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Preliminary Overview of Institutional Structures and Models: Information Systems for Energy/Environmental Planning and Management in GDR, Rhone-Alpes, and Wisconsin

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IIASA Working Paper

WP-75-142

1975

PRELIMINARY OVERVIEWS OF INSTITUTIONAL STRUCTURES AND MODELS - INFORMATION SYSTEMS FOR ENERGY/ENVIRONMENTAL PLANNING AND MANAGEMENT IN GDR, RHONE-ALPES, AND WISCONSIN

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October 1975 WP-75-142

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October 24, 1975

In preparation for the IIASA Workshop on Integrated Management of Regional Energy/Environment Systems, each of the three collaborating institutions* has written a short overview of the institutional structure of the energy/environment planning and management within its region and also given an indication of the nature of the corresponding models and information systems. These three preliminary overviews, contained in this working paper, will be expanded and refined in final papers presented at the workshop.

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This paper is one of a series describing a multidisciplinary IIASA research program on Integrated Energy System Modelling and Policy Analysis. The initial phase of this research program is focused on the energy systems of three retions: the State of Wisconsin in the U.S.A.; the German Democratic Republic; and the Rhône-Alpes Region in France. The primary purposes of the study are at least three-fold:

(1) To identify existing patterns of regional energy use and supply at appropriate levels of disaggregation.

(2) To compare alternative methodologies for regional energy forecasting, planning, and policy development.

(3) To use the above methodologies to examine alternate energy policy strategies for each of the regions, to explore their implications from various perspectives using sets of indicators related to environmental impacts, energy use efficiency, etc., and to evaluate the adequacy of the alternative methodologies as policy tools.

Out of these above three items should evolve improved methodologies for energy systems research and policy analysis. The comparative method, intersecting the different disciplines and nations which would be involved in this project, should serve as a powerful tool to the mutual benefit of the participating nations as well as to other countries facing similar energy problems. It could also serve as a prototype for similar studies on other resources such as materials, water, air, i.e. as a vehicle for development of an approach for improved resource management.

W.K. Foell

Papers in the series describing this research program are:

(1) Foell, W.K. "Integrated Energy System Modelling and Policy Analysis: A Description of an IIASA Research Program" IIASA Working Paper WP-75-38, April 1975.

(2) Dennis, R.L. and Ito, K. "An Initial Framework for Describing Regional Pollution Emissions in the IIASA Integrated Energy System Research Program" IIASA Working Paper WP-75-61, June 1975.

(3) Hölzl, A. and Foell, W.K., "A Brief Overview of Demographic, Geographic, and Energy Characteristics of the German Democratic Republic, Rhône-Alpes, and Wisconsin" IIASA Working Paper WP-75-65, June 1975.

(4) Weingart, Jerome, "Preliminary Data Requirements for a Feasibility Study of the Solar Option in the Rhône-Alpes Region of France" IIASA Working Paper, WP-75-68, June 1975.

(5) Bigelow, J., "Transportation Modeling in the Comparative Energy Study" IIASA Working Paper WP-75-73, June 1975.

(6) Dennis, R., "Data Needs of the Environmental Model for the Integrated Energy Research Program" WP-75-105, August 1975.

(7) Buehring, W.A., and Dennis, R.L., "A Methodology to Assess the Human Health Impact of Sulfur Dioxide Emissions" IIASA Working Paper WP-75-108, August 1975.

(8) Hölzl, A.,"Energy Supply and Consumption for the GDR, Rhone-Alpes and Wisconsin" IIASA Working Paper WP-75-126, October, 1975.

(9) Hedrich, Ufer, Martin, Finon, Pappas, "Preliminary Overviews of Institutional Structures and Models - Information Systems for Energy/Environmental Planning in GDR, Rhône-Alpes and Wisconsin, October 1975.

(10) Hedrich, P., Lindner, K., "A Paper at the ECE Symposium on Application of Economic Mathematical Models in the Energy Sector, Alma-Ata", September 1973.

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Leipzig, Oct., 1975

Planning of Power Industry in the GDR

Starting from the socialist production conditions in the GDR there arises the possibility and necessity of entire social planning. That is due to all spheres of national economy including power industry.

Power industry influences all spheres of social life and comprises winning, transformation, transport and application of all energy carriers.
The Ministry for Coal and Energy is responsible for elaboration and realization of national power policy. The base of this sphere of activity are considered to be the resolutions of the Socialist Unity Party of Germany. The Ministry for Coal and Energy works according to the principles of economic policy of the country accepted by the Council of Ministers and is subordinated to the Council of Ministers .

The State Planning Commission is subordinated to the Council of Ministers as the most important staff organ which elaborates the strategy of development of national industry and therefore is considered to be an important partner in the process of planning power industry.

The Association of Nationally-Owned Factories (VVB) of Brown Coal, Hard Coal, Power Stations and Power Supply as well as the Complex of Gas Factory Plants "Schwarze Pumpe" (Black Pump) are subordinated to the Ministry for Coal and Energy. The single producing factories are subordinated to the Association of Nationally-Owned Factories. The Association of Nationally-Owned Factories of Power Stations for instance comprises the great lignite power stations, nuclear power stations, gas turbine power stations, pumped-storage power stations and the grid system beginning with 220 kV. The Association of Nationally-Owned

Factories of Power Supply is divided territorially. In each district there exists one factory of power supply, whereby mostly two or three of such factories are united to complexes of power enterprises. To the factories of power supply belong heating plants, greater heating works, gas works and stations for distribution of electric energy, gas and district heat. They are considered to be the market organs of power industry for these energy carriers.

Thus the Ministry for Coal and Energy is responsible for the greatest part of power delivery. As exclusions are only to be regarded the primary working of mineral oil which falls to the sphere of the Ministry of Chemical Industry, the winning of natural gas which is subordinated to the Ministry of Geology, and the industrial power plants in the different branches of industry as well as the municipally-owned heating works and other plants of local significance.

Under consideration of the responsibility for the strategy of development of power industry the Ministry for Coal and Energy has to fulfil a double function :

1. It is responsible for the delivery of energy carriers by its subordinated economic units, i.e. about 78 % of total primary energy.
2. It is responsible for realization of principles of rational use of energy and thus for power policy in all spheres of national industry and social life, including all energy carriers.

The most important instrument for realization of power policy is regarded to be the plan, especially the energy plan. This plan has been elaborated since more than 10 years by all essential power-consuming factories and institutions for annual and five-year planning.

As the aims of planning are subordinated to the interests of whole society the process of planning is centrally leaded by the Government and is carried through by means of coordination on all levels of leadership up to the factories in which working people play a decisive role in determining the figures of operating plans.

The GDR is a member of the Council of Mutual Economic Aid. The plans of the member-countries, especially the five-year plans, are coordinated with each other, in order to gain a steady and quick development of national industries of all socialist countries.

The planning is carried through by means of coordination over different periods. Thereby we chiefly distinguish between annual planning, five-year planning and long-term planning which comprises some decades especially in power industry. In this connection the forecast of scientific-technical development of single processes and procedures in which is to be seen a presupposition for a qualified planning, is of great importance.

As starting point for the planning of power industry is regarded the planning of demand for service energy. In this connection there is necessary a detailed knowledge of development of national industry, above all of intended production of energy-intensive products and of development of living standard. Moreover there are required informations about scientific-technical development of processes in which energy is applied, in order to derive from it the development of data characterizing the specific power consumption.

By means of the so-called substitution optimization model (SOM) there is elected from different possibilities of designing processes and of applying energy carriers such a possibility which results in the lowest social expenditure with reference to the production of a certain assortment of products.

From the service energy determined by means of economic-mathematical models and global methods there are calculated the necessary total amount of all energy carriers and the demand for primary energy in a second phase of planning.

In the long-term planning an optimization model is used which considers the interlacement of energy carriers between each other (the long-term planning comprises about two decades). The application of this model, the so-called production optimization model (POM) leads to the election of such a variant combination of energy-winning and -transformation plants, by which the demand for service energy can be covered with a minimum social expenditure. Certainly these calculations are supplemented by calculations on the base of global methods, above all as far as it concerns such periods exceeding the year 2000.

This phase of planning is connected with investigations on scientific-technical development of procedures for winning, transport and transformation of energy. The calculations require detailed knowledges about sources of energy available in the country and about possibilities of import. Moreover certain economic sizes, as investments, wages, prices for imported energy carriers, are of importance for the calculations.

After this phase of planning of power industry there are following investigations about incorporating these results in the development of whole power industry, i.e. in relation to the demand for investments and manpower, the expenditure on import of energy carriers and energy equipment and to the factors of environmental load. From these investigations on the one hand arise concrete tasks for scientific-technical researches (development of improved procedures of winning, transformation, transport and use of energy etc.) and on the other hand starting points for new calculations of service and primary energy.

