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Energy Scenarios: Science-Theoretical Aspects of Energy Forecasting

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ENERGY SCENARIOS: SCIENCE-THEORETICAL ASPECTS OF ENERGY FORECASTING

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Preface

Long-term energy forecasting has traditionally been a major concern of applied systems analysis. In inter-disciplinary research approaches, economists, engineers, natural and social scientists have developed complex models to assess systems' behavior in the future. Influenced by the technical nature of systems analysis, uncertainties in a model and its predictions have primarily been understood as a function of the quality of the model design. Deviations observed between forecasts and actual developments have thus been considered as a property of the model.

Although over the past decade knowledge of systems has been increasing and forecasting techniques have been improved, this progress was not always reflected in a higher forecast accuracy. Deviations often resulted from important changes in the exogenous environment of the forecasting model: these have been more pronounced in the past decade than in previous periods. As a response to mounting exogenous uncertainties the scenario technique has been developed. This technique has sometimes been interpreted as a means of immunizing the modeler from criticism, as with an increasing number of exogenous variables the responsibility for the forecast's accuracy could be assigned to the forecast environment.

It is the intention of the present paper to contribute to this discussion by abstracting from the more technical understanding of energy forecasting and looking upon basic structural features of any forecast.

The results presented here are part of a doctoral dissertation and were conducted during a fellowship at IIASA in 1983. The author would like to thank the Energy Group for their warm support. The fellowship was generously sponsored by the Alfried Krupp von Bohlen und Halbach Foundation, Essen, F.R.G. Very valuable aid and comments were also provided by Dr. E. Jochem (Fraunhofer-Institut für Systemtechnik und Innovationsforschung, Karlsruhe, F.R.G.), Dr. M. Härter

(Gemeinsame Forschungsstelle der Europäischen Gemeinschaften, Karlsruhe, F.R.G.). and E. Fulda (Institut für Philosophie, Universität Karlsruhe, F.R.G.). The author would be grateful for any comments and criticism on the paper which may be addressed to: Michael Kraus, International Energy Agency/OECD, 2, rue Andre-Pascal, F-75775 Paris Cedex 16, France.

Abstract

Starting off with the historical development of energy forecasting, Chapter 1 describes the emergence of conditional prognosis – so-called if-then statements – from an increasingly politicized energy environment. Inherent limits of energy demand forecasts are shown as stemming from basic structural differences between economic and social sciences and natural sciences. The scenario approach is discussed in greater detail. To clarify the various scenario terms a distinction is made between a narrower and broader scenario concept. The IIASA energy model of 1980 is used as an example to show specific characteristics of the scenario technique and the problems arising during its application.

A general definition of prognosis is given at the beginning of Chapter 2, based on the deduction scheme of Hempel and Oppenheim. Thereafter, the structural identity of explanation and prognosis is disussed. In response to the current lack of universal laws in the economic and social sciences, an attempt is made to develop a pragmatic understanding of forecasting laws. The extent to which prognosis can ever be founded is investigated through the example of the "Münchhausen-Trilemma". Two important featurs of prognosis are analyzed, conditionality and reflexivity, and their political implications are discussed. Finally, the problem of forecast evaluation is investigated and methodological criteria for an evaluation are presented.

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Science-theoretical Aspects of Energy Forecasting

Michael Kraus

1. Introducing the Problem

The demand for forecasts in the field of energy economy is met by various sides. Private firms, research institutes of the economic and engineering sciences, administrative authorities, and supranational organizations try to make future developments transparent. The methods practiced thereby range from the classic methods of the economic sciences to the newer systems analysis approaches of the natural and engineering sciences.

Along with the increase in prognostic activity over the last decade substantial changes have occurred in the practice of forecasting. While until the end of the '60s alternative variants of energy prognoses were rarely published, as of approximately 1974 alternative estimates, so-called scenarios, began to be published in order to document the precariousness of energy demand estimation.

The switch to scenarios was partly a reaction to progress which has been made in epistemology. A concious separation of the predictable from the unpredictable caused the withdrawal from the practice of formulating predominantly categorical forecasts. Conditional prognoses, so-called if - then projections, whose accuracy depends explicitly on the fulfillment of certain postulations, now intend to emphasize the uncertainties always present in "scientific" prognoses. "Scientific prognosis is distinguished from prophecy by its conditionality" [1]. The limits of prognostic efficiency were thus made more transparent for the prognosis user, but simultaneously the information value of these forecasts diminished in comparison to the alleged informational value of an unconditional (categorical) prognosis.

