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ENERGY ANALYSIS AND ENVIRONMENTAL SYNTHESIS

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From the very earliest times man has had the desire to measure his activities in terms of energy, and this desire has given rise to numerous experiments and research studies. The method proposed by T. H. Odum, tested in a great number of cases, presents several advantages. Founded on the theory of systems, his method opens the way to a study of the geo-complexes which interrelate a great number of physical or human components. The paper presents the systematic foundations and the graphic language of the energy calculations, gives numerous examples of their application, and deals with the advantages and limitations of the method.

This short essay dedicated in homage to Professor E. Mazúr aims principally at showing the advantages and the limitations of energy analysis in the science of environmental geography. These two entities are not of recent origin. Humanity has always found interest in organizing nature, in order to overcome its constraints, and this by means of his work, therefore of his energy. From the earliest of times, landscape and energy are thus linked in the mind of men. Numerous studies have been undertaken in western Europe, in the Soviet Union and in the United States.

After presenting the systemic foundations and the graphic language of the energy calculations, a few examples of their applications are described; finally a series of limitations are reviewed.

1. FROM THE SYSTEMIC FOUNDATIONS TO COMPUTERISED SIMULATION

All energy analysis contains at least two phases, the representation of a geosystem by a graphical language, then the quantification of the energy costs, in the form of a balance sheet and within the framework of a computerised programme.

Take the case of a forest. Its systemic representation is obtained by means of a series of steps. First, an outline by dotted line represents the limits of the system under investigation (Fig. 1A). Then, the energy sources, from the exte-

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rior, are shown by circles: on the left, are shown the most diffused sources of energy, whereas the most concentrated sources are on the right side (Fig. 1B). The third step consists in distinguishing the internal components of the system. The language proposed by T. H. Odum enables us to distinguish three subsystems — productive, consumptive, or stock (Fig. 1C). The penultimate step consists in adding arrows to indicate the direction of the energy fluxes inside the geosystem: it then becomes necessary to display the fluxes of depreciation and of dispersion, for all work liberates heat: these two types of loss are directed towards one point (Fig. 1C). Lastly, it is possible to specify the relations, and particularly the interrelations of flux inside the subsystems of con-

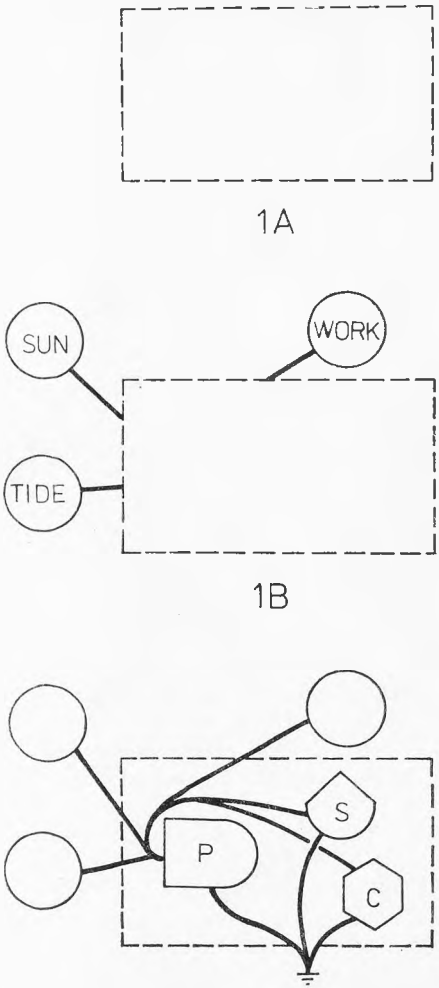

Fig. 1. Geosystem in Odum Language.

sumption and production and the monetary fluxes which are in the opposite direction to that of the energy fluxes.

This language which H. T. Odum proposes, offers the following advantages. Firstly, it is perfectly coherent with the theory of systems, which enables the study of the complexity of the geographical systems, the cycles of self regulation, positive or negative, the hierarchy and the organized principles which control the geosystems.

Secondary, this language enables us to give several representations of a system at different levels. Then, it is possible to change the degree of aggregation of the geosystem's components and to differentiate the sub-components inside a component.

In addition, the arrows representing the fluxes and the stocks in the diagram are in this way quantified. This quantification can be direct, when measurements are known: then the energy flux of the sun is well-known. But many other energy fluxes still remain to be better evaluated, in spite of the wide spread diffusion of tables of equivalences. Lastly certain fluxes are evaluated by deduction from monetary fluxes which are in many cases better known. Effectively, monetary fluxes circulate in an opposite direction to energy fluxes, and the knowledge of a monetary flux enables us to know the energy flux which is pointed in the opposite direction.