This iterative process is repeated up to that time, where is reached a sufficient degree of correspondence of energetic demands with the possibilities of national industry.

A special attention is paid to the relations between power industry and environmental protection. The measures of environmental protection are included in the development of national economy systematically in that way that they exercise an effective influence on safeguard of social reproduction process. A corresponding example consists in a possibly extensive use of waste products as secondary material.

The Ministry of Environmental Protection and Water Economy has elaborated main directions for development of environmental protection up to 1980. Starting from these directions there are created concrete conceptions for districts of industrial conurbation on the base of socialist legislation for environmental conservation.

In 1975 two thirds of the investments on environmental protection are concentrated upon districts of industrial conurbation which simultaneously are considered to be the most important areas of power industry.

For understanding the contents and mechanism of model system and the differentiated use of several sub-models the knowledge of a uniform basic structure of all optimization models is of essential importance.

Uniform basic structure

The aim of optimization consists in a minimum of total social expenditure under consideration of essential restrictions. For that aim serves the factor of expenditure being obligatory for the whole power industry. Besides single and current expenditures this factor contains the demand for surplus for extended reproduction of productive funds (investments and extension of circulating medium) and the social consumption. Both sizes are applicable to social average. They are being derived from sizes of national economy. Social consumption means application of net income in the unproductive sphere for

- science, as far as it is not directly integrated in the production,
- public education,
- culture,
- public hygiene and sanitation,
- national defence,
- state administration.

The demand for extended reproduction of productive funds is regarded by the factor of accumulation q.

$$q = 1,065 \approx \text{const in its temporary development}$$

It is related to investments.

The factor of consumption q_k is related to wages. It is considered to be a temporarily dependent size.

Year	1971-1975	1976-1980	1981-1985	1986-1990
q_k	1,7	1,9	2,1	2,4

In practical modeling the factor of expenditure is used in form of cash-value.

$$AW_o = \sum_{j=1}^{-d} I_j \cdot q^{-j} + \sum_{j=1}^{n} I_j \, q^{-j+1} + \sum_{j=1}^{n} U_j \, q^{-j+1}$$

$$- q^{-n} \sum_{j=1}^{n} (U_j) \qquad + \sum_{j=1}^{n} (l_j q_k + k_{m_j}) \, q^{-j}$$

I	=	Investments	M
U	=	circulating medium	M
l	=	wages	M/a
k_m	=	expenditure of materials	M/a
q	=	factor of accumulation	M/a
q_k	=	factor of consumption	M/M
n	=	working life	years
d	=	building time up to the begin of production	
j	=	index for years	

Besides minimization of expenditure there are to be considered the following principles :

1. Each expenditure which has already been realized is not calculated once more, i.e. that it is not necessary to take into account related to funds sizes as amortizations, gain etc. for plants which already existed at the beginning of the period of consideration.

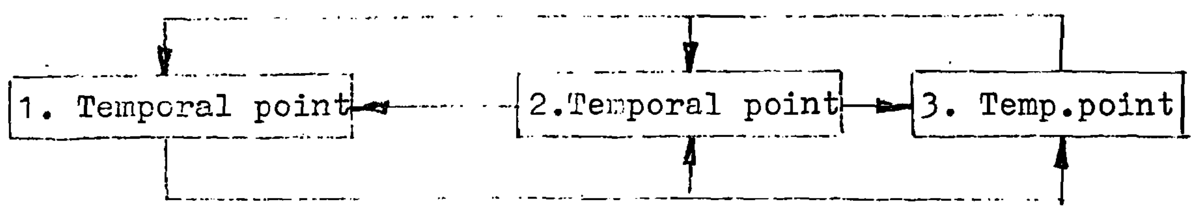
2. The working life of plants is only restricted by their physical working life. The calculation of optimization decides on the economic working life by means of moral wear.

3. There is not allowed any economic double valuation, i.e. there are only scheduled those components of expenditure which are

flowing to the system from outside in form of investments, expenditures of material for imported energy carriers and other raw materials and auxiliary agents, wages and aid from outside. What concerns energy carriers being generated in power industry they are not further calculated in form of expenditures of energy carriers.

4. In order to guarantee the comparability of all elements of expenditure there is taken into account the structure of energy carriers and installations which exist at the end of the period of consideration in their infinite effectiveness.

5. The right interconnection of several temporal points in a period of consideration is extremely decisive in relation to the results of calculation. Thereby we start from a real optimization of periods which permits the mutual influence of all installations in a range exceeding the single periods of the system. In this connection there is applied the principle of permanent forward and backward calculation .



By this procedure it becomes necessary to create such models that their balances of material interlacing also comprise the total space of time. By that way the balances of the single temporal points are clearly emphasized. Simultaneously ist becomes possible to interlace the technical-technological, material-technical, resource-conditioned and economic restrictions with each other.

6. Each plant or resource is scheduled by its efficiency x orientated towards time (installed capacity or arranged maximum delivery) and their temporally differentiated rate of utilization y. The relations between these two factors are expressed by the

condition

$$x - \sum y(t) \geq 0$$

7. Y-sizes are introduced only for those temporal points and plants for which there are to be expected a rate of utilization and operation varying in dependence on time. Besides that there are applied capacitive sizes x' which are characterized by a constant or previously determined different rate of utilization.

8. The registration is not done annually, but only in each n-year. In the last years for instance there were scheduled the following years:

1976; 1978; 1980;1985; 1990,

whereby the reference year was considered to be 1975.

9. This gradation may lead to a distorted reflection of economic influence coefficients. In order to restrict this appearance there was modelled a linear development of demand and elements of expenditure between spaces of time over several years.

This relatively simple description of basic structure of models clearly shows that we start from a consequent consideration of spaces of time. The insulated consideration of only one point of time leads to serious error estimations.

Model system

The strategical model system of power industry in the GDR is a hierarchic one.

Starting point of all considerations are regarded to be models which are located on the central level. They consist of the central production optimization model and the substitution optimization model (ZPOM and SOM).

The central production optimization model represents a central model of power industry in the narrower sense. It comprises all

plants of winning, transformation and import of energy carriers.
To them belong all plants of
coal industry
gas industry
electroenergy industry
primary working of mineral oil
public heat supply
important industrial power plants
and heating plants,
independently on their subordination to a certain level of leadership.

The load of electroenergy system and gas system is represented approximatively in steps.
The size of demand is the demand for service energy of the whole country or the demand for energy carriers outside of power industry.
This model is used permanently for aims of planning and research.

The substitution optimization model is also concentrated on the central level. It comprises energy-intensive processes which are to be decided on central level (i.e. production of iron and steel, building materials as cement, bricks, aluminium, copper, chlorine, plastic and elastic materials, transport industry etc.) and energetic mass processes, the principal direction of which is to be determined. These both central models may be operated in a single and iterative way or in a mathematical coupling.
Each branch of power industry itself which is represented in the central model has its own model. By means of these models it is possible to simulate the several plants and their seasonal behaviour far more exactly. The aggregation is essentially lower.

The disadvantage of these models consists in the impossibility to take into consideration all influence sizes of power industry. Therefore there can only be reached usable results, if they are used in the model system or on the base of calculated restrictions applicable to whole power industry (certain exclusions are only permitted in the case of special researches).

The third decisive component are considered to be the optimization models of territorial structure (TSM). These models optimize power supply to be determined on terrritorial level. In this connection the most important points are regarded to be supply of population, communal economy and locally led industry.

The models are connected with each other by a special coupling algorithm.

The model system is operated as follows :

1. On the base of calculations of central models the sub-models get premises about highest and lowest limits of demand and the possible supply of energy carriers. In the same way are demonstrated the specific expenditures of energy carriers which were delivered from other spheres of industry. Thus the central model (ZPOM) is withdrawn from the further process of calculations.

2. On this base the subdomains and territories calculate any number of variants, but at least two.

3. The results of these investigations and differentiated variants of the substitution optimization model are introduced into the coupling algorithm in form of variants. The coupling algorithm is also based on the principle of linear optimization and minimization of expenditures. The input of several variants is done complexly in a rigid material coupling with the value of aim function. As each double counting must be avoided the costs of energy carriers which were delivered from other spheres of industry are again eliminated in advance. For each variant there exist three possibilities :

   1. It is used completely — Value = 1
   2. It is not used — Value = 0
   3. It is used partially — Value > 0 and < 1

It becomes evident that there may arise mixed variants. In the case of mixed variants the results are transmitted to sub-systems for further processing. It is to be proved under these conditions whether such a mixture of variants is practically admissible. If it is admissible the calculation is continued as follows :

1. The optimum variant or combination of variants gets the valuation 'zero' for all energy carriers to be delivered. Simultaneously the sub-system gets the additional expenditures of sub-optimum reference vectors of output derived from the coordination model. Thus a counter-proposal must contain such an economy that all losses arising in other subdomains can be comprehended by it.
2. The counter-proposals are taken over into the coordination model. Therby the former variants are not eliminated. That is why the size of model steadily increases witheach step of iteration.
3. The calculation is interrupted, if there is reached a certain correspondence between the step n and (n + 1).