However, world and energy politics, particularly both oil price crises in the '70s, were also responsible for the ever increasing use of scenario approaches. Due to the relatively stable fundamental conditions in energy policy and economics, until the early '70s an energy prognosis was a planning instrument for the energy business and government authorities, in order to meet the expected energy demand with a well-balanced energy supply. Due to the open development of the mineral oil price and the possible reaction of the energy consumer, this supply oriented energy policy needed to be replaced by a more comprehensive policy, which placed more emphasis on the rational use of energy. Administrators had to widen their concepts and measures to include the demand aspect, in order to react suitably to the altered fundamental conditions with a rational use of energy and mineral oil substitutes. This created new conflicts in the goals of political levels as well as substantial uncertainty among forecasters, who tried to compensate the imponderabilities with new approaches of method (scenario and simultation techniques, systems analysis). In addition, climate and environment factors, combined with the constantly growing world energy consumption, increase in political importance.

Together with the turn to if-then statements , the danger of a certain - desired - immunization also rose and the professionals were faced with public criticism. The debates on nuclear energy and environment particularly led to a demand for more transparency when presenting postulations, calculations and estimation procedures and their results. In consequence, a series of new prognosticating groups developed at universities and other institutions, while in a counter-movement the prognostic departments of firms and the traditional energy institutes improved their instruments and emphasized the conditionality of their own prognoses. Thus energy prognoses were given the character of suggestions for action, for which the addressee may or may not agree with the premisses.

As a result, politicians and the public alike became further doubtful: "Possibly hidden values nourished a mistrust of potential consumers in political practice, as well as the colleagues of traditional scientific institutions"/ 2 /. Instead of obtaining clear scientific statements about the future, diverse prognostic values accumulated. The span among the prognostic variants and the prognostic values of individual institutions have presently taken such an extent, that the apparent informative value of energy demand estimates has been reduced substantially.

1.1 The limits of energy demand estimates

Up to the present, criticism of energy demand estimates had been based on the fact that prognostic values deviated from the consumption actually observed. Although this deviation is certainly the target variable to be minimized, it should not reversely be taken for a measure of prognosis' quality without further consideration. Most of the past critiques of energy demand estimates were in error by uncritically transferring to energy prognosis the comparison of theory with empirical findings (a method usually possible in the natural sciences), eg. a strict comparison of the predicted with the actual energy consumption variables. Such procedure must either banish prognosis to the realm of complete irrationality, because rationally found deviations of the actual value from the prognosticated value are not recognizued, or the prognosis is only sufficient for a few trivial recommendations.

Application oriented prognoses should not be measured with the standards of classical natural science. There remain grave differences, even if the economic and social sciences have partially adopted the analytical procedure of the natural sciences. Both scientific disciplines start with a simplified model of reality by reducing it to a network of effect relationships. But the degree of abstraction in natural science models is generally less than that of the economic and social sciences, for which neither the fundamental conditions of the object under study can be presumed constant, nor the great number of existing or expected relationships be represented by a model / 3 /. The success enjoyed in physics in the last two centuries has been so great because the fundamental conditions of an inanimate system can be reproduced relatively simply (laboratory prognosis) and the range of effect relationships is relatively small in comparison to socio-economic systems.

In the energy sector the socially, economically and technically relevant proplems overlap. The "laws" of socio-economic and technical systems can claim no strict universal validity, but are understood rather as limited in time and space and more as quasi-causal relationships (for example the hypothesis which links energy consumption to economic growth). They cannot be universally valid because the presumptions and marginal conditions, as well as the complex structures underlying the rough model can never be explicitly recorded completely. They can be used, however, until they are questioned empirically: "Quasi theories contain an essential reference to a particular spatial and temporal region, the limitation of their application is due to being 'historically' restricted to certain objects" / 4 /. Thus, for example, in the early '70s the majority of energy demand estimates turned out too high, because the prognosticators extrapolated relationships and fundamental conditions which were true for the '60s, but which no longer applied to the '70s. The regional variability becomes evident in an international comparison of the energy economic development of countries which can be considered to have similarities. For example, the comparison of the Federal Republic of Germany with the United States, being popular in the '60s, and the view it expressed, namely that the development in the USA leads the way for Germany at a certain distance, could be proven only for particular sectors (traffic development, trend towards a service sector).

The problem of the lack of knowledge about relationships of effect is intensified by a lack of knowledge about the initial situation. Again, the standards of natural science cannot be applied. It is basically true for all sciences, that it is not feasible to make measurements or collect data without an underlying theory. "The theory supplies the instructions for measuring the phenomenon. This is a matter of course in physics, but still not the case in the economic sciences and even less so in sociology, where theories are still predominantly speculative" / 5 /. This has repercussions on prognosis, which cannot be better than the description and analysis of the past development of the object under study and the factors of influence or their present state (diagnosis).

