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Topical Problems in the Cybernetics of Energy Systems

The present development and the prospects of using cybernetics in the theory and practice of energy systems will bring about considerable economies of energy, cybernetics will lead to an increased availability, reliability and security of these extremely complex systems.

The field of power engineering was among the first to have largely used the results of cybernetic research, to have introduced and used process and numerical computers for systems management and for their optimization.

In the past ten years, there was much talk about the so-called "informatic revolution". The introduction of the new energy resources, the re-organization of the national energy system, the automation and cybernetization of production have introduced electronic and computation equipment for the efficient use of energy.

The cost of microelectronic equipment has become still more reduced [1] (figure 1) whereas the cost of energy has developed exponentially [2] (figure 2).

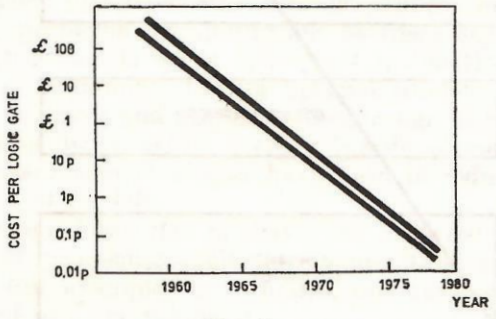

Fig. 1

The paper was presented at the meeting of the Commission for general systems and cybernetics, in January 1981.

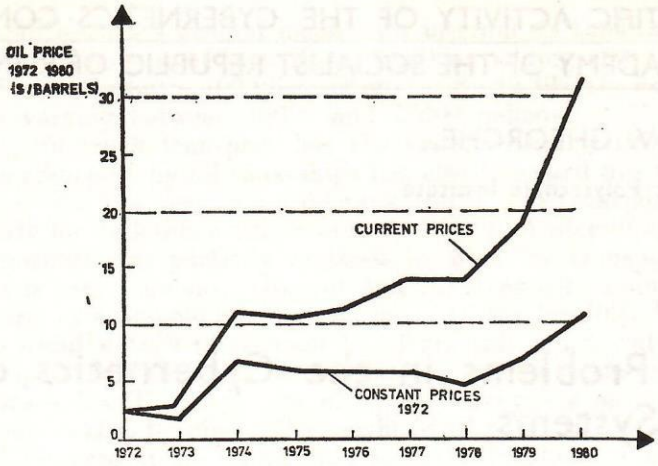

Fig. 2

Each of the two apparantly disjunctive fields (micro-electronics and energetics) have developed in relation with their growing complexity. They have passed from a small scale to a very large scale integration (figure 3).

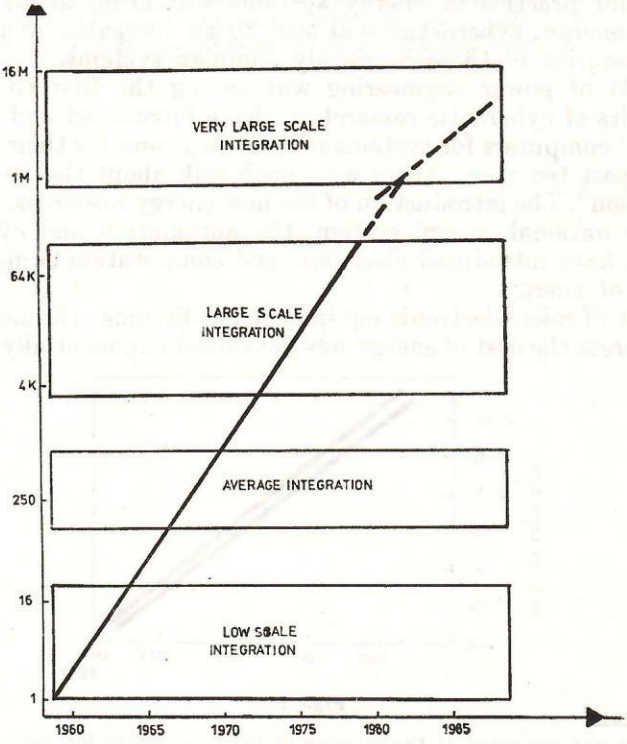

Fig. 3

On the other hand, the complexity of the structure of the national energy systems has also increased through the diversification of the types of resources used and through the extension of the dimensions of the systems [3].

The consumption of informatic structures and equipment has extended to the field of energy systems; this is known as the Maslowe-Engel effect [1].

