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NATURAL ENERGY & SOCIAL POWER

METAPHORS FROM PHYSICS TO POLITICS

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INTRODUCTION

Although energy has fascinated man since the discovery of fire, it was not until modern times that it came to the forefront of scientific investigation. It was even more recently that energy became a public issue in the global scale and thus began to interest social as well as natural scientists.

The so called "energy crisis" of the contemporary world may only be a passing phenomenon, but it has triggered a popular debate and more serious thinking on the relationship between natural resources and human society. The pessimists, on the one hand, warn of the depletion of energy and materials and look to conservation or steady-state economies as the answer; while the optimists, on the other hand, believe in the coming of a new era of energy abundance through high technology.

Between these two views, of course, there are many grad ations and nuances which look upon energy in society from various vantage points. The point from which we shall regard this issue focuses on the relationship between physical <u>energy</u> and political <u>power</u>. Around this relationship are to be found many significant connections among natural and social systems which we shall present in this paper.

To begin with, we shall make explicit a conceptual framework which includes both nature and society by using a <u>systems</u> approach. In so doing, we define the scope of this study and put down the assumptions underlying it.

On the basis of these premises, we shall then make some deductions about the nature of energy and power. Throughout this exercise, we shall apply the same terminology to both natural and social phenomena and thus highlight their similarities. With this understanding, we shall introduce the concept of <u>entropy</u> both in its physical and human contexts.

Finally, we shall build some hypotheses relating these physical phenomena to social events and ask some pertinent questions as to where our hypotheses might lead. If energy is a determining factor in society, then control of energy conversions should be the central concern of politics.

From this general and well-known idea flow several controversial corollaries which we can only touch upon in this initial study on the subject. If enough people find these hypotheses interesting, more work could be done to explicate them further in later projects.

I - CONCEPTS

We shall begin this study by a brief presentation of a few basic ideas upon which rests our entire view of reality. This will necessitate going back to fundamentals, in order to explicate what we all take for granted. Such exposition may seem trivial and yet it is important to reiterate, so that there is no doubt as to any hidden assumptions.

First of all, we must build a conceptual framework which can make some sense of our reality. The building blocks of this framework may be divided into two primal aspects: one of which sets the context of all things and the other states the content. The following two sections will describe each of these aspects and the essential concepts which compose them.

1. Context

The contextual aspect of reality relates to the dimensions within which we conceive everything. These dimensions are of two kinds:

a) SPACE: Perhaps our most fundamental concept is that our universe exists in a three-dimensional space. This space engulfs all existence and delimits our conception of things.

In more mundane terms, space underlies the infra-structures of our environment, both natural and social. Geography is only one aspect of this space, but a very important one for practical purposes. It is quite evident that geographical considerations influence most basically the existence of human societies and the relations among them.

More specifically, geopolitics relates space and power and emphasizes the relevance of geographical location in international affairs. Moreover, geopolitical space is now becoming three-dimensional with the exploration and exploitation of outer space by human beings. In all these human manifestations, both individual and collective, spatial factors play a primordial role.

b) TIME: Sometimes called the fourth dimension, time completes the contextual understanding of our reality. Together, the space-time continuum, relates the existence of these two types of dimensions to the extent that one can hardly be conceived without the other.

As space measures distance between two points, time measures duration between two events. So, as geography focuses on positions, history focuses on periods. Human history is the interpretation of the record of what happened in the past in chronological sequence. Unlike space, however, time's arrow is uni-dimensional; it always moves from the past to the future, with the present being only an instant.

Prospective studies are presently trying to investigate the future, just as history has been doing for the past. If one believes, however, that the future is not pre-determined, prognosis must be very different from history, because man can still affect it by his actions. This and other considerations make the concept of time indispensible to our ideas about reality. Whatever other contextual dimensions there may be, at least space and time are enough to give us a basic notion of our environment.

