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Entropy and Development: A Regional Approach to Energy Problems

The intense development of industry during the post-war period in correlation with the specific structure in which this development was achieved has led to an increasing gap between resources and needs both as regards raw materials and energy. In the field of energy this gap got an acute form with the onset of oil crisis in the early '70, a crisis which would be seemingly surpassed only 16 years later.

The energy problem contains numerous different elements as compared with that of raw materials, the main difference being the irreversible nature of the consumption of energy. Thus, if raw materials can be recycled or exploited from low-grade minerals, energy once consumed is lost forever to man.

The rising requirements of energy, as well as the fact that the regions with great levels of energy consumption are not the same as those which possess such resources, transformed energy into a commodity in great demand on the world market. But not even a single country of the world can afford to fully plan its development on the basis of energy imports only. That is why the researches are directed both to the discovery of new energy resources and to the changing of the characteristics of consumption. This implies new structures of economy and new technologies. However, for the transition period, the most important source of energy is to eliminate as much as possible any form of waste.

The problem of energy does not affect only the highly industrialized areas — North America, Western Europe, Japan; it affects all the regions of the world at different moments and in different degrees as a function of the structure and the rate of the consumption growth, as well as of the regional or national availability of some resources of energy. From a regional point of view the situation of energy in the late '70 and early '80 can be described as follows:

Japan depends to a high extent on imports, especially from the Middle East area, because of its limited resources of fuels. This situation is not likely to change until the end of the decade.

United States and Canada can be virtually independent for the imports of energy in the early 90s because they have important resources of both conventional and unconventional fossil fuels, as well as ambitious programmes regarding the unconventional energies.

In Western Europe the situation differs from one country to another. Great Britain has virtually the best situation. It has the most important deposits of coal in Europe to which, from 1980, it adds natural gas and oil from the North Sea. Germany, France and Italy depend relatively in a high degree on imports but they strive hardly to implement intensive nuclear programmes. A direction of action is represented by the extensive exploration of the shores and open sea areas of the Atlantic and Mediterranean sea. Italy has favourable prospects for the development of geothermal energy.

In the developing countries which are characterized by an intense process of industrialization the consumption of energy increases much faster than the growth, rate of GNP. This is due to the fact that the chosen technologies both in industry and agriculture, as well as the life styles of the people, are great consumers of energy and capital. Generally, the selection of these technologies was not made on the basis of a careful analysis of the future availabilities of labour and energy. In the long term these countries will have to face some serious problems of supply with energy both as regards the cost and the availabilities. It is important to determine if these countries will be able to bear the costs implied by the transition to more advanced technologies and te change of the structure of economy.

Numerous regions with a low level of industrialization in Africa, Asia and South America will also have to face some energy crises in the long term. This situation, can be explained by taking into account the total dependence of imports and the lack of any alternative energy sources on the background of a low level of research and development activities.

A particular case is represented by the oil exporting countries. In the medium term these countries will not have any problems with the supply of energy. But they must think of the moment when this situation will no longer be possible.

In general the socialist countries in Europe are able to satisfy the energy needs on the basis of their relations with the Soviet Union. A place apart is occupied by China which has important resources of coal and oil and can satisfy its energy demands even in case of a sustained economic growth. These resources will be enough at least for the transition period to more efficient technologies of energy production.

The recent reductions of oil prices do not substantially change these trends on long term. According to an IMF (International Monetary Funds) report the western industrialized countries will pay in 1986 by $ 60—80 billion less than in 1985; the reduction of oil prices will make inefficient in the next period a number of unconventional technologies or the exploitation of low-grade deposits. But everyone is aware that this reduction of oil prices does not mean in any way a return to the situation previous to the '70s.

The oil exporting countries will cash less, will be compelled to reduce their development programmes and to apply for loans. Some of them which already have problems with the repayment of credits (Mexico, Venezuela, Nigeria) will be confronted with diverse situations.

The situation of non-exporting oil developing countries will present specific features as a function of the volume and the structure of their imports and exports.