A special compensating block which can cover, take up and reverse deficiencies and excesses of several systems at each time leads to a high flexibility, also under the conditions of a relatively rigid basic structure of several variants in the coupling algotithm.

The utilization of this model system is based on the principle of democratic centralism. That means that sub-modles on the one hand are erected by those who have the greatest knowledge of subject, and on the other hand that interests are subordinated to the whole. In dependence on the number of hierarchic levles also the reaction time increases essentially. Therefore the model system is characterized by such a structure that the system can be applied in some combinations, i.e. it is not necessary in every case to use the whole system at once.

Corresponding premises for sub-models by the central model and coordination model permit abundant scientific investigations. In the practical use of modelling results the recognition is of greatest significance that these results are considered to be the starting, but not the final points of complex energetic investigations carried through by specialists of several branches.

The results of calculations must fundamentally be analyzed by groups of experts and must substantially be extended with regard to contents. It must not be forgotten that the advantage of models consists in elaboration of essential connections. That is why the work of experts must lead to an extension with regard to contents which on the other hand results in new model calculations.

We want especially to emphasize that the work with such economic-mathematical models is considered to be the more effective the more they are integrated into the process of leading and and planning.

In the GDR it would be possible to gather good experience on the base of methods of long-term energy planning which are described in this context. The corresponding procedures were regarded to be a valuable aid for the elaboration of strategies of energetic development.The good results which were reached in the fulfilment of five-year plans and are based on the described methods also plead for the quality gainded in long-term planning.

In future we shall steadily continue the course taken in the field of planning of power industry in the GDR. We expect especial success from the further extension of common planning with the other socialist countries in the frame of the Council of Mutual Economic Aid. That is considered to be one of the most important tasks of our future work.

FRENCH ENERGY MODELS AND THEIR RELATIONSHIP TO ENERGY/ENVIRONMENTAL PLANNING IN THE RHONE-ALPES REGION

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Translated by A.C. Foell

Part I

A model is always a simplified representation of reality taken from a certain point of view which reflects the status and the interest of the modeler (or of the one who is in charge of it). This way one will find purely cognitive models, in other words, models meant to improve a knowledge of reality (physical, social cultural ...), and decision models, the use of which would help a person or an institution to make the best possible decision. In the sense of a similar decision field, this last one will vary along with the status, the functions, the temporal horizon, the space of reference ... of the determining instance. In dealing with energy matters, for example, one usually distinguishes between 1) the corporate models which help in choosing a commercial strategy or a long term investment strategy in a given market (coal, oil, natural gas, electricity...) and 2) the public planning models put into practice by a governmental authority in order to identify the incoherencies which could be caused by incompatibilities between the strategies of the firms. Thus, from one economy to another, (United States, German Democratic Republic, France), the decision structure (in other words; the group of relations which tie together among each other the decision centers of which we have just spoken) changes. Here, the State can limit itself to an a posteriori and indirect monitoring of the activity of the firms, whereas elsewhere, it is actually the State who determines the objectives to which the latter must adapt their program. In this case, the territory of intervention of the firms and of the State can correspond to the limits of the studied region when in another one it can greatly exceed it.

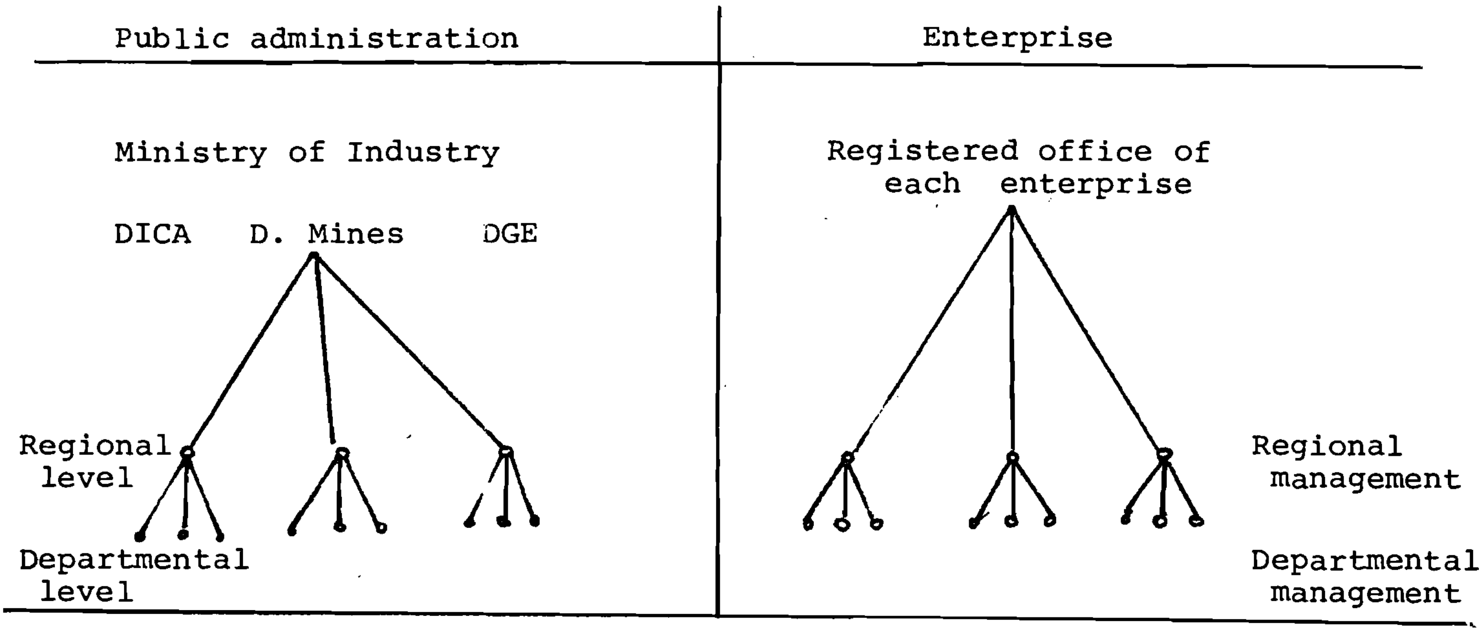
From these few considerations we maintain that no evaluation of a model can be made, except an evaluation of their intrinsic coherence, without referring to the objectives and to the means of the authority by which or in the name of which the model has been made. With reference to a given region (State of Wisconsin, GDR, Rhone-Alpes region), the relevancy of a decision model increases as a function of the decision capability existing in the region.

How does the Rhone-Alpes region fit into the framework of the economy and of French institutions?

I - THE INSTITUTIONAL STRUCTURE

Two aspects of the French economic and political organization are of importance for an understanding of the energy and environmental decisions in the Rhone-Alpes region.

In the first place, for historical reasons the entire French decision system is extremely centralized. This accounts for the State apparatus in which sense all decisions are centralized in the high level administration (the ministers) geographically concentrated in the capital, and also for the important firms in which the power is also centralized at the registered office, which itself is located in the capital. These two structures, of which we shall see the overlapping later on, could be represented by bodies with greatly expanded heads and with atrophied limbs, reduced to the executing orders coming from the top[1]. For a long time, the framework of this execution of orders was the department (Napoleonic creation) of small dimension (about 90 in France) in order that it could not compete with the central authority. Recently, a shift has been brought about, namely the creation of the "Region" which regroups several departments (from 4 to 10), depending on the specific case), but which does not yet dispose of a true autonomy. In simplified terms, we shall thus encounter the two following decision structures:



[1] If the least difficulty arises on this occasion, the department or the region refers to the center which indicates how it will find it agreeable to overcome the obstacle. If this indication is not sufficient, the center sends a high official who settles the problem on the spot.

In the public structure, as well as the planning, the monitor-ing and the regulation are only carried out at the national level; in other words they are uniform for the group of regions. The regional and departmental levels collect information for the sake of the center and inform the decisions of the center while watching their application (2). In the area of energy and environment the center does not have any group model available. It limits itself to arbitration between the decisions taken by the firms which, as we will see further on, produces good national models.

The second characteristic has referred to the status of the corporations. The structure of the energy sector, in other words, the relations which connect the firms between each other, in this viewpoint, is very particular in this sense that it differs from the one of other sectors of the economic industry. These latter ones usually consistof a more or less important number of firms of private national origin. The corporations of this type have practically disappeared from the energy sector into the extent where only two types of firms occur(3):

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(2) This structure is so very resourceful that it is capable of approaching all the innovations to shape them to their logic. A recent study has pointed out, for example, that contrary to all expectation, the generalization of the information processing in French enterprises has favored the centralization. cf. Catherine BALLE - The computer, a break in the reforms of structure of enterprises, Le Monde, 18 September, 1975.