2. Content

In order to fill the void of space and time, we need a content. This content is the being of existence. Everything that is, exists in the context of space and time in some way. We shall here distinguish two basic ways of looking at this content.

a) QUANTITY. When content is seen quantitatively, it becomes the substance which occupies space. It is the matter that fills the void. All material things in the universe, including man, belong to this space-filling category. In our three-dimensional space, all mass has volume or displacement. Matter can thus be located in space and time.

Earth and its natural resources are material things, indispensible to the existence of man. There is no need here to go into details about the significance of matter, both animate and inanimate, for our argument. In this order of things, man is perhaps the most complex of these material configurations and may even be the mesure of all things, which brings us to the final characteristic of reality.

b) QUALITY. Although space and time may be taken up by material things, the mind of man can conceive of things "beyond" these four-dimensions. In this sense, there are certain intangibles which are immaterial in the strict meaning of the term. These things cannot be measured quantitatively, so we have devised this qualitative category for them.

The principal characteristic of qualities is that it is subjective to the human mind, it may therefore, have no objective existence apart from its common sharing among humanity. This qualitative category includes spiritual,metaphysical, normative, and esthetic matters as well as other concepts which cannot be given in material coordinates.

Although the need for such category can be questioned by many people, we still feel it is necessary to include it in the overall scheme of things in order not to leave out any possible class, even if it has no members in it. In this way we avoid an extremely materialistic position, and allow the possibility of more complex contents, even though we may not be able to experience or explain them.

With these four concepts of space-time and quantity-quality, we have covered both the context and content of reality. This all-inclusive conceptual framework makes explicit what is usually left implicitly. The fundamental nature of these concepts make them axiomatic to our subsequent argument, therefore, will enable us to construct more complex ideas just on these four assumptions.

II - SYSTEMS

The scientific study of any subject must begin with the delini ation of a restricted context and content from the universe of things. This finite portion of space-time set aside conceptually serves to focus our attention and is called the "system". Once the system is chosen, all other things outside of it are its environment. A system is therefore defined as a set of elements or a certain interrelated content within a particular context.

In our case, the system selected for study is human society, surrounded by its natural environment. Of course, we are not here going to study everything about the social system, but only certain of its relationships: namely those between energy and power. Before we come to that, however, we shall outline the significant parameters and characteristics of the system in question.

1. Structures

After a system has been selected, the next step is to describe it in terms of certain qualities and quantities which characterize its behavior. To do so, one may adopt one of two perspectives: macroscopic and microscopic. The former focuses on the gross characteristics and large-scale properties of the system in general, while the latter goes into depth and studies the minutae of particular sectors of the system.

Here, we shall adopt primarily the macroscopic point of view and thus avoid details or specifics of any kind. The first thing we notice from this vantage point is the structure of the system. Structure refers to those properties of the system which remain constant over a given time period.

a) ORDER - Structure presupposes the existence of an order, which is the property of the system prone to mapping in terms of a set pattern. This order and structure permits a system to preserve its identity in space and over time. In this sense, the essential structural elements of the social system are individual human beings and their persisting relationships, which we call institutions.

In quantitative terms, the substance of the social system is the biomass of its members and their artifacts. The mass of these material components is characterized by a certain inertia which gives the system its stability. Thus the more massive the structure of the system, the greater is its tendency to continue in a particular state of being.

b) BALANCE - As long as external or internal conditions remain unchanged, a system is said to be in equilibrium. Every system has an "equation of state" which describes the conditions for its equilibrium. These "equilibrium states" are described by certain spatial, temporal or material coordinates in a certain relation to each other. The number of those variables required to fix the state of a system determine its degree of freedom. Social systems have high degrees of freedom because they require a large number of variables or components to describe their states.

Moreover, their equilibrium conditions are so complicated as to make it impossible to state them with any precision.

Social systems rarely approach equilibrium states because the are open and dynamic: i.e. they interact both internally and externally. These interactions bring about a "change of state" by varying the coordinate of the system either spontaneously or by outside interference. Under these circumstances, the most that social systems can attain is homeostasis, i.e. a balance between inputs and outputs or opposing forces.