To predict the energy consumption in individual sectors the forecaster for example, requires quantitative data concerning individual technical energy consumers, such as industrial equipment and machines or household appliances. But this information problem could still not be solved, even if empirical data were available; the question would remain concerning the reliability and representativeness of these data. Even if the data were satisfactory in these terms, it would still remain open, which influences should be removed.

For example, the general state of business influences the extent to which capacities are utililzed and thus indirectly influences the energy consumption of many branches of industry, or the climate influences the demand for room heating in private households per temperature, precipitation and wind. The analyst can reduce or eliminate part of these inadequacies by removing data appropriately. Nevertheless, substantial uncertainty remains as to whether the data employed represent the initial situation sufficiently / 6 /.

1.2 The scenario approach

With the turn from categorical prognosis to conditional prognosis in the '70s the formally identified hypothetical character of predictions increased at the expense of practical usefulness. This finally led to a "new method" of anticipating the future called "scenario technique" / 7 /. It is less a new method than a more concious methodical handling of problems concerning the provability and the conditionality of prognoses

The original notion of scenario developed by Kahn and Wiener comprised the description of one or more hypothetical chains of events, which resulted from the following questions:

- How does a hypothetical situation come about, step by step (rational provability)?
- Which alternatives are possible at each stage for each participant, with which he can prevent the further process or guide it in another direction (conditionality)?

Along with giving the future development of the study object it is the aim of scenario techniques to explicitly state the assumptions of an interrupted regressus ad infinitum. "Besides the better understanding of forecasting there are new aspects for dealing with problems, particularly better conceptions of the margin in which the values of interest can plausibly develop "/8 /.

A very broad concept of "scenario" led to a diffuse state of terms in the discussion on prognosis. Misunderstanding and errors occur especially when scenarios are taken for conventional prognoses or when prognoses are labeled scenarios as uncertainties become evident.

To clarify the term, in the following we shall distinquish a narrower from a broader scenario term. Both have in common that their result depends on the explicit assumption of particular future developments, similarly to conventional prognosis. However, not the most probable suppositions are assumed, but rather postulation conditions are varied independently of their probability, in order to observe the effects these have on the results.

There is no unanimity among forecasters on the question of which conditions should be varied most meaningfully. The narrower concept of scenario allows solely variations of suppostition constellations - which must also satisfy plausibility and consistency controls - in the range of exogenous factors of influence. However, in the actual area of study, for example energy, as always, only exclusively empirically proven relationships may be used. Thus this is a conventional prognosis technique, in which however the values of exogenous variables are combined to very different conceivable bundles of presumptions. It is futher of methodical importance, that the very strict definition of scenario is generally founded on qualitative-intuitive arguments for the exogenous environs and/or employs prognosis results from other disciplines and institutions (such as prognoses on economic growth or the availability of mineral oil), but uses quantitative formal methods in the main area of study (Fig. 1.1).

The broad concept of scenario not only begins with the variation of exogenous secondary conditions, but also varies the conditions of the object under study with qualitative-argumentative methods. Usually these are less complicated, but difficult, if not impossible, for third parties to understand.

