-insulated people inside is better for people than a computerized Exxon solar house? Maybe that old wood-burning stove does more for participation than solar-cell roofing and electric heat-pump systems? These are questions, not answers, pointing to energy efficiency as an important issue not to be left to experts, even if they are experts in <u>saving</u> energy and at present stand out as enemy number one to the giant energy corporations. As indicated above, such experts may find themselves coopted by the same people they now believe to be fighting, precisely by suggesting too clever ways of cutting wastes in the industrialized West.

Does this apply also to non-industrialized countries? Certainly, although the problems seem more manageable in some cases. Contrary to popular belief, having a low energy budget does not mean that whatever little is used, it is used efficiently. As Bent Sørensen has pointed out,(14) the conversion efficiency of a typical open firewood stove used for food preparation is as low as about 2%, a figure which easily could be increased tenfold by using simple built-in and insulated stoves. In other words, simple, intermediate technology(15) which is easily understood by all could, in many cases, drastically increase end-use efficiency without requiring high-level engineering skills. However, in the debate about energy efficiency this may be the biggest challenge: how to perform needed tasks in an efficient but at the same time simple way, so as to preserve self-reliance at all levels, from the individual and up and not vice versa.

NOTES

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1. Wilfrid Bach and William Matthews arrived at a range of 25.9 to 42 TW in 2030, p. 713 in cf. reference given in footnote 7.
2. We are not, of course, against planning as such, only against leaving planning exclusively to the ruling elite, the top bureaucrats, capitalists and the intelligentsia.
3. Amory B.Lovins: *Soft Energy Paths. Towards a durable peace*. Penguin,1977.
4. Council on Environmental Quality: "The Good News About Energy." US Government Printing Office, Washington, D.C., 1979.
5. Ray Greece: "The Solar Blackout. What Happens When Exxon and DOE Go Sunbathing Together." *Mother Jones*, Sept./Oct. 1980.
6. Structural and psychological impediments to changes in official development planning are discussed in Dag Poleszynski, "Overdevelopment and Alternative Ways of Life in Norway: The Case of Norway." Chair in Conflict and Peace Research, University of Oslo, and the GPID Project/UN University *Papers*, no.88, Oslo, November 1980.
7. Wolf Häfele: "Global Perspectives and Options for Long-Range Energy Strategies," in Bach et al. (eds): *Renewable Energy Prospects*. Pergamon Press Ltd., 1980.
8. See page 746 in the above-mentioned book (footnote 7).
9. Bent Sørensen: *Renewable Energy*, Academic Press. London 1979.
10. Some highly populated areas in Europe include (1978 population per km^2 in parenthesis) Denmark (119), Belgium (322), Italy (188), Netherlands (341), England and Wales (325) and West Germany (247). Few countries in warm climates match these figures, basically only Bahrein (555), Bangladesh (588), Japan (309) and South Korea (376), besides several city-states such as Hong Kong (4408) or small island states like the Bermudas (1094) or Puerto Rico (373).
11. The breakthrough report in this respect was the AIP Conference Proceedings No. 25: *Efficient Use of Energy*, American Institute of Physics, New York, 1975, which showed that the theoretical energy efficiency of the US economy was as low as 10 to 15 per cent.
12. See Amory Lovins' *Soft energy paths* or Amory B.Lovins:"Bedarf und Ressourcen" in Siegfried de Witt and Hermann Hatzfeldt : *Zeit zum Umdenken!*. Rowohlt Taschenbuch Verlag GmbH, Reinbeck bei Hamburg, July 1979.
13. This view is now accepted even by the US Department of Energy in "Low Energy Futures for the United States." DOE/PE-0020, Washington,D.C.,June 1980.
14. Bent Sørensen: "Energy Study for Rural Tanzania." preliminary outline, Copenhagen, April 1980 (mimeo).
15. Or, as P.D. Dunn would say: *Appropriate Technology, Technology with a Human Face*. The Macmillan Press Ltd., London and Basingstoke, 1978.