The dynamism and complexity of the social, as well as any "living", system requires that it be described both in quantitative and qualitative terms. Thus in addition to various indicators measuring the mass of its population and the size of its institutions, we also need impressionistic perceptions of more subtle characteristics which make human systems more than merely material structures.

2. Functions

Having presented the basic elements of our system, i.e. the context, content and order of society; we are now ready to specify their correlations We shall be able to do so by using the three concepts of space, time and matter, which were introduced before. The fourth concept of quality should always be kept in mind, even if it is not immediately and directly used in the following definitions.

a) MOVEMENT. In addition to the constant aspects of systems, there are the variable ones involving changes of state. Change may be defined in terms of space (s) and time(t) by using the concept of velocity(v). In this sense velocity is the rate of change in position or the distance covered during a certain time: $v = s/t$. When matter is added to this space/time ratio, we have a certain mass (m) moving in a certain velocity, giving us the concept of momentum = $mv = ms/t$. Applied to the social system, these relations mean that a society tends to maintain its state of rest or motion in proportion to its mass (law of conservation of inertia).

b) FORCE. In order to effect a change of state in a system, one must overcome the inertia or momentum of its mass. Such change in the rate of motion is called acceleration (or deceleration if negative). Acceleration (a) can therefore be shown as the ratio of velocity and time. $a = v/t = s/t^2$.

But in order to bring about this change of displacement, one must apply force (F). In this way, we can define force as whatever can give a body an acceleration: $F = ma = mv/t$. The formulation, of course is Newton's Second Law (the first was the one related to momentum).

In social terms, these laws mean that the amount of force needed to change the normal state of affairs in a society increases along with the size of that society and the magnitude of the required change. Thus, large social systems are harder to interfere with than smaller ones; and greater social changes are more difficult than lesser ones.

Related to this conceptualization of force is that of gravitation. The force of gravity operates between two bodies and attracts them to each other in direct proportion to their masses and inverse proportion to the square of the distance separating them. This famous law of universal gravitation or square-distance law of Newton, also has social applications, especially in geopolitics. The further away a society is, the greater power necessary to influence it, because the effects of force diminish very rapidly with distance.

III - FORCES

On the basis of the concepts and systems which were presented in the last two chapters, we shall now enter in the heart of the matter, where complex relations and interactions take place. Thus by using the assumptions and definitions of fundamental notions such as space, time, mass, structure, motion and force, we are now ready to investigate the central concerns of this study which relate to energy and power. This will be done presently in the next two sections.

1. Energy

As with many other terms, the concept of energy is used very loosely in the social sciences to mean many different things. Part of such looseness is unaviodable given the qualitiative aspects of social systems; yet by using more scientific definitions, we shoudd be able to impose more clarity into these complicated ideas.

Building upon the concepts introduced so far, we now continue by presenting another one closely related to energy:

a) WORK. This new concept here is the widely used term meaning the application of effort in order to perform a given task. Although this meaning is close enough, we prefer to give "work" a more rigorous definition by relating it to the concept of force. Accordingly, we shall consider work (w) to be the application of force over a certain distance. $W = Fs = mas$.

In order to do work, one must exert some force and move something in space. Work in society is thus required to move things. A system in the state of equilibrium cannot do work and therefore cannot change, unless some force is applied to it from inside or outside of it. The larger the system or the further the distance, the more work is needed to move anything.

b) ABILITY. From what we have said, it is evident that it takes something to be able to do work. This something is energy. We can thus define energy as the capacity for work or the ability to act. This capacity is a "many splendored thing" and therefore has several manifestations.

One is thermal and appears as heat. This type of energy is related to temperature; pressure and volume in the following way: T = PV. Pressure itself may be defined as force per unit area, or P = F/s which in thermodynamic terms is translated as P = T/V. This means that temperature which measures heat, is also a measure of force exerted in space. In other words T = PV is the thermodynamic equivalent of the mechanical W = Fs, since volume measures three-dimensional space and pressure measures force, heat is a measure of work. Therefore, high energy systems create great pressures when confined in small spaces. A very active society tends to be expantionistic so that it can dissipate the excess heat it produces.