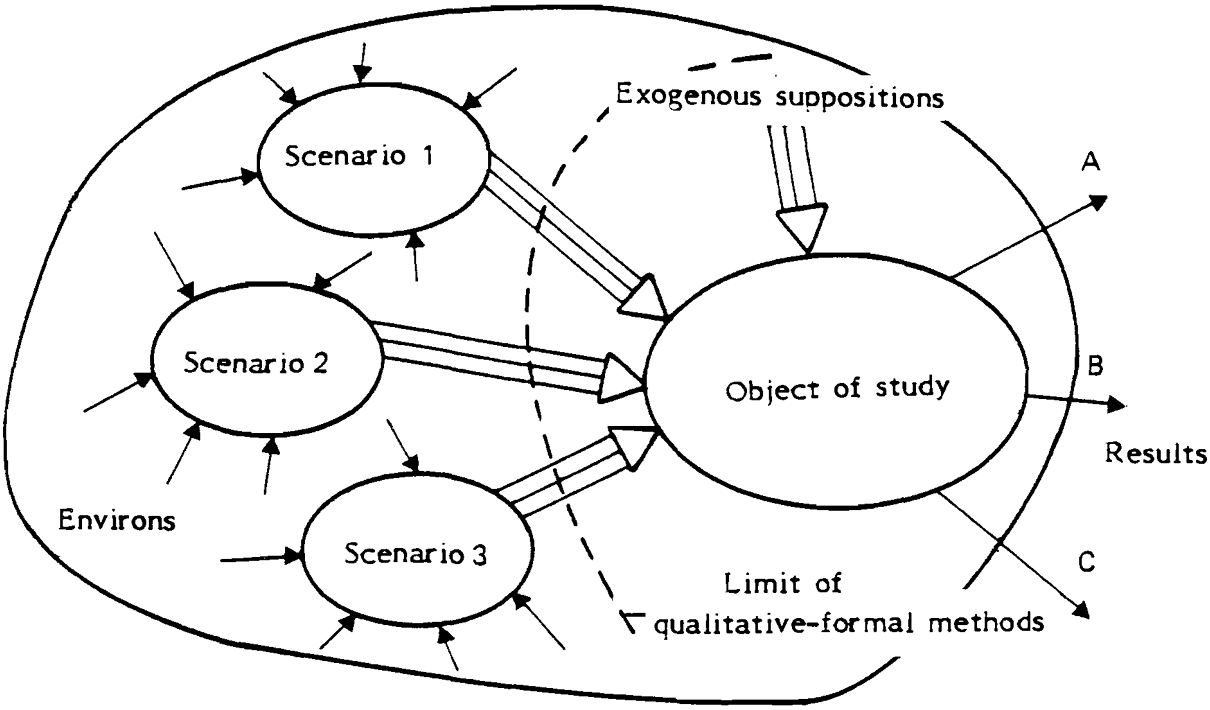

Fig. 1.1 Description of the scenario method

Finally, in accord with Kahn and Wiener's second question, the results can be normatively defined by desirable conceptions. In this case the problem is not to find to which results specific constellations of suppositions may lead, but reversely, which presumed values will lead to specific goals. Starting with any moment in the future the examination is done step by step back to the present to see if and how the given goal can be achieved. In this case the scenario has the character of a technological prognosis. Not the anticipated future development is sought, but instead the constellation of exogenous variables which politicians, for example, must first create, in order to achieve a particular goal / 9 /.

One example for this type of policy scenario is the Energy Model of the International Institute for Systems Analysis (IIASA) /40/, whose structural make-up is shown in Figure 1.2.

But also energy studies which claim to offer an alternative to conventional methods of observation and demonstrate "soft energy paths" are partially