(3) The emergence of "nuclear" leads, however, towards modifying this situation since we help to check a part of the sombusticle cycle by Pechiney-Ugine-Kuhlman who represents one of the largest private French firms.

- branches of multi-national firms which control about 50% of the French petroleum market;
- public enterprises or mixed industry, either competing (CFP and ELF-ERAP in the oil branch) or monopolistic (EDF, CDF, GDF, CEA, SNAP, CNR ...).

The first ones show a changeable autonomy according to the structure and the strategy of the firm upon which they depend. At any rate, they never decide by themselves since the stakes are of some importance (large investment in the refining or the transport, for example).

For them the Region is at the most a sub-group of consumers with which it agrees to consider the characteristics (quantity, density, rate of crossing) in a model representing the conditions of development of future sales. The results of the model can influence the politics of the enterprise in the sense of the placing of investments.

The second ones show large power which is, however, far from being complete because their public status makes them subordinate to the State authority. This subordination varies, however, according to the extent into which the enterprise shows a monopoly or not (the guardianship of the State is less constraining for the firms like CFP and ELF ERAP which compete with the branches of the multi-national oil enterprises) and can face or not its investment charges (EDF which had become more than 50% self-financing, had acquired a much larger autonomy than CDF or GDF). No matter what their exact impact is in the final decision -- in other words, especially the one which concerns new investments -- all these firms resort to models in order to diminish the uncertainty which encourages the evolution of their market, prices of their newly imported materials and technologies to which they resort. But these models, as we shall see, are conceived by and for the center. The regional specifications have only been taken into consideration in the form of exogeneous data and of restraints:

- probable evolution of the energy consumption
- the availabilities in energy sources
- or, in sites and in water cooling for the large installations.

* * * *

Before passing by a short description of models planned and used by the firms in the national plan, one could say a few words of the ties between the two determining structures. It really is the mechanism of the State which came first because it is a pillar of the entire history of a nation dominated by the struggle of the center (the monarchy) against the provinces (the feudal systems). The second structure, that of the firms, has been traced back to the first for reasons easy to understand. Since the foreign oil firms have been installed in France, from the beginning of the century, they have tried to influence a legislation which has not always been favorable to them, and, in order to do this, have installed their aerials as close as possible to the state power. Later on, since the great wave of nationalization of 1945, rationalization will be synonyme for uniformization - standardization - centralization ... as a reaction against the crumbling away of the mechanism of production (especially electricity and gas), which is the result of a slightly dynamic and slightly concentrated capitalism. Between all these heads, the osmosis will be made considerably easier and will be speeded up by another aspect of the French centralization, namely the uniform fabrication in the large schools of engineers also concentrated in the Paris region. Through the well known and studied phenomenon of the "pantouflage" the same personnel turns from the direction of administrations to the one of the public and sometimes private firms.

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II - THE MODELS USED IN THE RHONE-ALPES REGION

As had been underlined, the group of economic and in particular energy activities of the Rhone-Alpes region does not consist of an economic system by itself, since the institutional and economic structure of France is very centralized. Moreover, no proper energy models exist in the Rhone-Alpes region and the majority of the ones which do exist are centrally represented by French industries. We will, therefore, here especially deal with models, the spatial area of which is the nation rather than the region.

1. - The determining models

The majority of these models are very specific and point out rather the operational research or the simple gesture of enterprises.

1.1. - The oil branch models

The different oil corporations have been elaborated at the brand level[4]:

- refining models which optimize the gesture and the running of a refinery, taken into account its technical characteristics, oil qualities, the supplies and the production program imposed by the central office of the society, taking into account its market in the viewpoint of the refinery. In order to do this, the changeable expenses (the buying of unrefined material, utilities, various products) are reduced to objectives of given production, and while taking into account specifications of products, to the assistance of programming techniques;
- models of transport and distribution which reduce the transport expenses, and of the availability of different oil products taking into account the siting of refineries, of departmental storage places and of main areas of consumption. These models are most often regional and also use the programming of the various algorithms.

Much more general and global models do exist which try to optimize the strategy of oil companies by planning their investments of exploration, of refining and of distribution and by optimizing their strategy of market aquisitions (fuels, white products ...). We must again remind you that half of the French oil market is controlled by branches of multi-national firms of which the politics of investments depends on the group strategy.

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(4) See MAURIN - Linearly applied programming - Technip - 1967, 375 p.

And, with this title, the strategic models do not exist at the French level in these branches.

1.2. - <u>The gas branch models</u>

In addition to the models which optimize the management of a gas pipe-line, taking into account the possible extension of different regional markets and availability of gas (national resources, contracts of import), and in addition to models of reservoir management with underground storage in order to regulate the areas of demand, few models have been developed in France by Gaz de France concerning gas. One must also specify that different methodologies taking the place of informal models have been utilized either to analyze the competitiveness of gas, or to help in choosing the investments.

With the first methodology the outlets of gas have been studied cases for case by considering the different areas where it is usable and/or used[5]; one determines a price of equivalence of gas from the price of the competing fuel, while taking into account the profit of utilization and the costs of equipment and of exploitation of the usable installations.
With the second methodology[6], "Gaz de France" studies the profit of investment projects; with the help of a test, it determines amongst the mass profitable operations (in other words

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[5] These areas are just as specific and precise as the tubular boilers, different types of heating, baking of burnt earth .. etc.

[6] Cf. Toromanoff - The choice of investments at the Gaz de France - <u>Revue Francaise de l'Energie</u>, n°260, February '74.

those of which the profit rate is superior to the rate imposed by public power), which attribute the best financially estimated result. It is indeed necessary to cut down on less profitable projects for the benefits of investments adjusted to the public means are limited.

1.3. - The electricity branch models

This branch has been a delicate object particularly from the part of the modelers: the first models of linear programming used in France were developed this way in 1954 at the EDF for the choice of electrical investments. And since this date, the researchers of this enterprise are at the point of progress and utilize new techniques of calculation (non-linear programming, dynamic programming, theory of the optimal order ... etc). Let us first point out the existence of very specific models such as the optimization of the cycle of the nuclear fuel[7], the optimization of the network of electricity transport, the maximizing of the security of this network[8].. etc. But it would be a good idea to dwell upon more general models and in particular on the models of demand forecast and the models of choosing electricity investments.

The forecasting models of electricity demand used by

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(7) cf. Simulation model of the nuclear fuel cycle - Charpentier-Naudet-Paillot - Commission of Atomic Energy, France, 1973, and Model SEPTEN - Service of Nuclear studies - Direction of the equipment of the EDF - France, 1972.

(8) J.C. Dodu- Probable model the study of the alimentation security of a transport network - EDF, 1973

EDF[9] are relatively simple and based upon extrapolation of the past starting from statistic relations of simple or multiple regression type. These relations (generally logarithmic) connect at the global level (or at the level of highly aggregated sectors such as the residential and urban sector or the industrial sector)[10] the quantities of electrical energy with time:

$$\log C_t = a + b \cdot t$$

or with the economic operation represented by an operational economic index of the National crude material type (PNB) or Industrial Added Value (VAI)

$$\log C_t = a + b \log PIB_t.$$

The forecasters of the EDF have indeed estimated that these models obtain the best results and that all the efforts to tie the electricity consumption in with other variables (such as the relative price of the capital, of the work or of the fuels with reference to the electricity in the industry, or the income and/or the amount of households in the residential and urban sector) prove to be unsatisfactory[11]. One must also point out that this econometric approach assumes that the consumption of electricity was unflexible to the price, and that the outlets of electricity developed in a relatively autonomous manner in the well specified areas. The new commercial strategy of EDF and the roughly calculated high price of

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(9) In English language - D. Finch, Forecasting the consumption of Energy and Electricity: the methods used in France - in Proceedings of the workshop in Madison, pp. 23-36.

(10) Or even still the high or low potential consumptions.

(11) See Y. Pioger - Forecasting Power Consumption and models for constructing load curves - Proceedings of the Madison workshop, p. 49-83.

fuel products, however, cancel all partition between the markets of different energies and produce more critical methods. The econometric forecasts must presently be confronted with the commercial objectives of the firm and are completed by a prospective carried out in terms of scenarios. One could never do without methods of extrapolation, but beyond a horizon of more than five years, the obtained forecasts can be used with much caution.

In other respects a forecasting model at intermediate course of the curve of daily charge, is used to define the output per hour according to the hour, the day, the week and the month from the extrapolation of different coefficients characterizing several parameters(12).

