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Energy Models - Instruments for Exploring Europe's Energy Futures

In the context of the non-nuclear Energy-research-programme the European Community developed a method which should enable politicians, economists and industry to better assess the future energy requirements of Europe. On the basis of existing national experiences the Commission has constructed jointly with the Member States a number of multi-national European energy-models which using the scenario-approach are capable to analyse the future developments in Europe up to the year 2000 and beyond. These instruments are not only useful to explore the consequences of possible socio-economic developments upon energy in general but provide also inputs to an energy research programme necessary for the development and the timely market introduction of new energy technologies. The results of well defined energy studies can make substantial contribution as to the future needs for alternative energy supply and energy demand technologies. They enable for example to assess quantitatively the contributions of those technologies in reducing Europe's energy import dependence and oil bill.

The rather frequent changes in energy policy during the past ten crisis years all over the world made it necessary to adapt continuously the structure of these models and the associated data bases.

To study the market potential of the new energy technologies requires - because of their long lead times-energy scenarios of up 50 years. It is obvious therefore that the more regional and sectoral short to medium term energy studies, often referred to in the past, could not capture these effects. As they were of econometric nature and consequently based on past trends these results were of short term validity only and needed continuous up-dating. In order to increase the value and the credibility of long term studies further it has become customary now to associate from the very beginning experts from all Member States in such exercise.

The US as a warning signal

To take a simple example - the demand for primary energy in the United States in the year 2000. This is a warning to the whole world. In 1974 the forecasts varied from 150 to 180 quads per year (3 800 million to 4 500 million tonnes oil equivalent per year). The estimates now put it at between 90 and 100 quads per year. The effect of "saving" some 1 700 million toe is very considerable when one reflects that this figure is nearly twice the present demand for primary energy in the whole of the EEC.

Such an uncertainty is only one of a whole set of imponderable ranging from oil production through price elasticity and the development of new technologies to forecasts of population growth trends and the like. They can quickly lead to highly subjective statements that give a false impression of accuracy and do not inform the policymakers as to the correctness of such analyses. Moreover, there have in the last seven years been many studies aimed at solving the energy problem in the whole world or in large parts of it, the purpose being to convince everyone of the gravity of the situation while at the same time endeavouring to understand how the socio-economic system as a whole and the energy system interact in practice. The mutual influences here are not quite clear yet, however, and there is no unequivocal technical solution to this very complex problem.

Nonetheless, owing to the economic consequences and the ever-rising energy costs decisions have to be taken for the time being with regard to the allocation of R & D-funds to satisfy specific energy needs. Here it is often far more limited matters that come into question, such as the technical aspects of power stations, better use of hard coal and insulation. It has also become clear that it is not so much the supply of available energy as the cost of that energy that gives cause for concern. If that were not so the use of hard coal, nuclear energy and renewable energy sources would no doubt have been promoted much more than it is now. The problem is that for a number of social and technical reasons such substitutions for oil - which is what this is really all about - make an expensive solution.

In order to be able to carry out an analysis of the above mentioned assumptions, three basic scenarios have been constructed. These three "assumptions scenarios" can be supplemented by other variants. It is not only the European Community that is geographically covered but the world as a whole, with or without international cooperation. The scenario assumptions are worked out for each country individually in order subsequently to study the consequences in the energy field for each Member State. Conditional energy forecasts in the context of the scenarios will then be made with the help of essentially two mathematical models : one of these, MEDEE, determines the long-term demand for energy and the other, the energy supply model EFOM, determines the energy supplies for satisfying that demand under a set of given policy constraints. Models of this kind - which will be looked at again later in the article - can make important contributions to the elaboration of new policies.

Scenario I - Competition

The first scenario assumes free and worldwide competition without any intervention from countries of the European Community or the Commission. The competition between American, Japanese and European firms is lively but unregulated and in particular directed towards the Western and Eastern European and Third World markets. This scenario leads to a tripartite economy : large industries that pull the economy along, other, less productive firms and a sort of underground economy. This scenario favours the US and Japan. Oil, brought to market by multinational, continues to dominate the energy market. Oil price fluctuations still influence the prices of other forms of energy.

In this scenario preference is given to economical energy production rather than energy-saving. Arbitrary price variations do not encourage industry to invest in energy saving either. Industry will at the same time be inclined towards short-term planning, and this does little to improve energy efficiency. On the other hand if the highly energy-intensive part of industry moves to countries where there are abundant energy supplies this will provoke a change in industrial energy consumption. Replacement of oil is determined by relative price trends in the short term. The variation in national energy supplies and balance-of-payments problems will reveal a difference of approach in the various countries.

Scenario II - Cooperation

The second scenario assumes increased international cooperation to revive the world economy with a joint international development programme for countries in the Third World. This will have to be done by creating new markets in those countries and in the industrialised countries. That means cooperation between the US, Japan and Europe and a successful North-South dialogue. The results are better and more quickly attainable in the industrialised countries than in the developing countries. The growth rate in some industrialised countries may even increase.