Another manifestation of energy is mechanical and is related either to position or motion. The former is called potential energy and depends on the force of gravity that all bodies exert on each other. Thus a heavy object located at a high spot on earth has great potential for work if it falls down. Hydroelectric energy is one example of this phenomenon.

Society, like any open and dynamic system, needs a constant energy-flow in order to exist. Whether organic or social, a system is a matter-energy converter. It must have some energy coming in from its environment, which it transfers into work to maintain itself. The capability of a society to convert energy determines its <u>cultural</u> level: i.e. structural complexity and behavioral sophistication. The higher the flow of energy the more structured and active the society has to be.

This increased rate of flow, however, brings with it many dangers as well as opportunities. High energy current can kill as well as cure organic systems, so one must be very careful as to its use; which brings us to the next important and relevant concept of our discussion.

2. <u>Power</u>

The rate of energy-flow, which was just mentioned means that work is being done. The rate at which such work is done is what we mean by power: $P = W/t$. Power is thus related to energy through its ability to use force ($P = Fs/t = Fv$); put another way, power is a moving force or force-in-motion.

Furthermore, if <u>control</u> is the determination of the "rate of flow", then power is the control of energy. He who has power is capable to convert energy or change the <u>order</u> (space-time relations) of things. We can say, then, that the power-structure of a system is a set of relations through which the power holders can control their environment, both natural and social.

Let us now see how we can translate the above definition of physical power into social and political matters.

a) SOCIAL. Whereas physical power is the ability to apply force in order to move an inert mass over a distance in a given time; social power is the ability to do the same thing to people. In order to "move" people, either literally or metaphorically, one needs power, which can only come by the control of energy. Through such control of material things, one is able to influence people. Influence, therefore, becomes the way of moving people's minds, rather than bodies: i.e. - getting them to change their opinions rather than their positions.

Whether mental or physical, however, social power comes down to making others do what one wants them to do. The more people involved in such change, the greater the power necessary for the transaction. The faster one wants to move somebody, the greater the power he must apply to it. Finally, the further he wants someone to go the more power one must have to get him to do so. Thus, these variables of space, time and mass, determine the amount of power, and hence energy, required for the job.

Since the basis of social power is control of matter and energy, those people who can control natural resources or economic goods, can also affect human thought and behaviour. In addition to controlling productive forces, control of destructive forces also confers power because both affect human values, positively or negatively.

Finally control of information is another source of power. Information is made up of symbolic patterns embeded in matter or energy. The flow of information is a movement of "energy-markers" through space and time and make communication among people possible. For that reason, control of the flows, whether matter, energy or information, confers power over people.

b) POLITICAL. This type of power is a particular aspect of social power and relates mainly to collective decision-making. Since politics is an activity of conflict resolution by dialectical means in order to reach a common policy for society; political power is the ability to influence public decisions. These decisions affect the lives of people; therefore, whoever can influence their outcome has definite power.

Just as the source of social power is the control of natural resources (matter and energy), the source of political power is the control of social resources (people and information). As is well known, popularity and knowledge can be easily converted into political power.

Since the main function of politics is to make the rules according to which matter and energy are distributed in society; the differentials of such distribution are crucial both as inputs and outputs of this process. The political sub-system provides the market-place where influence is exchanged among the participants. Of course, this exchange is uneven, because the power of the players is unequal.

In this sense, power is the *relative* capacity to influence more than to be influenced. One's net power is this differential between all the forces involved in the political transaction. The relativity of power distribution in society, therefore, determines both the form and content of public policy, which in turn determines the matter-energy-information flows throughout the system.

We can thus appreciate how interdependent are the natural and social aspects of energy and power. The presentation of some of these relationships in this chapter raise many interesting questions and hypotheses, which we shall try to deal with in the next chapter.

IV - TENDENCIES

From what we have said so far, it would seem that reality is a time-space complex of relations, interactions and conversions of various forms of matter and energy. These activities and transformations which give systems their dynamism, are neither random events nor do they continue with the same intensity indefinitely. As we shall see in this chapter, natural systems follow a process which leads in a particular direction according to certain laws. The following two sections will outline two of these fundamental laws.