Let us now consider the models of electricity investment choice. An important bibliography exists on this subject(13). These models reduce in the long run (1975 - 2000) the up-to-date electricity production cost over a long period of time to given production objectives; these objectives are determined by the forecasts of the global electricity demand brought into effect with the help of econometric models which have just

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(12) See Y. POIGER - Forecasting Power Consumption and Models for constructing Load Curves - in Proceedings of the Workshop of Madison, p. 49-83.

(13) See for example in English language: P. Masse and R. Gibrat: Application of liniear programming to investments in the Electric Power Industry- Management Science no.3 (1957). F. Bessiere: Methods of Choosing Production Equipment at Electric de France, European Economic Review, Winter 1969. (See also F. Bessiere in Proceedings of the Workshop of Madison (Oct. 1974).

been mentioned and by a representation of this demand with the help of weekly load curves. The different types of equipment of electricity production have been explicitly taken into account and are characterized by their capacity and the services they are supposed to render, in other words their functioning during the different hours of the load curve, taken into account their availability or hydraulicity for the hydro-electric equipments. The risks of the hydraulicity and the hourly electricity consumption are taken into account with the help of the established probabilities starting from past samples and allow to take into consideration possible failures of the production system.

The actual model[14] uses the theory of optimal control. The objective function of reduction is a function of cost composed of three terms (investment, operating cost, cost of failure[15]). The control variables are the equipment quantities created year by year, and the restraints express an obligation of satisfaction of future demand as is the case with the forced (or limited) development of certain types of equipment. The algorithm runs twofold: first, the variables of control are determined and then the optimal management of the given power equipment is defined. The program allows to obtain the optimal equipment plan at the national level, the duration of economic life of equipments, the probability of failure, the marginal costs of production of a

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(14) Called the new national model of investment. c.f. D. Levi, D. Saumon, Description of the New National Model of Investment, Internal Memo of the EDF, May 1973.

(15) The cost of power-failure is a non-linear function increasing in relation to the duration and the amplitude of the power failure.

kWh (according to the hour, day and month) and the values of use of equipments (values in use). The marginal costs which have also thus been determined, serve to establish the electricity tariffs. In order to do this, one adds to them the marginal transport costs and costs of distribution calculated in other respects and a "toll" which permits the EDF to reach the budget equilibrium and even to possess an appreciable self-financing capacity[16]. The values of usage thus determined serve for the comparison of individual hydro-electric projects with a reference equipment (classical thermic or nuclear), which serves the purpose [17] of studying their profitability.

These models or investment choice are particularly complex to the extent that the system of French electricity production is a hydraulic mixed system - classical thermic (or nuclear)[18], which makes a rather detailed representation of the management of the different hydraulic equipments necessary (current, locks, reservoirs, pumps) during different hours of the year, taking into account the daily, weekly or seasonal reports which they justify. In the actual model, a sub-model simulates the management of the electricity zone such that the diagram of

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(16) On this subject see: P.Stasi - The Rational Use of Electrical Energy. The Contribution of Tariffing, Symposium on the Rationalization of the Consumption of Electrical Energy - Varsovie, 1962.
Also see in English: C. Berthomieu - Theory and Practice of Electricity Pricing in France, Workshop of Madison 1974.

(17) This decentralized procedure is called the "Blue Note". See for example M. Boiteux and F. Bessiere: On the Use of Aggregate and Marginal Methods in Choosing Investments, in J.R. Nelson, Optimal Investment Decisions, 1962, Prenctice Hall, Inc.

weekly loading (or monthly) of the classical thermic zone would be as level as possible. On the other hand, if we define precisely that, amongst the successive models of investment choice which succeed one another, the only model "investments 85" constructed in 1965[18] was disaggregated in 5 regions: the region of the Rhone-Alpes, established with the Mediterranian region the Cote d'Azur, the South-West region of this model, and it was connected with the other regions by variables of interregional exchanges. The objective was not to determine the transport but to try to trace a primary scheme of optimal localization of the production equipments, while considering the siting of the hydraulic and consumers' resources.

It is necessary to define that these models of investment only integrate the private costs and, by no means social costs as far as the degradation of the environment is concerned dragged along by the atmospheric of water pollution and by the ground occuption. In other words not a single environmental restraint has explicitly been taken into account. From a practical point of view, for example, these models have never integrated explicitly the choice of siting of the electricity installations since almost the totality amongst them have not been regionalized [19]. Thus, in France where there are few water courses available enough to support without risk the installation of numerous thermal trenches, the cooling problem

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[18] and while using the non-linear programming

[19] The regional branching made effective in the model "Investements 85" was not fine enough to permit the taking into consideration of this problem.

of thermal central installations prevails over the transport expenditures ever since the choice of siting of these factories.

Considering the environmental impacts, it does not exclude, however, the preoccupations of the EDF and their calculations[20]. The ecological problems have been evaluated with reference to a group of factors dealing with areas as varied as physics, medicine, biology or psychology; certain considered elements are only qualitative or subjective and have been integrated because of judgements or explicit or implicit choices made by warned citizens supposed to express the behavior and the aspirations of the collectivity. The evaluation of the importance relative to ecological problems put by different production installations has been calculated according to the same unit by means of "ecological points". Seven types of ecological problems have been filed;[21] furthermore, for a similar type of ecological problem, the value brought up to date by impacts driven by these different techniques, has been evaluated; and finally, according to a comparison between the different types of impacts with the help of an implicit preference[22] function, the group of values of impacts of different installations has been calculated with these "ecological factors". Later on, one

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(20) Harmful effects of radio-nuclear origin, noise and vibrations of electricity or radio-electric origin, other harmful effects causing change of air, water, ground..etc.

(21) Units of 600MW, for instance, classical thermal central facilities.

(22) This function of preference expresses the level of preoccupations attached to each category of harmful effects and is based on subjective considerations (levels acceptable for change of natural environment, quality of atmosphere..etc).

can evaluate the ecological gain of each action engaged or to be engaged in order to reduce the harmful effects, and with the same one can obtain an implicit evaluation in monetary terms of this ecological point, an evaluation which will, however, remain more or less inexact. There is no room to dwell further and longer upon this approach of environmental problems which, you will remember, is not directly related to the choice models of the EDF investments.

At the sectorial level no global model of decisive type exists destined to inform of the choice of public power or of organisms close to those. In fact, it does not exist for the regional energy system. Previously, a method of energy planning existed, used in the framework of the IV° and of the V° Plan Francais[23] which was a kind of informal model and which permitted the determination of energy supply of France at the lowest cost while taking into account an objective of security provisions. But this method had been abandoned in 1970, since the concept of the V° Plan, as the public power did no longer have the command over the energy system.

Let us, however, mention the existence of a model of simulation of the financing of the energy sector which permits the forecasting of 1970 will 1985 (or 1990) of the consequences at medium and long-term modifications of energy politics (tariffs, taxes, investments, regulation)[24] on the financing, employment and annual needs of investment and the budgets of the sector

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[23] 1961 - 1965 and 1966 - 70.

[24] FINER's model constructed by D. Blain at the Ministry of Economics and Finances, No. 1972.

enterprises.

2. - The Cognitive Models

To our knowledge, very few efforts have been made in France to study the French energy system with the help of models in order to improve the knowledge and to make an exploration of its future effectiveness.

One can observe, for example, the use of a method of scenarios permitting the reduction of the complexity of the studied system by selecting the most important factors and one to trace different scenarios of the development of nuclear energy up to the horizon of 2000[25].

At the Energy Institute of Grenoble, a model of optimization of the energy sector[26] has been developed without a tie to the public power[27]. Its goal is to test the reactions of the French energy system with modifications of its political and economic environment:

- price of oil
- cost of nuclear facilities
- development of certain technologies
- policy of preserving the environment
- policy of securing the supplies or of limiting the oil dependency ...etc.

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(25) It does, in other words, not serve directly to help the sectorial decision makers.

(26) See the subject of D. Finon - The Energy Model - optimization of the French Sector of Energy by Global Approach; dissertation, 520 pages, Grenoble, March, 1975.
In English language: D. Finon, Optimization Models for the French Energy Sector, Energy Policy, Vol 2m No. 2, June 1974, pp. 136 - 151.

(27) It, therefore, does not serve directly to aid the sectorial decision makers.

The model uses the linear programming in order to reduce the group of actual costs of investment and exploitation brought into effect to satisfy the energy demand, while considering the utilisation expenses, and the one over the period of 1975 - 2020. This energy companies have been understood as being centralized, France being considered as one total.

The system, which is represented by a graph in which the curves represent the economic operations (extraction, import, treatment, transformation, transport, consumption) is pointed out by the group of energy companies on the French territory. It combines the energy consumptions with arbitrary possibilities between the different forms of final energy in the competing areas of ther thermal usages. In its actual version, only the emissions of SO_2 have been taken into consideration amongst the group of attacks on the environment, but the method of formation could easily be stretched towards other types of impacts.