Here, too, oil remains the dominant energy source. After a period of stability, world energy prices are showing uniform growth in the context of agreements with developing and industrialised countries, and the long-term trend is therefore clear. In this scenario it goes without saying that there will be long-term investment both in new industrial sectors and in new production processes. In view of the upwards trend of prices it looks as though considerable energy savings will be possible. Recourse will be made to local sources of energy, especially when they offer a respectable cost advantage. Replacement of oil by coal and nuclear energy is taking place satisfactorily.

Under certain circumstances the possibility may have to be faced of a nuclear energy moratorium for new power stations that should be ordered now for commissioning sometime after 1990. The likelihood of that happening will apply only to this scenario since here is assumed that there will be less tension in the energy sector. Furthermore, international cooperation not only signifies a willingness to cooperate with groups that are looking for such a moratorium but at the same time properly ensures a stable supply of energy from outside. Such a moratorium should only be one possible variant in this scenario and should not therefore form part of the basis of it.

Scenario III - Europe

This third scenario forms the third set of boundary conditions with the same point of departure as the cooperation scenario. If that seemed unattainable on a world scale the European Community would have to find its own solution. This, however, means a strengthening of the Commission and its duties, although the Community does not cut itself off from the rest of the world either. It should take up a position as a competitor of the US and Japanese economies and conclude cooperation agreements with some of the developing countries in the spirit of the Lomé Convention. In some respects the European Community scenario can come through as protectionist on the whole although the intention is clearly different.

Economic recovery is based on a substantial internal market of the ten member countries and on trade with countries outside. Here, too, imported oil continues to be the determining factor. Once Community policy and the bilateral agreements begin to take effect there will, however, be a clear difference between price fluctuations on the world market and the relative stability of prices within the Community, that are generally higher than the prices outside. These internal prices will have to make it possible to invest in the development of the Community's own sources. Bilateral agreements with specific developing countries can result in a sort of "Stabex" for energy products. Those factors indicate that the proportionally stable prices from 1990 onwards will nonetheless be high. The relatively high prices and their stability will in turn be a stimulus for a long-term policy, to the benefit of a more rational use of energy.

This is intended as a means of encouraging the limitation of oil imports and developing the use of own sources of energy. The tendency is towards a genuine Community energy market. Analysis of the energy results of these three scenarios for the EC and the Member States must make it possible to identify generally valid orientations with regard to energy. Particular attention is drawn to the balance between energy supply and demand, the necessary investments and balance-of-payments problems.

The technico-economic models

Two models have essentially been used to establish the energy balances associated with the above scenarios : the energy demand model MEDEE and the energy supply model EFOM. These models have been run by the Commission services on their proper informatics environment.

The MEDEE model can be described as a predictive model in the sense that it forecasts energy demand as consequence of the requirements and the changes in the technico-economic system : e.g., varying policy options in transport, habitat, industry, contrasting evolutions of economic structures, living styles, prices, technologies ... as well as any other main element of the scenarios referenced above.

The basic principle of the model can be characterised by a single scheme which is responsible both for the generation as well as for the evolution of energy demand : the demand in final energy (fuel-oil, gas, electricity ...) is generated through the requirements in energy (thermal, mechanical, electrical) satisfied through a system of energy transformation (boiler, motor ...) and supply.

The demand in energy or the quantity of useful energy thus corresponds to the need of satisfying a social requirement (comfort, social evolution ...) or to maintain or develop an economic activity (steel production ...) within a given physical and social context.

The overall final energy demand is then the result of the evolution of these two elements of socio-economic and technical nature.

This approach is valid for all MEDEE sub-systems, i.e. the urban, industrial and transport system . The final energy demand, obtained for these systems is a measure for the quantities of petrol, gas, solid fuel, electricity, urban heat, wind energy et al which they would consume under the hypotheses of the assumption-scenarios.

The EFOM model is a multi-national European energy supply model. It simulates and optimizes the supplies in primary energy and the investments necessary to satisfy the energy demand requirements as for example obtained through MEDEE.

The energy system's optimization consists in determining the optimal supply structure for the different European energy activities at minimum costs or for any other desired objective function - over a period of up to 40 years.

The energy activities in EFOM refer to the 16 main energy sub-systems describing the supplies of primary energy, the energy conversion and the consumption of energy.

The constraints of the model can be of physical nature e.g. energy demand constraints, constraints of plant capacity, of flow limitation etc. There are also political constraints to account for objectives complementary to those of the objective function.

The EFOM model represents not only the energy supply structure of each individual Member State but, it is also of multi-national character in the sense that the Member States can be interrelated through energy trade. The components of this trade are : steam coal, metallurgical coal, coke, natural gas, crude oil, LPG, light, medium and heavy distillates, uranium, enriched uranium, plutonium, electricity and hydrogen. Within the Community a distinction is made according to which country is concerned; outside the Community the distinction is between the Eastern bloc, OPEC and the Western countries.