1. Entropy

We saw that according to the first law of thermodynamics,energy is always conserved, even though it is converted. This process of conversion is carried out by doing work. Unfortunately, however, there is an absolute cost in performing work. This cost corresponds to an increase of disorder in the universe. Since work involves the dissipation of heat, whenever work is done potential energy is degraded into the disorderly motion of heat and hence becomes unavailable for further work.

This principle of degradation of energy is the second law of thermodynamics and affirms that all natural (non-organic) processes irreversibly lead towards higher states of entropy. In formal language:

$$\Delta \mathcal{E}_u = \Delta \mathcal{E}_s + \Delta \mathcal{E}_e > 0$$

That is to say: the change of entropy of the universe is equal to the change of entropy of the system plus its environment, must always be a positive quantity. Entropy in this sense, is the measure of degradation or disorder.

Since natural processes are governed by the laws of probability, they tend towards greater probabilistic states which are also more entropic. This means that, left to themselves things will eventually run-down in energy or break-down in matter. Order is much less probable than disorder, because order is highly structured and requires a lot of energy to maintain it intact. Only perfect structures (crystals) at absolute zero temperature, where all motion ceases, have no entropy at all. Everything else is at various stages of disorder and getting worse all the time.

Fortunately, although this pessimistic tendency holds in general, it can be reversed locally and temporarily. This exception has made it possible for organic (live) and social (human) systems to operate. Living things may be considered as order-building and structure-maintaining islands in a degenerating and destructing sea of entropy. Only the will to live and the intelligence of man (if not Maxwell's demon), can reverse and postpone the inexorable spread of entropy, at least in a small part of the universe.

The cost in doing so, however, is to increase the overall entropy of the universe. In order to keep functioning, systems must suck-in energy from their environment, thus hastening its degradation. Human societies, can,therefore, be considered as complex mechanisms which degrade high quality and quantity of energy into waste heat in order to promote life and order. The survival of the social system, however, cannot be ensured without the survival of its natural environment from which it draws its energy. One, thus, has to be very careful as to how this conversion process is being carried out.

Man's relation to the environment is similar to that of other organisms: i.e. It is a constant effort to secure some control over nature so as to extract sufficient energy from it. Man's uniqueness, however, lies in his capacity to invent and use extrasomatic tools which multiply his power. Through intelligence and technology, humanity has been able to find ways of concentrating and transmitting large amounts of energy over large distances in very short time. It is in this ability to manipulate high energy potentials that lies mankind's extraordinary talent both to create and destroy.

2. Evolution

According to the law of entropy, all systems must eventually "die". Meanwhile, however, they go through various stages of slow or rapid growth, maturity and decline.This process differs for different species. but in all cases it is related to the quality and quantity of energy flowing through them.

In their growing stage, the energy through-put is very high and its conversion of matter very large, so that there is a net accumulation of structural elements. In mature systems, this accumulation ends and a steady state is achieved by a balance of inputs and outputs. Finally, in their decline, the energy of systems diminishes either by exploding or fading away.

The repetition of these cycles throughout several generations of organic and social systems undergoes a cumulative qualitative change which we call evolution. The evolutionary process tends to increase the probability of a system's length of survival by better adaptation in its environmental conditions.

Here again, human society differs from other systems, in that its evolution has taken it beyond mere adaptability to its environment. In the last couple of hundred years, technological innovations have made it increasingly possible for man to change his environment, not in order to survive but so that he could fulfill his growing desires.

The technological progress related to the Industrial Revolution may be seen as a trigger of energy-extractive mechanisms which accelerate the flow of energy through the social system. Modern societies are, therefore, characterized by energy-intensive activities brought about by harnessing and processing large amounts of energy.

This intensification of social interactions requires greater degree of coordination and organization in order to avoid chaos. Obviously, increased energy flows demand more controls, and control seems to have a centripetal tendency. As the system moves to higher energy levels, power moves towards the centre. Thus the accumulation of energy and the concentration of power tend to evolve in parallel.