At a last step, the model is translated into computerised language, in order to permit the carrying out of experiments by the method of simulation. The following program, written in BASIC, is a formalisation of a simple ecological model, which shows the process of photosynthesis and breathing. The DYNAMO language is also very much used, being well adapted to the study of stocks and fluxes.

2. NUMEROUS EXAMPLES OF APPLICATION

Eco-energy analysis has been used initially to represent very simple and very generalised systems. Figure 2 shows a town with its environment. The town is assimilated to a consumption component, with the forests, agricultural and free areas without any human occupation are production components. The water, soil and nutrients constitute a stock. Several energy fluxes, incomplete moreover, introduce energy into the geosystem. This general scheme can be applied to real towns.

The model representing the functions of a tree (Fig. 4) drawn by T. H. Odum is much more complex, especially regarding the sources of energy. This second model illustrates an important factor in this language, the possibility of constructing very dislocated plans and of introducing the concept of scale. A great many eco-systems have been analysed by this method, particularly hydrological eco-systems, such as a lake, the Black Sea, Caspers, 1957, or various estuaries.

This energy modelisation is not limited to the physical components of a geographical sector. It has also been used to show the relations between human societies and the various eco-systems. On a micro scale, CUNNINGHAM elaborated a model of the Cobb-Douglas economic function to represent the Development of the paper industry in Finland.

T. H. and C. E. Odum have put forward an eco-energy model of the United

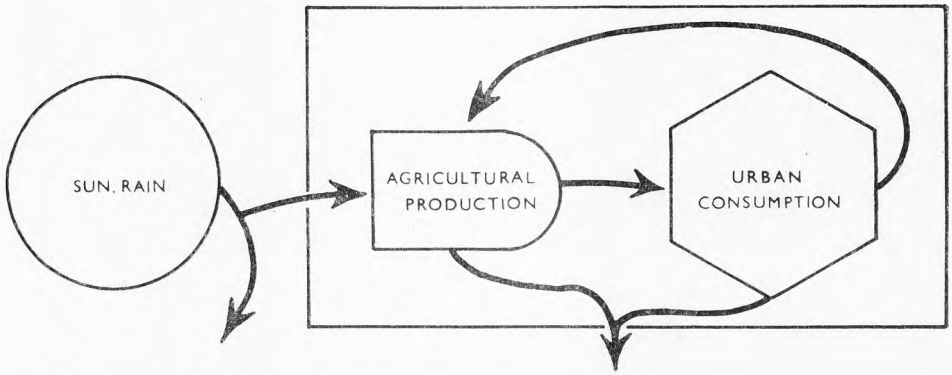

Fig. 2. Town and Agriculture.

States, which associates the physical formations, for example forests, prairie and deserts, with the functions of production and consumption and even with the super structures such as political power and religion.

More geographical are the attempts to represent towns, urban systems and regions. Thus Standhill constructed an energy model of the city of Paris in 1850 based on a regional system which was still essentially agrarian, while Zuccehetto modelised the development of Miami in the regional framework of Florida.

In the quantitative Spatial Analysis Laboratory, at Nice University, we have constructed a simulation programme to represent the energy models of the world and of the town of Nice. This simulation will be on exhibition at the City of Sciences and Techniques at the Parc de la Vilette.

Today, the research student who has at his disposal a great number of examples, can have a critical vision of this implement.

3. THE LIMITATIONS OF THE ENERGY SYNTHESIS

3.1 Original advantages

The energy instrument is very useful for a variety of reasons. In the first place, it gives a new vision of a geo-system, thus facilitating the comprehension and the explanation of geographical processes. This new approach is all the more interesting since our world has entered (which remains to be proved) into an era of restruction, which could be the cause of a decadence comparable to that undergone by the Roman Empire.

Even if one refuses to entertain the ideas conveyed by the ecoenergy instrument, a perception of all phenomena in terms of energy is a good thing.