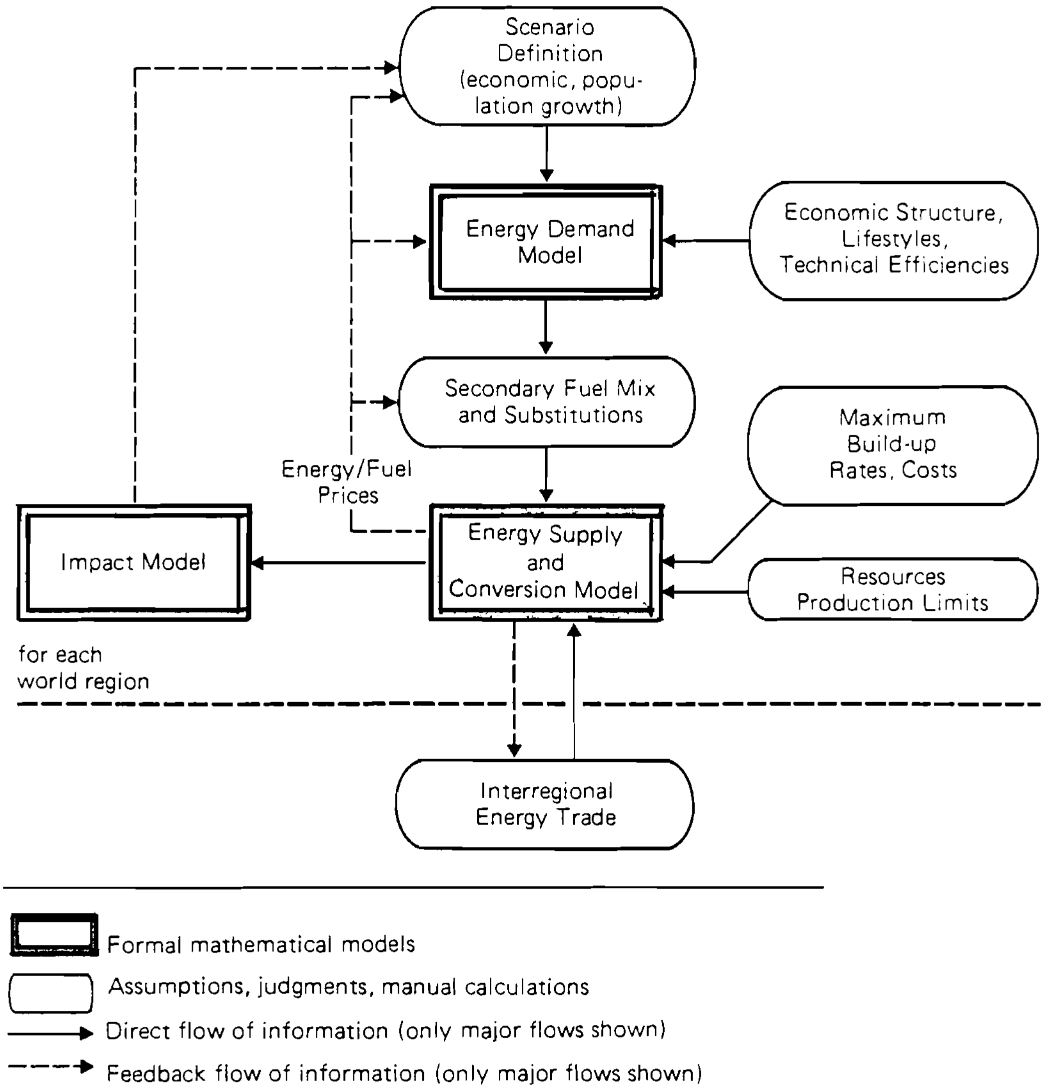

Fig. 1.2 IIASA Energy Model 1980 /10/

founded on this so-called "backcasting"/11,12/. Backcasting projections though have the same difficulties as forwards oriented prognoses, because relationships must be described for which the conditions and network complexity are unknown and are handled with simplifying hypotheses, quasi laws or empirical generalizations such as trend extrapolations.

Independent of the question, whether scenarios are only concerned with the environs in which the actual events of the energy sector occur, or whether they include the fundament, they do not spare the trouble to give reasons for the data used and the formal relationships involved. Thus they introduce difficulties into the prognosis which should not be underestimated, because they concern an entire bundle of values and dependencies, although in addi -

tion the demand for consistency among all interdependencies requires fulfillment. This cannot be fulfilled, because it would imply the complete endogenezation of all observed values. The theoretical pretension and the practical intention linked with the concept of scenario technique thus do not lessen the actual problems of prognosis / 13/.

In the most unfavorable case - which we usually have in the energy sector - the results are so sensitive to the assumed variables, that several scenarios placed side by side show nothing more than the spectrum of possible development paths. And for these it nevertheless remains unclear, which are the uncertainties of the various developments, when no statement is made with respect to probability. This is occasionally used as an argument for the practical worthlessness of scenarios, because the results pass on the major problem and can apparently also produce arbitrary results /9/.

This judgment at most applies - if it does not implicitly suppress the dilemma of the prediction's limitations - to an understanding of scenario which operates exclusively with qualitative-intuitive methods (see above). However, it entirely fails to recognize the implications of a complex topic such as energy consumption, in which problems of social, economical and technical relevance overlap.

Thus the great degree of complexity of energy models found in the backcasting approach does not allow the direct calculation of the normatively determined future values to thus compatible scenarios. The compatibility of the base scenario's parameters (which to begin with define the essential impact factors, which actually must yet be found in the form of consistent scenarios) with the normatively determined target variables must be examined (compare Figure 1.3).

Compatibility is usually not given at the beginning of model calculation, so that in a further series of model runs the exogenous scenario parameters are varied repeatedly until a relative model stability is achieved with respect to important factors of impact (zero order results). These provisional results must then be examined in terms of their technical and economic plausibility, their social execution(acceptance of nuclear energy) and their political desirableness (dependence on crude oil). In succeeding iterative model runs not only further (exogenous) scenario and (endogenous) model parameters, but also the target variables are varied, in order to finally obtain consistent result scenarios.

The problem of this iterative procedure is demonstrated by the following elementary calculation. x^n different constellations can be arranged for n exogenous scenario (or target) variables with x alternative values each. With only two alternative values (such as high and low) and 15 exogenous variables there are 32,768 possible alternative variants. For practical reasons it is absolutely necessary to achieve stable provisional solutions which reduce this multitude of alternatives to a size which can be easily handled. Such provisional solutions, which must also satisfy a large number of technical, economic and political restrictions, can certainly not be found with formal mathematical methods. They are the result of vast experience with energy models and the energy field. - Hereto we should mention a further aspect of models, which has recently gained increased attention: "the computer as mediator" /14 /.