Power centralization provides an effective method of harnessing and releasing large amounts of energy by which great feats can be performed. This means that fewer and fewer people can control more and more energy, which gives them power over other people who value energy. Such increased control in turn seeks more energy to bring under its control, thus creating a vicious spiral of concentration and augmentation of power.

As a result, social systems concentrate decision-making power by forming more inclusive structures and higher levels of integration. Thus, as the system becomes more complex, fewer decisions by fewer people determine the lives of the whole society. With each incremental growth of structures and activities, new bases of social power are created and each time power expands, the system must increase its complexity to contain the extra power.

The thrust of this argument is that energy conversion is an independent variable in an equation where complexity, centralization and power are dependent variables. This means that the kind of government a society gets depends on the amount and method of energy conversion in the system. Low energy societies tend towards minimal government and decentralized structures, whereas high energy societies develop heavy governments and centralized institutions. Social systems, therefore, evolve along the lines of their use of energy.

Based on these givens, various hypotheses can be made, one of which is that in evolution, natural selection favors those systems which can control large quantities of energy. This so-called "Lotka's principle" sees the evolution of culture as a steady increase of energy flow in the social system. This increase is not only a quantitative measure of growth, but a qualitative index of improvement or development. Accordingly, social progress is correlated with increased energy conversion. Great civilizations can only develop as a result of high energy concentrations, and their rate of development is proportional to the increase of energy flow through the system.

If all that is true, it may be that human systems need not necessarily follow natural ecosystem laws. Because of his culture and technology, man may be able to escape for a long time the life cycle of other species who trace a sigmoidal curve. It is true that the quantity of energy conversion cannot be accelerated forever. But if he is careful of the choice of his energy mix and attains a steady-state, man may develop indefinitely in other respects.

V - ISSUES

We begin the third and last part of this study with this chapter on some important public issues relating to energy in society. These issues will be considered in two groups, divided along political and economic lines. The following two sections cover these issues by focusing on the central theme of each.

1. Equity

Social problems involve the quantity and quality of matter-energy production, distribution and consumption in human communities. All these are very important and far ranging problems, which require economic, cultural and technical knowledge to solve them. In political terms, however, the most crucial issue is "who gets what, when, and how." Obviously this is the perennial question of distribution of wealth in society, which raises the thorny problems of justice and morality.

Relating these issues to what we have said so far, the question is whether political power differentials are as necessary to social life as physical energy differentials are necessary to organic life. As we have seen, when energy is evenly distributed, it is in a state of entropy and cannot do work. Does this mean that if power becomes too widely distributed among the people, it looses its capacity for action? Is inequality of distribution necessary to stem entropy?

These questions are of great political import, because their answer would influence public policies as well as private ideas. As is well known, the distribution of wealth in the world is extremely unequal. The notorious North-South gap between the rich and poor countries when translated into energy terms has been found to be in the order of 250. This means that the most energy intensive societies on earth (i.e North American) use 250 times as much energy as the least energy consuming societies (i.e. African) per capita.

Such orders of magnitude have raised insistent demands for more equitable redistribution of wealth. Moral considerations, instinctively lead us to concur that these gaps are excessive and that they should be closed. But will such a move be entropic? That is the question which has never been asked before!

On the other side of the coin is the historical record which shows that human beings cannot handle large amounts of power very responsibly. The old adage that power corrupts is nowhere as apt as here. There may be a critical threshold of energy beyond which it surpasses human capacity to handle it. As energy increases it becomes more dangerous, therefore, requires more control. But it is difficult for those who provide the controls not to abuse it. Excessive power in the hands of few controllers tempts them to exploit it for their own interests.

The "Illich principle" that after a certain level, energy and equity grow at the expense of each other, may be quite true. It may be that high quanta of concentrated energy degrade social relations, just as they endanger the physical environment. If such direct proportionality between equality and entropy does exist, it would mean that a complex and dynamic society would tend to be stratified and unequal. The question is to what extent does inequity and inequality correlate?