Moreover this approach offers the attraction of being applied to geo-systems which have both physical and human components. Without entering into the eternal debate over the unity of our discipline, and while recognising the essential fact that a physical relation does not have the same finality as that which can give to a human action, the classical geographer in his anxiety to preserve the unity of his subject matter, had no unique standard of measure-

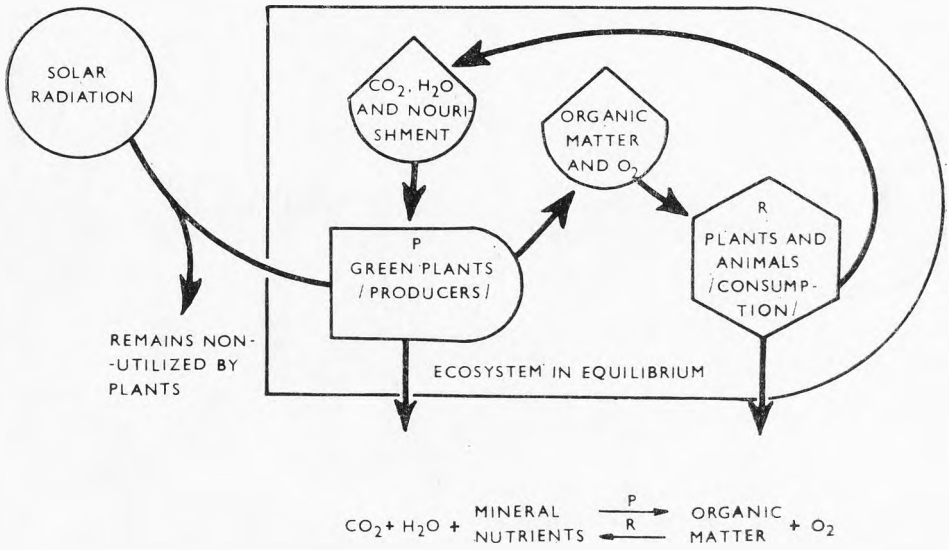

Fig. 3. A P—R System.

ment which could cover both the lawns of the physical world and those of social activities. Eco-energy analysis, which transforms monetary flux into energy flux, is an endeavour to unify in this direction.

Finally, this instrument is adaptable to simulations: it is therefore a powerful instrument which can be utilised in a forecasting procedure, particularly in a study of environmental impact.

3.2 Limitations still imperfectly understood

In spite of these advantages, which have their importance for our subject matter, eco-energy presents two serious defects.

Firstly, the translation of a monetary flux into terms of energy flux has been the subject of many criticisms. In the works of one and the same author, it is possible to find tables of equivalence which are quite different, where a monetary unit is converted into different calorific values. Even if such errors can be corrected, economists remain sceptical when faced with this assimilation. „Much remains therefore to be done in order to be able to utilise the system proposed by Odum" (B. Desaigues, 1978).

In any case, all equivalences are always relative in time and space: a dollar or a franc has no stable energy equivalent.

Moreover this approach takes no account of the spatial dimension of the phenomenon under investigation. The energy language is an alphabet of which no letter is spatial.

The introduction of a spatial component force is indirect, and can be made either from empiric analyses or from theoretical reasonings. In all cases, this kind of solution finally sets up models which are very dislocated, with a com-