It is clear therefore that the energy problem remains acute and that a viable and comprehensive solution is still to be found. This solution will compulsorily imply the taking into account of the law of entropy.

Entropy is one complex notion.* Webster's Seventh New Collegiate Dictionary gives us the following definition: "Entropy is a measure of una-

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* The second principle of thermodynamics, like the first one, it is also a law of nature. The main formulation of this principle was made by S. Carnot. The next formulation was announced by Rudolf Clausius in 1850 when he wrote that the heat does not pass by itself (in a natural way) from an object with lower temperature to one object with higher temperature. The third statement of the second principle belongs to W. Thompson Kelvin.

The second principle of thermodynamics leads to the notion of entropy, while the first one leads to the introduction of new notions as internal entropy and enthalpy.

The expression given by formula: $\delta Q/T$ was named "entropy" by Clausius and was defined by the relation:

$$dS = \frac{\delta Q}{T}.$$

In international measurement systems entropy S has dimensions J/K but in technical system, kcal/K. In every thermodynamic comutation we frequently work with specific enthalpy, s:

$$s = \frac{S}{m}\left[\frac{\text{J}}{\text{kg K}}\right]; \qquad \left[\frac{\text{kcal}}{\text{kgf K.}}\right].$$

By integration we obtain:

$$S = \int \frac{\delta Q}{T} + S_0$$

The absolute value of entropy is determined by taking into account the approximation of S_0 representing entropy in its own state. In computation we usually take into account the variation between the two levels of entropy's states:

$$S_2 - S_1 = \int_1^2 \frac{\delta Q}{T}$$

This formulation represents the mathematical expression of second thermodynamic principle especially for reversible processes. We may draw some conclusions upon heat changes effectuated between the thermic agent and environment and taking into account the sign of entropy variation:

— if $dS > 0$, meaning increasing entropy, then $\delta Q > 0$, so the thermic agent receeiv heat;

— if $dS < 0$, meaning decreasing entropy, then $\delta Q < 0$, so the thermic agent looses heat;

— if $dS = 0$, meaning that entropy of the thermic agent remains a constant, the process is adiabatic, reversible or is entropic.

If we want to make the computation of entropy variation into reversible transformation for one perfect gas, we replace in this relation the ordinary heat δQ by one of its own mathematical expressions resulted from the first thermodynamic principle.

vailable energy from a closed thermodynamic system in connection with the state of the system in such a way as a change of the measure varies with the change of the ratio between the increase of absorbed heat and the absolute temperature at which the heat is absorbed".

Beyond this disheartening definition lies one of those ideas which change the course of history. The necessity for taking into account the law of entropy in solving the problem of energy results very clearly from the following considerations.

On the one side energy can not be either created or annihilated, and on the other side at a certain level of human knowledge only some energy resources can be utilized, and thus at any moment there is a limited quantity of available energy which by means of utilization is transformed into unavailable energy ensuring temporary utilities. In this process which has as a main feature an irreversible character, entropy increases.

Thus a quantity of oil contains a given quantity of available energy. We name this energy "available" or "free" meaning that at the present level of development we can use this energy for heating, for an automobile or for generating electric current. In this process of utilization the total quantity of matter and energy do not change. But matter and energy have been transformed qualitatively. As regards energy this transformation refers to the change from the available to the unavailable form meaning that we can not use any longer the gases which result from this process ar the quantity of heat given off to the environment.

We must add that the law of entropy shows the autonomous character of the process of qualitative degradation of energy. In other words the transition of energy from the available to the unavailable form takes place irrespective of the fact that people or other rational beings exist andact or not. A good example is represented by solar energy. In the Sun a process of entropic degradation takes place no matter if the available energy is used by someone or not.

We further discuss some interpretation of entropy meaning:

— entropy and molecular disorder,

— entropy and information theory.

Increasing of entropy taking place in every natural processes represents the molecular state disorder of a system.

The discovery of the XIX-th century made on the relation between entropy and thermodynamic probability determined the appearance of entropy and information theory connexions; meanwhile the thermodynamic probability of an system, and information we have of it, represents the same notions and of course a well determined ratio.