It seems that mankind must pay a price for manipulating high energy potentials. This price may be inequality and inequity. Conversely, one cannot equalize the distribution of energy in society without enervating it. This dilemma can only be answered by each society for itself. If trade-offs must be made, every social system must decide the point beyond which the social costs are no longer worth the energy benefits.

2. Economy

Cost-benefit analysis brings us to the economic problems of production, transmission and consumption of energy. We shall look only at some of these problems which have wider socio-political implications. Primary in this category is the input-output ratio of energy conversions i.e. how much gross energy is needed to produce a certain amount of net energy.

It seems that as energy levels increase, so do the costs of production; so that additional increments above a certain point require larger and larger expenditures of energy. This rule of diminishing returns sometimes reaches the threshold of negative returns, when certain forms of high quality energy (i.e. luxury foods) need more energy to make than the energy they give when consumed.

Obviously, when societies reach such wasteful practices, they must be able to afford excessive amounts of energy. At these levels, a social system becomes energy obese and over-dependent on energy fixes for its fulfillment. What is worse, the dosage of energy must keep increasing as the system becomes addicted to higher and higher potentials.

In order to maintain such growth, the system must draw more and more energy from its environment or its neighbouring systems. Expansionism and imperialism may be considered as phenomena which reflect this pathological condition akin to a cancerous growth.

It does not take much foresight to realize that such situations as the above cannot go on indefinitely. Exponential growths must taper off either before or after they exhaust the energy available to feed on. As energy resources deplete, the competition for them becomes fiercer and hence the conflict among the competing systems becomes more severe. Such increasing conflicts are quite common in the contemporary international system and promise to get even more common as economic systems become more energy intensive at a time of decreasing resources.

As long as countries are not self-sufficient in energy, international frictions and wars will be unavoidable. Energy and resource interdependence in general make for a more dangerous world; which is another price we have to pay for the higher standards of living made possible by increased energy use.

It has been estimated that the human equivalent of the energy we use would bring up the world's population to 50 billion of which 20 billion would live in North America, that means that each of the 250 million inhabitants of Canada and USA have the equivalent of 80 energy "slaves" working for them. Certainly, our dependence on so many slaves makes our life easier; but what does it do to our freedom and security. As the slave owners of old, we become more vulnerable and the risks of disruption become proportionately greater, which in turn increases the costs of our protection insurance. Finally, it may be said that as the expenditure of energy adds <u>value</u> to goods and services, it makes the accumulation of capital easier. In this sense, <u>capital</u> is stored energy ready for use to create or destroy other things. Therein lies its ambiguity and controversial nature. Since the accumulation of energy presents dangers as well as opportunities, how can we minimize the former and maximize the latter? If high energy leads to the concentration of power, how can mankind use this power safely? Similar questions, of course, have been asked since Prometheus and the definitive answers are long in coming. All we can do here is reiterate them in the new context that our unprecedented power has put us.

VI - RESEARCH

We shall conclude this preliminary study by outlining some of the things to be done as a follow up to what we have said here. In effect this will be a research agenda for various in-depth studies on some of the ideas presented in this report. For that reason, this chapter will make its suggestions in two steps: procedural and substantive.

1. Methods

At its broadest and most general level, a lot of research needs to be done to find correlations between natural resources (matter-energy) and social systems (human institutions), within our contextual reality (time-space). This holistic research should ultimately aim at a unified theory of man in his natural environment, thus integrating the knowledge of various disciplines and filling the gaps among them.

Of course, such endeavors will require coordinated efforts of many people for a long time. Meanwhile, a necessary step in this direction would be the development of operational hypotheses linking together different factors in these various areas. This step of theory-formation can begin with tentative and partial correlations which are gradually combined to building higher order models.

What we have done in this paper is set the stage for such further work by mentioning some hunches of several thinkers on these matters. These hunches can be transformed into hypotheses by more systematic and formal methods.

Model-building in the social sciences is not as advanced as in the natural sciences. It is for this reason that we have taken many of the concepts used in the latter to see if they apply to the former. What we can say at this point is that there seems to be some correspondence between the two domains of science for its to provide a promising direction for further work.