The model chooses between the different processes of production of different types of energy, which are represented by the diagram, on the basis of the minimizing of the cost, under the restrainst of demand satisfaction and under different political constraints (limitation of the oil dependancy, possible speeding up of the nuclear program, limitation of the level of emissions ... etc). The variables of the model are, in other words, the flows assuming the arches of the graph during different years (variables of exploitation) and the instalment capacities to be created in the future (variables of instalment). The different parts of the model, in other words, have been built according to a sub-system of consumption and to a sub-system of production.

a) <u>The sub-system of consumption</u>: The demand is partly endogenous to the model. In addition ot the proper consumption of the sector, the consumptions to be satisfied are disintegrated in three groups of consumters (industry, transport, domestic furnaces), nine types of final energy (coke, coal, gas, electricity, motor fuels for the transport systems, naphtaline for chemistry, domestic fuel, heavy sulphurized fuel, heavy weight fuel with a sulphur content). One actually distinguishes among two types of usages: the specific usages and the usages which can be substitutes. These last ones are mainly constructed by the area of thermal usages(28) in which there exists the competition between the different forms of energy.

Suppose c is a group of consumers:

ϕ	a form of final energy
$x^{1}(\phi,c)$	the flows of this form are directed towards specific usages
$x^{11}(\phi,c)$	the flows directed towards the use of thermics
$r(\phi,c)$	the output of utilization from consumer's c apparatus
$D(\phi,c)$	the specific needs of energy used by the consumer
Uc	the needs of thermal energy used by the consumer
$T(\phi,c)$	the starting capacity of the energy utility apparatus of the consumer up to the thermal expiration
$X(\phi,c)$	the capacity created between the starting date and the considered date.

(28) One considers different areas in which the characteristics of the competition between energies are different (use of heat and oven heat in the industry, heating of individual homes and collective heating in the residential sector).

Restraints of satisfaction of the energy demand

- specific needs: $x^{1}(\phi,c) \geq D(\phi,c)$ for all ϕ

- replaceable needs: $\sum_{\phi} r(\phi,c) \cdot x^{11}(\phi,c) \geq Uc$

Capacity restraints: $x^{11}(\phi,c) \leq T(\phi,c) + X(\phi,c)$

The objective function of this sub-system is a part of the objective function of the complete system and contains the cost of utility installation and the expenses of purchase of energies[29].

b) The subsystem of production: The model is connected with the different sub-systems of production (coal, gas, electicity and oil). The graph shows the interdependances between the operations and represents the ways of manipulating the installations: contribution of electricity installations to the various honorary posts of the load curve, considering the different types of unrefined oil and of different severities of distillation. In the new version used at this actual moment, it combines the low enthalpy geothermics, the solar energy for heating of halls and the recovery of the heat of central installations, etc.

The optimization permits the realization of various arbitrations:

- arbitrations between energy forms in the different competing areas

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[29] We should underline the fact that the model combines this way possibilities of choice between energies at the level of final consumption parallel to the classical arbitrations of the energy production system. The representation of phenomena of replacement between energies has nothing to do with the consumpti price flexibilities, the use of which appears critical in every long term models

- arbitrations between the processes which are more or less capitalistic
- arbitrations between energies to be imported and energies before they are locally produced
- arbitrations between production process and more or less polluting consumption production[30].

It is thus possible to obtain for the various years of the 1975 - 2020 period, taken into account the value of the different parameters,

- the primary energy evaluation
- the global or disaggregated end-energy evaluation
- the production zone and consumption facility
- the activity of the different facilities
- the rising of necessary investments to the adaption of the park
- the needs for necessary devices for import of fuels
- the year to year total expenses (brought up to date or not)
- the emissions of pollutants considered in the model

This type of model, which by no means can take the place of the "decision makers", would allow them however, to appreciate the rigidity of the energy structure, the competing situations between the energy types in the various areas where there is

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(30) The limitation of the emissions develops at the global level of France. Such a procedure can seem to be limited and even be criticized, especially as a single impact is considered. However not everything should be rejected at first sight: at the national level on can thus fix thresholds of emissions or of waste materials not to be overlooked, which would be defined in such a way that the harmful effects observed by individuals would be acceptable at the level in the most polluted geographical sectors. (See the subject of D. Finon, "Evaluation of the Costs of an Environment Protection Policy on the French Energy System in OECD", Energy and Environment, Paris, 1974, pp. 239 - 273.

competition,and possibly their managing of operation[(31)]. This is in our opinion the ideal tool to obtain some idea of the future of an energy or new technology 15 - 25 years from now (for instance, solar energy, geothermics,hydrogen or recovering of heat from central facilities)[(32, 33)]. In the future the model will be reviewed to study specifically these new energies and techniques; it will also be improved at the level of the representation of the arbitrations of consumers by a disaggregation which is more pushed by the type of usages and of considered agents.[(34)].

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(31) See the example of utilization of the model on a variation of the investment cost of the central facilities.

(32) Others have a much more normal idea of this type of tool and would like to use it to calculate the optimal distribution between the various energies and to reduce the prices and optimal tariffs (with the help of dual variables) which allow to guide the consumers' choice in the best sense for the collectivity. We prefer to tune a more prospective function with this type of tools.

(33) The model in its hew version is actually used in a very pragmatic manner on the energy sector of nine countries of the CEE with the help of a graph general enough to be applied to each amongst themselves. The goal is to calculate at the same time the annual needs of investments and devices from 1985 on and to trace various energy futures up to 2000-2080 taking into account the value of the parameters. One foresees the further study of the compatability of the optimal locations with the global optimum of nine sectors which are integrated together.

(34) And this, in connection with the research developed at the IEJE by B. Chateau and B. Lapillonne on a prospective by systems analysis of the enrgy demand at the year 2000,this demand was seized from an analytical point of view by the consumers' sector and taken into account with the present and future techniques.

No matter what the situation is, let us underline that this type of model can be (and will be able to be more in an improved version) a good instrument to appreciate the three fundamental elements of the energy policy:

- the energy economy
- the development of national resources
- the choice of the sources of input

for the sake of various criteria: the lowest cost for the (taking into account the financing problems), the least economic dependancy towards abroad, the security of supplies, and finally, the ecological consequences which should be limited[(35)].

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In short, no specific models exist in the Rhone-Alpes Region, but models covering the group of French operation of one branch or of one sector. This is mainly due to the institutional and economic centralization of France.

Among the existing models, the most numerous ones are decision models covering one branch and, in this particular branch, well specified operations. They utilize in general the optimization techniques. At the global sectorial level, the only formalized model which exists rather serves a prospective goal without a real tie with the centers of public or private decision.

[(35)] The reduction of the dependancy towards abroad by the development of national resources and by energy economy has strong limits resulting from the criterion of lesser cost.

Part II

EXAMPLE OF USAGE OF THE ENERGY MODEL

Energy Institute
Grenoble, 1975
Translated by A.C. Foell

Before the reformulation of the model in 1975, the program contained 1180 lines and 4585 columns and was solved on IBM 360-65 computer in 45 minutes.

The ENERGY model has been tested during the entire year of 1974 in order to study the reactions of the French energy system to modifications of its economic and political environment:

- price of imported energy
- cost of nuclear reactors
- policy of reduction of oil dependancy
- policy of limitation of emissions of pollutants.

The confusions of the energy context have increased the difficulties of working out hypotheses concerning the evolution of external parameters, in particular at the level of energy consumption. A series of thirty tests have nevertheless been effective and their results have provided a rich instruction.

The utilization has been put into practice beginning with a variation of parameters around a base case. One of these variants which we will present here concerns the cost of nuclear installations. In the basic case, this investment cost was assumed at 1 220 F/kW (in F 1970, interest during construction and the first initial fuel loading were included).[1]

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(1) Which corresponds with a simple investment cost of 900 F/kW (agreed in France 1975, 1 280 F/kW).

In the variant considered, the same cost was fixed at the level of 1 700 F/kW[2]. By using the forecasts of demands corresponding to the evaluations of the Planning Commission before the crisis[3] and a price of oil of 10%/bbl (given price), we obtain in the basic case and in the variant the following results:

<u>Table: Primary compared balances</u> (in Mtec, non-energy oil not included)

1000kWh = 0.33 Tec	1980		1985		1990		2000	
	B	N	B	N	B	N	B	N
Fuels	350.9	350.9	382.2	405.2	433.6	449.1	472.0	478.3
Primary Electricity	34.7	34.7	111.2	69.2	163.9	139.1	315.8	304.6
TOTAL	385.6	385.6	493.4	474.2	597.5	588.1	787.8	782.9

(B = basic case; N = variant)

From one test to another, one observes in 1985 and 1990 a decrease in the production of primary electricity, benefiting imported fuels and in particular, hydrocarbons. However, one sees no alteration in the results for the year 1980. Thus the relative similarity of the results for the year 2000 would reveal that the leeway for nuclear electricity was taken up between 1980 and 1990. The substitutions for the primary demand are found again at the level of the secondary demand.