By examining some series of examples anyone can obtain:

— null entropy which means the existence of complete information;

— entropy with higher value corresponding to some small quantities of information.

If, for instance, one problem has P answers (solutions) equally probable, the knowledge of the real solution or the quantity of information of it varies proportionally with P.

Writing down I for information quantity and taking into account Hartley's relation we obtain $I = K \log P$, where K is a constant coefficient.

The analogy of this relation with Boltzmann's formula is obvious and feeling the isomorphism some authors made very clear that negentropy is information.

There is some cases when the second thermodynamic principle loses its validity but this phenomenon has such a small probability and takes place only on the corpuscular phenomenon scale.

We must not forget that any moment the space-time dimensions accessible to we man are well defined. The transition from one source of energy to another takes place exactly because man extends these limits with the development of his civilization. But if we consider finite periods of time, periods which can vary from millenia to decades as a function of the rate of development of human society, these space-time frontiers are clear and nobody can pass beyond them.

On a much general plane Harold Blum shows in his "Time's Arrow and Evolution": "The small decrease in entropy represented in the building of the organism is coupled with a much larger increase in the entropy of the Universe".

People themselves survive by ensuring a continuous flow of energy using their culture as an instrument of extraction from an environment with ever expanding dimensions.

The energy base is so important as it determines the shaping of our culture. People change their production mode when the existing one can no longer afford the extraction of energy from the environment wiht the well-known means and new ways of using the available energy left are to be found. This fact becomes evident if we analyze the history of human society from the point of view of the main energy sources. (We must mention that up to now the human society has presented as a specific feature an energy monoculture. It is likely that the future will imply the utilization of a variety of energy sources.)

Initially the energy base was represented by wood. It was a renewable source of energy which could be easily obtained. By the end of the sixteenth century a profound wood crisis broke out in Europe. And people were forced to look for something else. The answer was the transition to coal, transition which determined the industrial revolution. It is worth mentioning that the extraction of coal implies a greater energy consumption than that of wood. The industrial civilization initially developed on the basis of coal and then the place of coal was taken by oil. The transition to oil was not based on the exhaustion of coal but on the superior characteristics of oil as a source of energy, and on the possibility of convenient extraction of this fuel. The low price of oil encouraged not only the great industrial growth but also waste, and thus the visible and worying decrease of the oil resources was to be expected. What we must thoroughly understand is the fact that the enormous industrial development in the post-war period was possible not because humankind would have found a marvellous solution for the domination of the environment but because in this environment there were non-renewable resources representing the solar energy accumulated in 3 billion years. These resources were very great. Bus limited.

The transition to other sources of energy among which a well-defined place is occupied by nuclear energy is a complex and difficult way, which has more technical maturity than we have had up to now. The fact that at present the problems proliferate faster than the solutions is however a clear sign that there are many things to be done.

The solving of the problem of energy can not be approached separately from the rest of the problems which confront the national economies. An

integral approach which takes account of the action of the law of entropy will lead to the replacement of the maximization of profits on short and medium term principle with the minimization of future regrets principlet The utilization of this principle has the advantage that it takes into accoun two aspects regarding the law of entropy:

a) The law of entropy does not determine the speed of the transformation of energy from the available to the unavailable form;

b) The law of entropy does not limit the types of structures which may occur.

Therefore, the law of entropy tells us only that with in system a closed entropy implacably increases with the flow of time. In this respect, Sir Arthur Eddington said: "Entropy is time's arrow". But the speed of this process depends on the structure in which the consumption of energy takes place. The implementing of the minimization of future regrets principle not only slows the pace of entropy but leads us to the image of a world in which the accent is placed on diversity.

The various regions and countries of the world are characterized now by great differences as regards the anea, resources, population, the level of technology and the dominant type of culture. It is obvious that the slowdown of the entropic process will imply completely different means from one country to another, from a region to another. It is also obvious that our mode of looking at the world itself will change.