Apart from technical data on the energy processes themselves investment and operating costs per unit of capacity, acquisition costs of imported energy products and exports are taken into account by the model. In certain cases environmental pollution, radioactive waste and job opportunities are being considered. The two versions of the EFOM model (12C and 12D) that were developed within the energy research programme are both operational now with a user-friendly software for all EC countries.

The econometric models :

A number of different energy models representing the European Community are being used by the Commission Services for analysing energy-economy problems. These models have been specifically designed to enable studies of the interface between economy and energy. They are capable of answering questions of specific energy demand nature for the short and medium term (1 to 7 years). Those models are generally speaking of econometric nature.

The EURECA model is a dynamic and macroeconomic model for the Community, with reference to the rest of the world. Account is explicitly taken of the role of energy. The model has a multi-national structure, which means that it is built up from national units representing the different Member States of the Community that can be used independently of each other. It is primarily conceived for medium term economic forecasts. The COMET model is a similar model which produces results over a period of five to ten years but in greater detail than EURECA. EURECA and COMET are both very useful for calculating the effects of changes in energy imports, prices, investments, overall demand, etc., on the basis of the particularities of the energy market of each Member State but seen in the European and world context. Both models are operational for the Member States of the Community; Spain and Portugal can be brought in as well.

EXPLOR/EDM is a medium term model that enables to analyse energy demand for the industrial sectors by type of energy. A demand forecast can be made under a variety of assumptions such as different energy prices or structural changes in the energy supply system that influence growth in a number of sectors, in investments, in consumption, in imports, etc. The chief purpose of this model is to obtain information on production activities for 13 main industrial sectors and their associated energy consumption, split into the nine main types of energy.

The New-Generation Models

The development of the above described models could be completed with the conclusion of the two preceeding non-nuclear energy research programmes . The models were subsequently tuned and are now operational for all Member States at the Commission computing facilities as well as in most Member States. A certain number of necessary methodological improvements and extensions in the representation of their economic and energetic structure was initiated for the reasons explained before.

More recently the development of two new models of the "New Generation" has started : MIDAS and HERMES. For the planning of these two new projects all experience gained so far has been put to work. The new models will be operational soon and will provide additional information to that what can already be obtained with the models in use within the Community and the Commission.

The MIDAS model enables medium term energy-demand forecasts for all Member States of the Community. It is characterised by several advanced methods : it integrates energy supply and demand in one system, it uses a technico-economic approach, it is econometric and dynamic and accounts also for the system's inertia.

All that equally applies to the HERMES model which enables to make in depth analyses of the interactions between economy and energy. This model is macro-sectoral and multi-national at the same time, i.e. the economy is split into nine sectors and each country is represented individually by a single model similar to each other and inter-related with each other and with the rest of the world.

Energy plays an important role in that model to the extent of being represented as an autonomous sector and at the same time as a production factor.

HERMES therefore will not only ensure coherent economic projections for the different European countries interrelated though energy- and non-energy trade but also allow for integrated energy-economy analyses of the highest quality taking into account such important factors as investment, employment, commercial balance, inflation et al.

In 1984 each country will be making the first national simulations with HERMES. This will be done in parallel in order to achieve a large degree of consistency. In each country a network of experts has been set up which have full knowledge of the model's potential . Naturally, that expert network in support of the Commission energy studies should not run counter to national objectives and plans but shall provide additional European information for the Member States.

There is still room for further improvements in the system's description of the model, such as a more detailed treatment of structural changes and of energy consumption in industry, the inclusion of technical factors (characteristics of buildings, choice of heating systems, insulation behaviour, etc.) and a better identification of the determining factors for demand in transport and the corresponding energy demand. A further sophistication can, however, only take place step by step, otherwise the model, that already contains thousands of elements, would become unmanageable.

Research

As mentioned earlier, it is very important to provide oneself with economic guidelines for the justification of a research and development budget with a view to reducing the Community's oil bill. Although the present models are not all specifically designed for such a problem, by carefully working through and interpreting different test cases, guidelines can be mapped out for proposing such funds. Any estimate of the development costs of new energy technologies and of thus possible market penetration is bound up with uncertainties. For a possible R&D programme about 30 new technologies were selected that have the effect of reducing energy consumption and energy imports in general. That idea has now been taken a stage further by trying to assess the economic benefits of introducing new energy technologies.

To that end a study has been conducted to find out in greater detail which of these new energy technologies could be appearing on the market rather soon to relieve the Community's problem of independence with regard to energy imports. The first results indicate that there is no basic dispute concerning the priorities to be accorded to these promising energy technologies. The analysis of such studies provides a clear indication for the priorities in the context of a new non-nuclear Energy research programme in support of the Commission's main socio-economic objectives.

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