This study aims at analysing two important aspects of the use of cybernetics in the problems of energy systems, namely:

a) the modelling of the national, regional or global energy policies;
b) the future use of distributed control and automation.

1. THE CYBERNETICS OF THE MODELLING OF ENERGY DEVELOPMENT STRATEGIES

It is well known that energetics is a branch intensive in capital. Its future development requires important expenses both direct, on the building of energy objectives and on the research development activity.

The technical-economic cybernetic models were largely used in the past few years in clearing up the elements necessary for choosing a medium and long-range energy policy (for a synthetic analysis see [4]). It is known, however, that the use of models can give only a partial image of the way of solving the problems of energy planning in the complex conditions of the restrictions of time, space, resources and environment protection.

As Manne and others [4] point out "it can be imagined that the processes of the counter-modelling type and the estimation by the third will help in making a distinction between the objectives of the analysis and the unilateral points of view". The technical-economic cybernetic models especially in the field of energy may represent a basis for discussion and in the end they may become an instrument of the debate.

The types of energy policy models can briefly be classified into the following categories:

— models of interaction between economy and energetics;
— medium and long-range planning models;
— decisions in conditions of incertitude.

The first category of models uses especially linear or non-linear optimization in solving problems of equilibrium between energy consumption and availability. Other models use a social welfare function and are solved by using quadratic programming. For an optimal solution, the dual variables are interpreted as prices and they show long-range incremental increases in the cost for covering the necessary energy. Specific elements in connection with the energy conservation strategies have been introduced in the structure of this category of models.

The medium-range forecastic models have included into their structure the objective of producing multiple commodities, a mixed energetic dynamic behaviour (for example: coal, hydro, oil, nuclear, etc.), the flexibility of the prices of primary resources.

The models of long-range energy strategy are most often formulated in the form of a linear programme; in the long run, an optimal mix is determined and an adequate spacing out of transitions in the analysed energetic

structure. The technological estimation models estimate the economic value of the new energetic technologies. The interaction between the energy sector and the rest of the national economy was also examined [4].

The decisions in conditions of incertitude for the field of energetics are mainly present when a long-term planning activity is carried out. The analysis of decisions represents the general methodological framework for solving such problems. The method of decision-making trees and of events is used. In elaborating this model, the decision maker will be able to choose, in the end, certain feasible energetic alternatives by diminishing the risk and incertitude in connection with the promotion of the new energy technologies.

2. HOMEOSTATIC CONTROL: DISTRIBUTED CONTROL AND AUTOMATION

Homeostatic control represents a new way of approach in the control and economic functioning of the energy systems[5],[6]. The practical application of this concept mainly refers to the prevention of total damages in the electro-power systems, the conservation of primary energy, especially of oil, the integration of solar and eolian energy, the system control in case of energy shortage.

This new cybernetic concept of control in the energetic systems refers to cooperation between the energy producing enterprise and the consumer and to the user's independence.

It is known from the classical theory of present management of nonergetic systems that the producing enterprise is the one which has to make the maximum effort to obtain an optimal functioning and structure of the energy producing equipment. As is known, "the consumer regards the energy system as an infinite source able to satisfy the necessary energy required by it." Thus, it results that the energy producing enterprise" must plan an installed power and a transport capacity in order to cope with the damages". At the same time within the system there must be a complicated automation system likely "to answer rapidly and correctly the large variety of distorsions beginning with the damage of an equipment and ending with natural disasters" [5].

In order to avoid the unilateral character of the consumer energy producer relationship, the concept of homeostatic control was introduced recently.

In the present structure of an energy system, the producer (for example: the electric power station or the distributing enterprise), has full control over the consumer. The producer's direct control often has negative technical and economic effects on the consumer. The homeostatic control fundamentally changes the above relationship, achieving a decision-making and action independence for the user.

These two principles of homeostatic control can be achieved in practice especially due to the present results in the field of microelectronics, both hard and soft.

Making a comparison with the biological field, the homeostatic term is associated with the control of an energy system because the latter "is associated with a living organism with many different elements (producers and

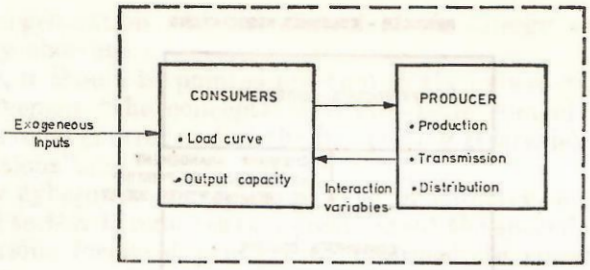

Fig. 4

users) which are acting independently but which are cooperating in a condition of mutual advantage, of equilibrium" [5].