The deep changes determined ba the development of science concern both the technical characteristics of the tools used by man and the criteria of evaluation and his options. The present mechanical paradigm imposed linear criteria of evaluation; the Western countries were considered as a model and the others compared with them. Thus, the result consisted not only in mechanical classifications but also in great efforts of many countries "to develop", namely to build economic structures similar to those in the western countries. The idea of a single model seems natural in a world whose outlook was dominated by the „tertium non datur" principle.

This situation is however going to change. And maybe no other element has a greater contribution to this process of changing than energy. The patterns are going to disappear and the world will gradually pass from the "large scale production" in which the identity of parameters is a virtue to the "production of singles" in which the value of the goods is given mainly by their individualization. When this transition is fulfilled, dialectics will have added one more spiral to its infinite spring.

The problem of energy must be solved within this framework. And the authors of this paper tried to do so. The proposed model takes into consideration the following elements as starting points:

— the existence of a situation in which the nations of the world are characterized by different degrees of liberty as regards the selection and following of a course of action; the restrictions refer both to resources and the socio-economic level.

— the desire for national assertion of developing countries.

— the necessity to utilize as much as possible the national material and human resources.

— the necessity for considering the minimization of the future regrets principle and the law of entropy.

— the necessity to maximize the number of elements which take part in the process of making decisions.

The presented model was entitled „Identity through development" because it has as objective the development of nations by means of maximum capitalization of national elements, therefore through the assertion of their identity. The model has in view the description of a society which is in principle compatible with its environment. The essence of the model is the following:

At a certain level of development of human knowledge the resources of energy are limited. There is a given amount of available energy which is transformed by its utilization in unavailable energy ensuring temporary utilities. From this process results also information under the form of know-how, conclusions and generalizations which result from the performed activities. But the classical theory did not think to include informatiin into the equation of energy among the other results of its consumption.

If we want to solve the problem of energy minimizing future regrets we must find solutions for slowing down the entropic process and not transferring some problems to our successours. Humankind cannot exist without consuming energy. The problem is therefore how much we consume and for what.

We propose the nations to conceive their process of development in two stages:

— The first stage has as objective to reach a level of development which can ensure the satisfaction of the basic human needs. These concern food, housing, education and health care. (It is obvious that this stage is necessary only for those countries which have not reached or passed it already.) This stage implies the utilization of present technologies but in a structure more efficient than the present ones. For the countries which do not have enough energy sources the import of energy will continue in this stage. The selection of the types of fuels and their utilization must be done taking into account the actual and future availability of labour and capital. It is necessary that instead of following the maximization of an economic indicator, such as GNP, to pursue the maximization of an aggregated indicator of the general living conditions of the population. The practice shows that the obsession of maximization of some economic indicators does not determine but a few short or medium term favourable effects.

An important role at this stage has to be played by education which must teach the young not long rows of data but how to think, how to create and manipulate information — the main commodity of the society of tomorrow.

— The second stage has in view an informational society. The informational society must not be seen as the following stage of the developed countries of today. All the countries can build such a society. It will be also an economy of commodities. An economy which will produce, distribute and consume information first of all. An economy in which each person can create something because in such an economy not even the simplest information is useless.

At this level consumption of energy will decrease as compared with the present one, even if the world's population will increase. A proliferation of soft technologies is expected. It is probable that each nation will be able to satisfy its needs for energy. This is not against the laws of physics. The efficiency of the human society will be simply greater than it is now and thus the entropic process will be slowed down.

The nations of the Earth will be able at this stage to be themselves, to better capitalize their culture and tradition, to take part in the international exchanges with as much information as they will be able to produce. We must specify that this information will not be limited to technical aspects but will concern the human knowledge as a whole.

Obviously this is a simple blueprint of the evolution of human society in the decades to come. The implementation of this process will imply extremely diverse forms because the variety will be exactly the main feature of the informational society.

Because of the entropic character of energy consumption for the predictable time range, the informational society seems to be the only viable answer to the problem of the sources of energy necessary to humankind.

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