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(2) Which corresponds with an investment cost of 1 280 F/kW (1 750 F/kW, agreed in France 1975)

(3) Source; Sketch of the French energy balance for the year 2000, Roneote, 5.p., October 1973.

Table: Secondary compared balances (in MTec)

1000 kWh = 0.33 Tec	1980		1985		1990		2000	
	B	N	B	N	B	N	B	N
Coal (except for coke	9.2	9.2	8.4	8.4	3.2	18.4	1.5	7.7
Oil products	175.2	175.2	190.1	211.5	22.6	22.6	268.7	268.7
Gas - GPL	37.1	37.1	37.1	35.5	42.0	42.0	53.6	53.6
Electricity	72.3	72.3	142.3	102.4	182.1	158.5	309.0	299.4
TOTAL	293.8	293.8	377.9	357.8	453.3	444.9	632.8	629.4

This one shows that in these tests there has been a development identical to the classical central thermal facilities, which confirms the comparison of electricity investment programs.

Table: Program of electricity investments (MW)

MW	1976 - 1980		1981 - 1985		1986 - 1990		1991 - 2000	
	B	N	B	N	B	N	B	N
Classical Thermal	2691	2691	-	-	-	-	201.2	201.2
Nuclear LWR	251	251	36336	16614	-	-	-	-
Breeders	-	-	-	-	22649	33846	77321	81133

On this last table one also ascertains the net delay with the nuclear program in the N test between 1981 and 1985 (19772 MW), a delay accumlated progressively beginning in 1986.

Table: Comparison of installed nuclear capacities (in MW)

MW	1980		1985		1990		2000	
	B	N	B	N	B	N	B	N
Nuclear LWR	4211	4211	40167	20445	39087	19365	36336	16114
Breeder	-	-	-	-	22649	33846	99970	114979
TOTAL	4211	4211	40167	20445	61736	53211	136306	131093

The total production of electricity shows also a sensitive decline from one test to another, explained by the fact that in 1985 only half of the nuclear capacity installed in the basic case is present in the test N.

Table: Comparison of the total productions of electricity (TWh)

1980		1985		1990		2000	
B	N	B	N	B	N	B	N
240	240	462	336	590	511	996	966

At the consumption levels this will be translated by a modification at the decline of consumptions of the industrial sector in the sense of electric energy consumed up to thermic expirations.

Table: Comparison of energy consumptions of the industrial sector (in M.Tec)

MTec 1000 kWh = 0.33 Tec	1980		1985		1990		2000	
	B	N	B	N	B	N	B	N
Coal - except coke	5.7	5.7	6.2	6.2	2.1	17.4	1.4	7.7
Oil products	41.0	41.0	39.2	58.8	58.5	58.5	110.6	110.6
Gas	21.6	21.6	14.3	14.3	8.0	8.0	10.0	10.0
Electricity	34.8	34.8	81.7	41.9	98.1	74.8	84.3	74.8
TOTAL	103.1	103.1	141.4	121.2	166.7	158.7	206.3	203.2

(Note: The consumption levels of an energy from which correspond, at the optimum, with the satisfactory levels of single specific needs are underlined).

The height of the cost of KW nuclear can in other respects not have an influence at the level of electricity use in domestic car heaters, for already in the fundamental case, the electric heating does not develop between 1976 and 2000.

The model thus allows us to analyse the impact of a modification such as the cost of nuclear KW. Such a rise also has an impact on the energy sector through a replacement of electricity by fuels in competing areas where electricity was competitive, and not through a development of classical thermic central facilities and while keeping installations run by electricity in the fundamental case. This absence of change in the respect of the classical thermics can be interpreted as a confirmation of the competing nuclear quality since, if the classical thermic production is situated in the competitive nuclear zone in the fundamental case, the rising nuclear cost in the N test would have had to favor its development.

This usage of the model compared with the results of tests carried our from the beginning of various hypotheses at the level of parameters, show evidence of the sensitivities of the presented system. Another kind of possible usage consists in the comparison of test results with the forecasts of the authorities and by drawing some instructions from it. It also seemed such that with retained data, the electric heating would not be available before the end of the century[4]; the result would not have been necessary for our representation since various calculations carried out in France by certain bodies such as ministries, Gaz de France, oil firms, IEJE, confirm this result.

As a matter of fact, like supplementary results of optimization, it is possible to deduce the expenses in capital and in currencies necessary for the supplying of the yearly collectivity, knowing that one is familiar with the equipment to be created and their cost just as the energy quantities to be imported and their prices.

The following tables have to do with a test carried out according to consumption forecasts established in March 1974 by the General Planning Committee.

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[4] For more detailed results, see, D. Finon, The Energy Model, Thesis, 520 p. Grenoble, March, 1975.

Table: Capacity of equipment to be installed during the different periods and annual joint investment expenses in 1980, 1985, 1990 and 2000 (Test B3)

	1976 - 1980			1981 - 1985			1986 - 1990			1991 - 2000		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Coking plants (M.T/year)	13.0	95F/T	0.247	1.51	89F/T	0.270	-	-	-	7.5	78	0.06
Storing of gas(10^9th)	0.57	24C/Th	0.003	-	-	-	-	-	-	-	-	-
Thermic gas (MW)	-	-	-	-	-	-	-	-	-	2046	470 F/KW	0.10
Nuclear LWR (MW)	15115	1082 F/KW	3.27	31100	961 F/KW	6.01	-	-	-	-	-	-
Breeders (MW)	-	-	-	-	-	-	34881	790 F/KW	5.51	83226	702 F/KW	5.84
Distillation	23.7	45F/T	0.21	84.9	45F/T	0.76	150.5	45F/T	1.35	146.2	45F/T	0.66
Cracking Plants	41.9	25F/T	0.21	37.8	25F/T	0.19	41.2	25F/T	0.20	98.1	25F/T	0.24
Desulphurization Gas oil	-	-	-	17.5	24.9 F/T	0.09	15.2	23.7 F/T	0.07	22.2	22.5 F/T	0.05
Desulphurization Fuel	-	-	-	-	-	-	4.6	57F/T	0.05	0.9	48F/T	0.00
Storage Products Oil	-	-	-	38.3	50F/T	0.38	28.75	50F/T	0.28	27.3	50F/T	0.13
Steam Cracking	3	270 F/T	0.16	2.9	270 F/T	0.15	4.6	270 F/T	0.25	5.6	270 F/T	0.15
TOTAL EXPENSES			4.10			7.85			7.71			7.24

Column 1: Capacities created during the sub-period

Column 2: Unitary cost of last year's investment of the sub-period (considering the technical progress)

Column 3: Investment expenditures (in 10^9 Francs, 1970) of each preceding year, the capacity created during the sub-period uniformly started again between the different years of those.

Table: Quality of Imported Energy and Associated Capital Needs (Test B3)

	1980				1985			
	(1) MTeC	(2) 10^9th	(3) c/th	(4) 10^9F	(1) MTeC	(2) 10^9th	(3) c/th	(4) 10^9F
Coal Gas								
Coal Gas	5.3	37.1	2.5	0.9	8.7	60.9	2.6	1.5
Coal & coke	29.0	203.3	3.2	6.6	38.3	268.0	3.4	9.1
Coke	3.0	21.0	4.7	0.9	1.2	8.4	4.9	0.4
Natural gas	24.5	171.5	2.8	4.8	10.2	71.4	3.8	2.7
Petroleum products	219.0	1533.0	2.9	44.4	236.5	1655.0	2.9	74.9
TOTAL CURRENCY				57.7				61.8

	1990				2000			
	(1) MTeC	(2) 10^9th	(3) c/th	(4) 10^9th	(1) MTeC	(2) 10^9th	(3) c/th	(4) 10^9F
Coal Gas	1.4	9.8	2.6	0.2	1.4	9.8	2.6	0.2
Coal & coke	34.9	244.3	3.4	8.3	35.7	249.9	3.4	8.4
Coke	8.9	62.3	4.9	3.0	12.7	88.9	4.9	4.4
Natural gas	5.6	39.2	3.2	1.2	16.5	115.5	3.2	3.6
Petroleum products	293.3	2046.1	2.9	59.3	339.0	2373.0	2.9	68.8
TOTAL CURRENCY				72.2				85.6

Column 1: Quantities imported in MTeC.

Column 2: Quantity imported in 10^9th.

Column 3: Cost of energy imported expressed in c/th.

Column 4: Required Capital, expressed in 10^9 Francs 1970.