In the concept of homeostatic control which integrates to a great extent computers and microprocessors, the notion of energetic system equally includes the energy consumers and producers (figure 4).

Figure 5 presents the information flow established within an energetic system operating under homeostatic control. The intelligent counter is a specialized microprocessor replacing the traditional counter. It performs the registration-price fixing functions and at same time it ensures the interface of the information exchange between the energy user and producer. A descentralized decision making function can also be attached to this device.

The homeostatic control categories can be achieved by momentary price fixing, micro-shedding and a descentralized dynamic control.

The momentary price fixing is a concept showing that the price of energy varies every five minutes in a day and it depends on demand-production capacity conditions and on the cost of energy production. The rates for

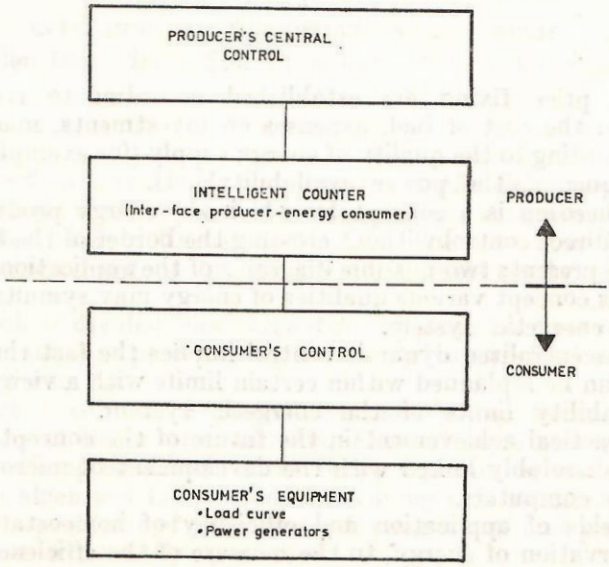

Fig. 5

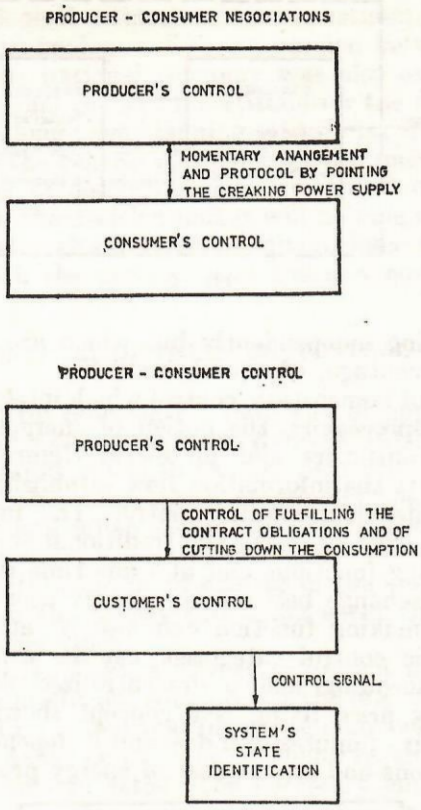

Fig. 6

a monetary price fixing are established according to economic criteria (for example: the cost of fuel, expenses on investments, maintenance costs, etc.) and according to the quality of energy supply (for example: the transport voltage, frequency, the power availability).

Microsheeding is a concept by which the energy producing enterprise may have a direct control without crossing the border of the intelligent counter. Figure 6 presents two possible diagrams of the application of this concept. By using this concept various qualities of energy may symultaneously appear within the energetic system.

The descentralized dynamic control implies the fact that a consumer's load curve can be replanned within certain limits with a view to ensuring the dynamic stability limits of the energetic system.

The practical achievement in the future of the concept of homeostatic control is indissolubly linked with the development of micro-electronics and of electronic computers.

The fields of application and efficiency of homeostatic control refer to the conservation of energy, to the increase of the efficiency of the energy consuming final installations, to the integration of solar, eolian energetic

technologies, cogeneration and the control of the energy system in conditions of energy shortage.

However, it should be pointed out that in the cybernetics of the energy systems managenent "the concepts of homeostatic control do not remove the need of classical control and of the functioning strategies within the electric power stations".

This new cybernetic concept is applied in industry, in the commercial and residential sector. It removes to a great extent the special strategies aimed at storing various forms of primary or intermediate energy.

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