If there are significant analogies between nature and society, as we expect, then a <u>global</u> model could be constructed eventually. Certain attempts have already been made in this direction and we hope to continue in the same way. The road from hypotheses to conceptual models then leads to operational models which can test the hypotheses in the real world and confirm or deny their validity.

The task of operationalizing a model is rather difficult in the social sciences, because <u>indicators</u> have not yet been developed sufficiently and the few that do exist are almost impossible to confirm statistically. The battle for social indicators has been going on for some time now and some progress has been made. Yet a lot remains to be done, both at the conceptual level and then on the testing ground.

So far existing tests correlating energy and social indices have shown some tenuous correspondence, but they still are too scattered and controversial to prove anthing. In any case, what they do show is that the relationship is probably non-linear. It goes without saying that much more work needs to be done in this sector and we could contributed to it by designing some of the tests.

2. Models

On the substantive side, the model we would like to work on places energy in both its natural and social perspective. As to the natural side, energy is part of the total content of reality which includes matter and information. These three ingredients are the basis for all our natural resources in whatever form they manifest themselves.

Conceived in this way, matter, energy and information are both the structures and processes of our systems. These natural resources provide the capital and flow in societies; the constants and variables of human life. To begin with, they may be considered as the independent environmental variables which affect all social activities. The central question is how and to what extent?

In order to answer this question, we should look both to the content and context of natural resources. As to the first, the problems relate to either the quantity or quality of matter-energy in society. Quantitatively, the question is how much energy correlates with socio-political institutions and processes. Qualitatively, the question is what kind of energy correlate with various cultures and policies. Therefore, how much and what kind of matter-energy should be extracted, converted, stored, distributed and used are critical questions for any society, which the proper theory should be able to answer.

As to context, the development of theory is tied to both space and time. In this respect, we have to do geographical and historical analysis of social systems. The first to answer how do different societies cope with natural resources at any particular time and the second how does a particular society evolve in its use of resources through time.

All these studies would lead to the relationship between natural resources and social power. More specifically, it would indicate whether the concept of entropy can be used in socio-political as well as physio-organic systems and whether the two correlate positively. If they do, we can learn a lot from the analogy and act accordingly.

In the final analysis, of course, these theoretical studies should not only enhance our knowledge, but improve our behavior. Knowledge can thus serve to increase our chances of survival and development, both as individuals in society and as species in nature.

CONCLUSION

As a conclusion to this report, let us reiterate what may be the most significant ideas arising out of what we have said here. These ideas involve the application of thermodynamic laws, and particularly that of entropy, to sociodynamics. If such correspondence is appropriate, then many sociopolitical phenomena may be explained in terms of increasing entropy.

One of Murphy's Laws proclaims that when left to themselves, things go from bad to worse. The truth of this law is obvious in view of the entropic tendency of the universe. What is not so obvious is how far human actions should help or hinder such tendency. Murphy's law implies that if we want to avoid the worst, we should not leave things to themselves. Fighting entropy, however, as pointed out, has its costs and the question is who is going to pay for them?

Strictly speaking, countering entropy means concentrating potentials and increasing differentials of physical energy. If that also means concentrating power and increasing inequalities in society, the explosive significance of that analogy becomes readily apparent. Such interpretation would make all democratic and egalitarian ideologies pro-entropic and hence anti-life; something which goes against our intuition!

But is this intuition or simply the dominant paradigm of our civilization? Are traditional elitist philosophies more natural to humanity? If that is so, how far can one go in concentrating power before its costs in other respects become intolerable? Entropy, after all may not be the worst fate for mankind; only its ultimate end if everything else fails.

As is often said, the only way to avoid old age is to die young. So, perhaps, the only way for man to avoid the slow death of entropy is to live dynamically (heroically) for a short time. Even if such dynamism means perpetuating exploitation, injustice and war?

Hopefully, these stark and equally distasteful alternatives, are not our only options. Human intelligence may find other ways which optimize the best of both worlds. For that, however, we have a long way to go and a lot of homework to do. This study is a small contribution to this endeavor.

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