Draft Outline for the Description of the Energy System Modeling Activities in Wisconsin

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Energy system modeling activity in Wisconsin is comprised of a variety of efforts in both the public and private sectors, aimed at an analysis of problems associeated with energy supply, demand, and environmental impact. The fragmentation of these efforts is extreme with many parallel modeling activities being carried on simultaneously.

The causality for the nature of both Wisconsin energy systems and the modeling activities associated with that system is found largely in the social, economic, environmental and political structure of the state. Wisconsin is richly endowed with both natural and human energy reserves. It does not, however, have any significant endogenous energy reserves. Historically, agriculture, resource extraction and processing, and tourism or recreational activities have played major roles in the state's economy. An intensive, broad based industrial sector has developed in the southeastern portion of the state and it is here that the vast majority of the state's populace now reside.

Wisconsin's energy system evolved in response to the energy requirements generated by this pattern of economic growth and development. This evolution occurred largely through the interaction of suppliers and consumers in a private market setting with virtually no integrated planning and relatively limited direct government intervention. This historical pattern of a limited government role in Wisconsin energy system development stems from many factors. The virtual lack of energy resources in the state, however, is undoubtedly a major factor, particularly when coupled with a national policy aimed at making nergy readily available in the private sector markets at relatively low prices. In short, the enrgy sector has historically been neither a major component of Wisconsin gross state product, nor a major constraint on the state's economic development. It has not, therefore, been an area of major concern to the state government.

Because of the primary reliance on private sector development of the Wisconsin energy system, and the relatively limited government concern related to this sector, the resultant disaggregation in energy analysis and planning makes it impossible to describe a unique well integrated energy modeling system for the state. Instead, one finds a variety of parallel modeling activities being carried on not only by the suppliers (and major consumers) of various energy resources in private sector, but also, because of the relatively recent realization of the importance of energy to the state's economic well being on the part of the state's political leaders, in numerous state agencies. Because of the disaggregation, we have chosen in this report to outline the various modeling approaches being used in both the private and the public sectors and to describe the institutional mechanisms through which linkages occur.

While energy modeling in Wisconsin encompasses the entire range of activities associated with analyzing the state's energy system -- from long range forecasting and planning to operation management -- most individual efforts are rather narrow in scope. That is, they focus on either a specific energy source, or on a particular energy policy problem. An exception to this generalization is the work of the Energy Systems and Policy Research Group (ESPRG) at the University of Wisconsin. This multidisciplinary research activity has resulted in the development of a computerized dynamic simulation model of Wisconsin's energy system. The Wisconsin Regional Energy Model (WISE) combines an engineering and economic approach to model the state's energy system within a multi-dimensional framework that descrives energy demand, conversion, transport and use -- explicitly accounting for technological, economic and environmental interactions. It consists of a collection of submodels which combine in simple mathematical terms, data and information about energy flows in

Wisconsin to describe or simulate the energy system and its relationship to other characteristics of the state, e.g. demographic, economic, and environmental. A simulation structure was chosen for several reasons.

First, simulation is a convenient method of integrating the variety of analytical techniques likely to be employed in a multidisciplinary effort of this type. Second, a simulation structure provides a great deal of flexibility in both the modeling process and application of the model to system analysis. For example, it enables one to modiy selected components of the system without the necessity to rework the entire model, and to focus attention on specific areas of the energy system as well as on the system as a whole. Finally, the simulation structure lends itself to the scenario generating approach that is extremely useful in the analysis of major policy issues and alternatives. That is, simulation facilitates the application of the model to questions of the "what if" type. The WISE model is designed primarily for intermediate to long-range planning analysis and has among other applications been used to:

1) forecast energy demand by energy source and user classification,
2) estimate the additions required to the electricity generating, transmission, and distribution facilities in the state,
3) examine the environmental impacts associated with alternative future energy use patterns, and
4) analyze the role that conservation can play in determining the state's energy future.

Rather than dwell on the specific structure and use of the WISE model (which is examined in detail in other ESPRG publications), we turn now to a brief look at other energy modeling activities in the state. We will structure this survey on the basis of model types and use.

Because of the virtual inseparability of energy use and economic activity, virually all modeling activities incorporate a general economic forecast for the state. These forecasts are prepared in both the public and private sectors using a variety of methodologies - ranging from simple trend projections to complex econometric and input/output models. Within the state agencies, independent forecasts are prepared by the Department of Industry, Labor, and Human Relations, the Department of Revenue, and faculty at the University of Wisconsin. Although these forecasts are prepared for a variety of different uses and are not often reconciled, there is a high correlation between the various projections. This undoubtedly stems in large part from the fact that Wisconsin economy and all state forecasts are inherently based on the same projections of national economic activity levels.

Population size and characteristics provide another basic input into all energy modeling activities. In Wisconsin this factor is modeled in detail by the Office of the State Demographer. This model is age, sex, and county specific and includes considerations of migration, fertility and mortality. Detailed population projections are provided out to the 21st century.

Energy demand forecasts in Wisconsin (other than those prepared by the ESPRG) have typically been on a single energy source basis. Until very recently, virtually all of this work was done in the private-sector and on a firm by firm basis. Thus, for example,individual electric utilities could be expected to project demand by major user categories within their respective service areas. Typically these projections entailed extrapolation of historical trends adjusted for any major structural change in user composition which the utility was aware of. These models served quite well over an extended period due to the regularity which characterized the development and growth of not only electricity, but also the entire energy system in Wisconsin until the beginning of this decade. The nature of demand modeling in the other energy industries closely parallels that in the electric utility sector. Gas utilities and suppliers of fuel oil and gasoline all tend to trend historical data on customer use, population and income growth, and market penetration to develop projections of future demand. In many cases the state is not the relevant market area, and hence, no "Wisconsin projection" is forthcoming.

Recently the state has moved into the arena of energy demand forecasting. These activities began with the public service commission (PSC) beginning to aggregate the forecasts of individual electric utilities and suppliers to develop a clearer picture of the projected generation, transmission and distribution system in the state. They have relied to this point on the projections provided by the utilities and by the ESPRG at the University, and while they are developing the capability for "in house" demand estimation, do not currently engage in an independent effort.

The other state agency currently directly involved in energy demand forecasting or projection is the Office of Emergency Energy Assistance (OEEA). This newly formed agency is charged with the responsibility for assisting with the allocation of energy resources when the market becomes inoperative because of a major imbalance between supply and demand (i.e. when price is not allowed to play its role as the allocative mechanism) and to assist in the development of an energy policy for the state. The OEEA has thus far been active primarily in short term energy issues and thus has not developed the capability for intermediate to long-range energy forecasting, relying instead on the ESPRG work and other externally generated projections in those instances where required.

Investment modeling activities in Wisconsin parallel closely those in the demand area. The individual utilities typically have detailed engineering models which project the time pattern of investment requirements based on projections of future system equipment needs and estimates of the technologically available means of satisfying those needs. These models are typically of either a simulation or mathematical programming nature with cost minimization the primary objective in the latter case. The PSC also uses a simulation model to evaluate the proposed investment schemese of the utilities. This work is done primarily on a company by company basis and only recently has work begun on a systemwide effort patterned after the work by the ESPRG. Investment planning in the oil, coal, gasoline and other non state regulated energy sectors is done again on a firm by firm basis. These corporate planning activities employ a variety of modeling techniques. In many cases the Wisconsin component is small -- relating primarily to distribution efforts in terms of in state expenditures -- and related to such items as growth in the Wisconsin market and relative profitability of operating in this state as opposed to others.

A final area where energy related modeling is taking place in Wisconsin relates to environmental impact. Here the effort is more completely integrated into state planning activities due to the need to ensure compliance with both state and national environmental standard. In this effort the Department of Natural Resources (DNR) has responsibility for both developing standards to ensure compliance with the codes and for monitoring emissions in the state. In this effort, they are developing their own models for some specific analyses. They are, for example, working closely with the PSC in the development of impact statements for future electric utility generating plants. Here the effort is similar to that used in the ESPRG environmental impact model but with greater emphasis on site specific relationships. Similar work is being carried on by the utility firms in the state as a part of the licensing requirement for new plants.

The DNR is also working on broader models of air and water quality. In the air quality effort they are extending the work of another University of Wisconsin Research Project. This model projects fuel use for industrial activity, transportation activity, and activities in the residential and commercial sectors which generate environmental pollutants. From this, emission levels are estimated and alternative standards evaluated. To date, these DNR modeling activities have been aimed very specifically at implementing environmental pollution abatement standards and are, therefore, both more site specific and less inclusive than the ESPRG environmental modeling.

This brief statement of the energy related modeling activities in Wisconsin is aimed at providing an overview of the systems used for energy analysis. It touches only briefly on even the most significant efforts and can by no means be considered a complete statement of either the individual modeling activities or of the linkages between the agencies and institutions involved. Considerably more detail will be provided in the forthcoming paper.