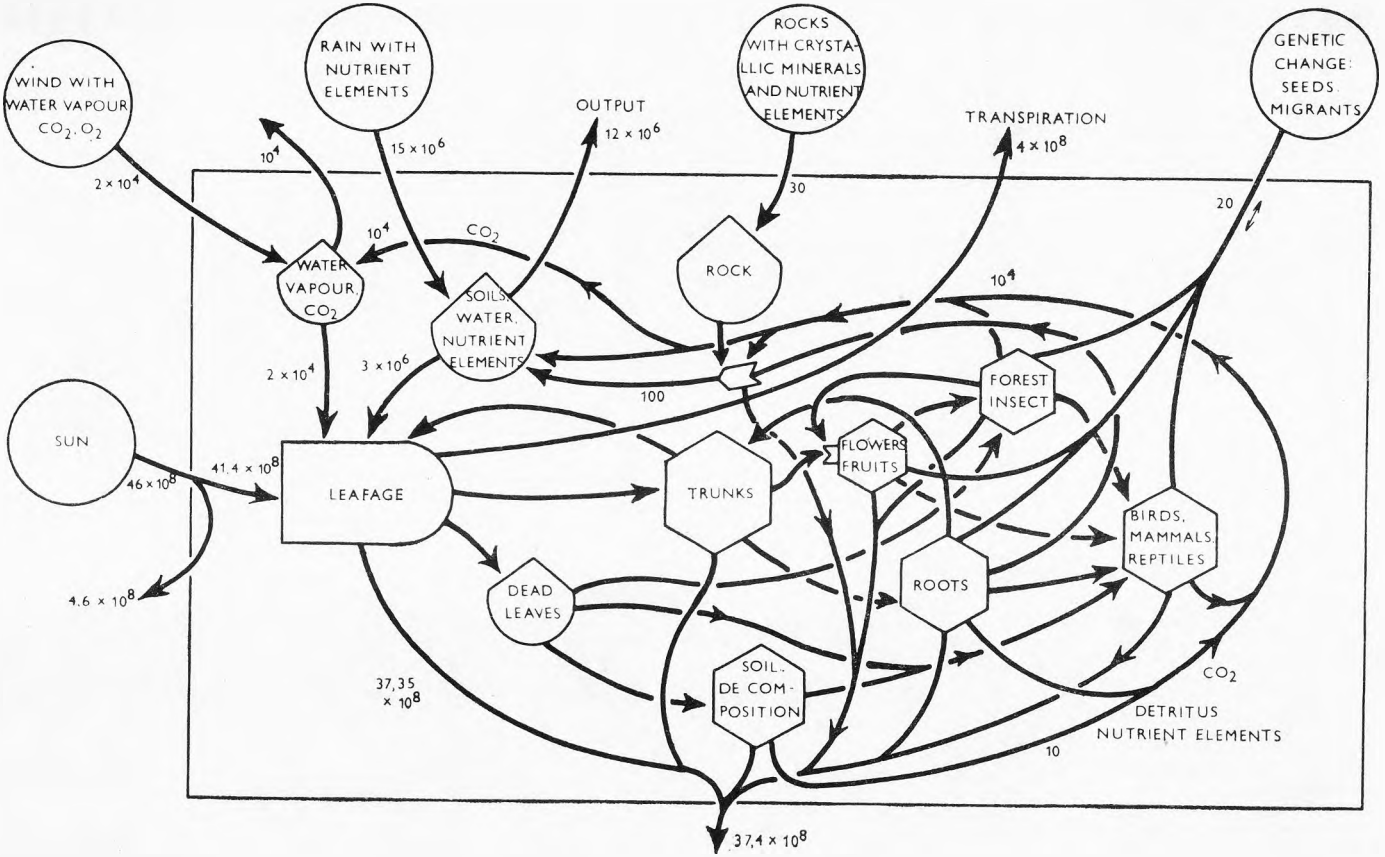

Fig. 4. A Tree System.

ponent force each spatial compartment. This solution is not entirely satisfactory, since it takes no account of spatial dynamics, in particular the evolution of the discontinuities which are rarely stable.

CONCLUSION

From the very earliest times, man has had the desire to measure his activities in terms of energy, and this desire has given rise to numerous experiments and research studies. The method proposed by T. H. Odum, tested in a great number of cases, presents several advantages. Founded on the theory of systems, his method opens the way to a study of the geo-complexes which interrelate a great number of physical or human components.

Nevertheless, the analogy between monetary and energy flux, and the absence of spatial dimension, reduces the effectiveness of this instrument. Research is continuing on the subject.

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ANALÝZA ENRGIE A SYNTÉZA PROSTREDIA

Od pradávna mal človek túžbu merať svoju činnosť v reláciách energie a táto túžba dala podnet k nespočetným pokusom a výskumným prácam. Metóda navrhovaná T. H. Odumom, testovaná v mnohých prípadoch, poskytuje viaceré výhody. Metóda sa zakladá na teórii systémov a otvára cestu k štúdiu geokomplexov, ktoré uvádzajú množstvo fyzikálnych a ľudských faktorov do vzájomných vzťahov. Avšak analógia medzi peňažným tokom a tokom energie, ako aj chýbanie priestorovej dimenzie, znižujú činnosť tejto metódy.

Práca podáva systémové základy a geografický jazyk výpočtov energie, opisuje niekoľko príkladov ich aplikácie a uvádza tak výhody, ako aj nedostatky metódy.

Obr. 1. Geosystém v jazyku Oduma.
Obr. 2. Mesto a poľnohospodárstvo.
Obr. 3. Systém P—R.
Obr. 4. Stromový systém.

Андре Дофине

АНАЛИЗ ЭНЕРГИИ И СИНТЕЗ СРЕДЫ

С давных времен человек стремился измерять свою деятельность в масштабах энергии и это стремление побуждало его к бесчисленным попыткам и исследовательским работам. Метод предложенный Т. Г. Одумом, который проверялся на многочисленных случаях, предоставляет несколько преимуществ. Метод основывается на теории систем и открывает путь к изучению геокомплексов, в которых сопоставляется множество физических и человеческих факторов до взаимоотношений. Однако, аналогия между денежным током и током энергии, а также отсутствие пространственной димензии, снижают действенность этого метода.

В статье рассматриваются системная основа и географи́ческий язык вычислений энергии, приводится несколько примеров их аппликации и перечисляются как достоинства, так и недостатки данного метода.

Рис. 1. Геосистема на языке Одума.
Рис. 2. Город и сельское хозяйство.
Рис. 3. Система P—R.
Рис. 4. Деревовидная система.

Перевод: Л. Правдова