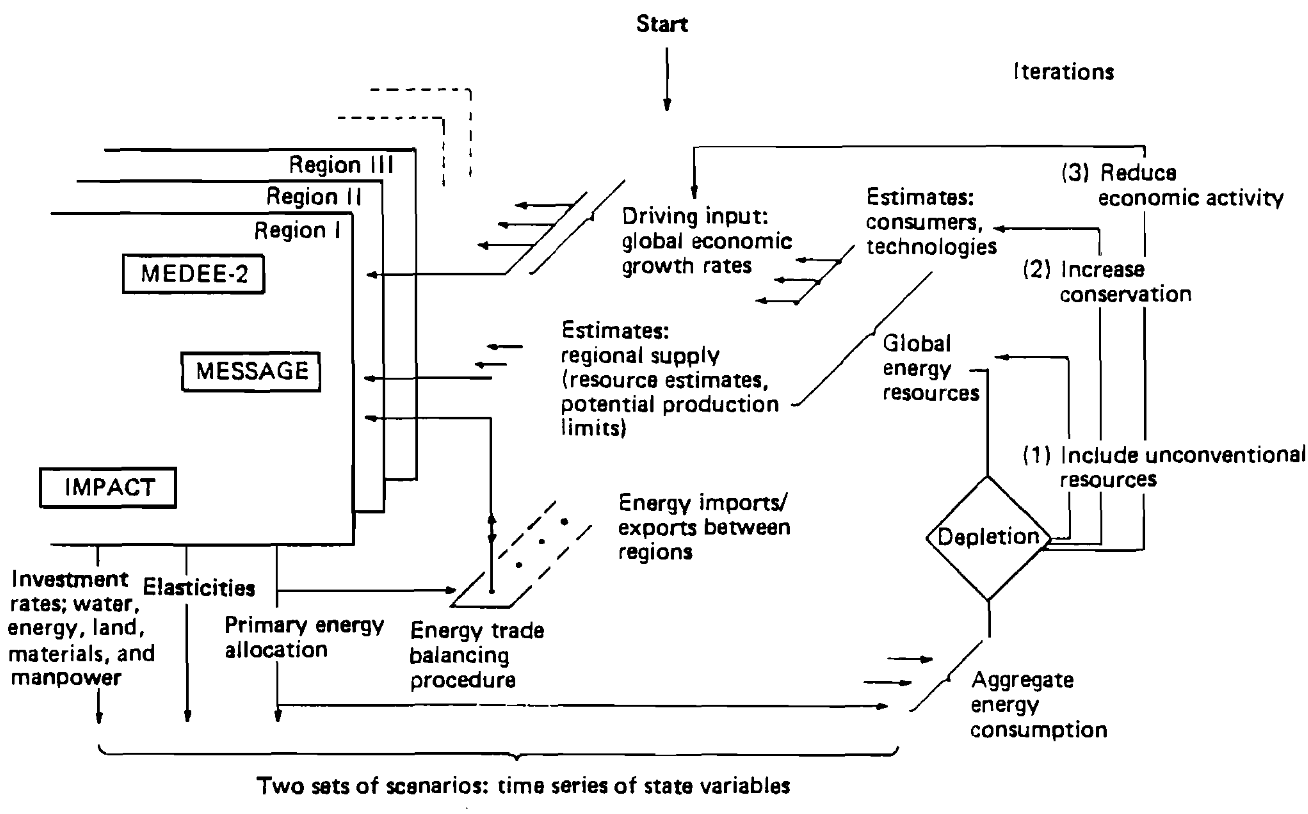

Fig. 1.3 Model Operation of the IIASA Energy Model 1980 /10a/

2. Introduction to the Problems of Prognosis

2.1 The definition of prognosis

The scientific discussion of prognostics is by no means complete; there still lacks a sufficiently explained, generally accepted definition of prognosis. The prerequisite for a satisfactory analysis of prognosis however, is a sufficiently clear definition of prognosis, which would render possible the formulation of adequate evaluation criteria for prognoses.

A narrow, initial, operable definition of "scientific prognosis" was given by Hempel and Oppenheim (1948). It claims that a scientific prognosis exists when the occurrence (or existence) of a single event is derived with the aid of a law (nomological hypothesis) or laws and through a logical deductive conclusion. Logical deductive means a truth-conserving deduction, in which no information is given which exceeds the information stated in the premisses. The prognosis process can be described schematically in Figure 2.1.

$\underline{A} = A_1, A_2, A_3, ..., A_m$ Initial and boundary restrictions (antecedent restrictions

$\underline{G} = G_1, G_2, G_3, ..., G_n$ General restsrictions (theoretical laws)

$\underline{P}$ Prognosis (explanation)

Fig. 2.1 Deduction schema of Hempel and Oppenheim

The prognosis P is the result of the logical deduction from A_1, A_2,...A_m and G_1, G_2,..., G_n. The symbols A and P each represent statements which describe single events (singular statements), G represents a general (or generalizing) statement. The minimal requirement of the hypotheses and postulation system ist that of being free of contradiction and logically sufficient for the desired results /15 /.

A closer look at the elements of this definition is advisable. The laws named above (nomological hypotheses) are statements, whose validity - according to their formulation - is not limited to a certain realm of time and space in any respect. Albert coins these "always-and-everywhere-if-then-statements" and thus also particularly emphasizes their universal character, along with their conditional nature /16 /. Such "all"-statements include above all the laws of nature, for example Newton's law of gravity; but also various statements from the social sciences are often considered to be universal hypotheses, viz. the hypotheses of learning theory, behavior research or the "law" of supply and demand in economics /17/.

Universal statements assert certain structural invariances in the events of nature, which should be valid at all times in all places. This claim simultaneously implies however, that such a statement - if no additional assump tions are made,- says nothing about the existence of individual facts, as Eucken pertinently formulated: " It contains no judgments about the occurrence of certain facts at certain places at certain times. It does not answer the question of when and where. It describes nothing" / 18/.

In contrast, the singular statements A mentioned above assert the existence of certain conditions with a well-defined reference to place and time. Such spatially and temporally limited statements for the existence of facts are of a purely descriptive character and are also called "there-is-statements". In prognosis they mean that at a particular time at a particular place conditions become actual, so that combined with the universal laws, in consequence a particular single event P will occur (forecasts). The technological aspect of laws lies in the fact that they can be used, by creating certain conditions, to induce their effects (for the term "technological prognosis" see /19 /).

2.2 Structural identity of explanation and prognosis

The deduction schema of Hempel and Oppenheim demands that the explanation supply single testable statements about a part of reality (see Fig. 2.1). It is not stated, whether this is a future or present reality; the time aspect is apparently of no importance. We tacitly assume, that the explanation refers to a future point in time and thus gives a prognosis which overcomes time and space (successive prognosis). This is not binding, however, because the prognostic statement can actually refer to a yet unobserved part of the present, which remained unknown because the conditions required to recognize it were insufficient (coexistence prognosis).

Independent of whether the time at which a prognosis was produced lies before or after the occurrence of the explanatory event, we must also distinguish between an ex ante prognosis (overcoming time and space) and an ex post prognosis (for the differentiation of pragmatic and ontological time relations see / 20/).

To produce prognoses and supply explanations, as well as to produce and test general hypotheses needed thereby, is considered to be the most important task of practical scientific activity. This is the purpose of

- the logical conclusion from past events and general (law) hypotheses to future events of scientific forecasts (ex ante prognosis) , and
- the logical conclusion from antecedent events and general (law) hypotheses to already known events of explanation, and eventually also the hypotheses test.

Several scientists interpret this to mean that there is no logical structural difference between explanation and prognosis. For more than thirty years the question of the logical structural identity of explanation and prognosis has been discussed with varying intensity. Particularly Hempel /21/ and Popper /1/ are of the opinion that for each (successful) explanation there is a prognosis with the same logical structure and vice versa..This means: "The difference is not one of logical structure, but rather one of emphasis; it depends on what we consider to be our problem and what we do not so consider. If it is not our problem to find a prognosis, while we take it to be our problem to find the initial conditions or some of the universal laws (or both) from which we may deduce a given "prognosis", then we are looking for an explanation... . If we consider the laws and initial conditions as given (rather than as to be found) and use them merely for deducing the prognosis, in order to get thereby some new information, then we are trying to make a prediction" /1/.

In this concept scientific explanation thus possesses the same logical structure as prognosis and is distinguishable solely in terms of the pragmatic temporal circumstances; namely not when the problem is given and the explanation sought, but reversely, the problem is sought and the explanation given (cf. Fig. 2.2).

Fig. 2.2 Structural identity of prognosis and explanation

		Law hypotheses	
		given.	sought
Explanans	given	tautology	prognosis
	sought	explanation	nonsense

This opinion has not remained uncontradicted, however. Starting with the assumption that it is principally possible to give rational reasons (not necessarily just explanations as for Hempel and Oppenheim), the criticism of the structural identity thesis begins with the question of the nature which such reasons must have, in order to be allowed in the development of a rational prognosis. Previously it was implicitly derived from the Hempel-Oppenheim deduction schema, that exclusively so-called reasons of reality or being could supply a sturdy foundation for prognoses which assume a cause for an event /20/.

The opponents of these theses however, also view forms of reasons for prognoses as existent and acceptable - so-called arguments of reason or belief - which would not be sufficient for an explanation as Hempel and Oppenheim define it. Arguments of reason - although they do not make an adequate explanation possible - are sufficient as arguments of rational prognosis, which means that rational prognoses are possible on the grounds of mere convincing arguments / 20/. For example, the economic forecasting with the indicative method of "Harvard's Barometer" turned out to be trustworthy, without having the power of explanation / 22 /. A reverse example is Darwin's theory of evolution, which explains the selection and variation of the species, but cannot predict them. Thus we must at least distinquish between (structurally identical) prognoses for the purpose of study (reasons of being) and prognoses as decision-making aids (arguments of reason). Along with Küttner /22a/ we should note the different circumstance of the existence of test arguments which confront prognosis and explanation in the same manner. The general (law) hypotheses are given and appropriate singular events are sought for the antecedence as well as the consequence. This enables a new order of explanation, prognosis and (independent) testing as follows (Fig. 2.3):

	Prognosis	Explanation	Test
given are	A	P	G
sought are	P, G	G,A	A,P

As long as theories of science cannot differentiate with sufficient precision between universal (natural) laws and other law-like statements, the thesis of symmetrical structures can be advocated at the most as a normative challenge. The resulting liberalization, however, meets the needs of the empirical sciences.

2.3 A practical understanding of forecasting laws

The science-theoretical conception described above only lends the predicate "scientific" to prognoses which fulfill the requirements of the Hempel-Oppenheim deduction schema. Thus the question of the scientific nature of a prognosis is actually reduced to the fulfillment of the requirement of spatial-temporal invariance of the underlying law (nomological hypothesis). With the exception of some limiting examples, the traditional view is that natural laws satisfy these requirements. But this is usually not the case for the "law-barren" social sciences anyway.

Theoretically, an exception is planning theory, in which the planner himself defines the future values and tends to their achievement (technological prognosis). This claim cannot be supported by practical work, however, because single individuals remain a substantial factor of uncertainty in their roles as performers and consumers. Past experience shows that an increase in living standards is accompanied by an increase in the importance of the "incalculable consumer" /23/. In a highly developed planned economy the requirements for prognosis are thus not much more favorable than in a market economy / 24/. If taken strictly, a categorical demand of the prerequisites and conditions mentioned above would have had the consequence that even today no one could have spoken of scientific prognosis in the social sector/ 3 /.

The current deficit on theory in this sector forces the use of law-like hypotheses, whose linguistic formulation itself already refers to individuals, particular epochs or even only to empirical generalizations (trends) /22 /. such general hypotheses with limited spatial and temporal validity are called quasi laws (for example the so-called linked hypothesis of energy consumption and economic growth in the energy sector).

Of course, they have no claim to universal validity, but should nevertheless be used until they are empirically questionable: "Quasi theories contain an essential reference to a particular spatial and temporal region, the limitation of their application is due to being 'historically' restricted to certain objects" / 4 /. The restriction of quasi theories and quasi laws to to certain epochs and regions, however, is a formal logic question of essentially general statements.

In face of the current lack of universal laws in the economic and social sciences the importance of the Hemple-Oppenheim definition is reduced to a desirable guiding standard, whose ideal rules must actually be broken and replaced by a reduced prerequisite level. This cannot occur without repercussions on the scientific self-understanding of prognostics. Limited by pure science on the one side and speculation on the other, prognostics is localized in the realm of "not-yet-science" /25 /. It is a trade or technology, which counts as one of the applications of science, but does not belong to its essence: "If forecasting techniques are successful, that is one fact more which scientists must and perhaps can explain" /26/.

2.4 Can prognoses be founded?

Chapters 2.1 and 2.2 have shown that scientific prognosis is distinguishable from prophecy by being founded rationally and methodically. Particularly when the prognosis' reasons include general laws (hypotheses), the existence of restrictions concerning their application must in turn be predicted for categorical prognoses. But this is only possible when the existence of individual restrictions are on their part deducted from laws and new antecedent restrictions. Since these in turn also partially refer to things of the future, one finds himself confronted - in the case of categorical prognosis founded strictly nomologically- with an infinite prognostic recourse. "If we demand justification by reasoned argument, in the logical sense, then we are committed to the view that statements can be justified only by statements. The demand that all statements are to be logically justified (...) is therefore bound to lead to an infinite regress" /27/.

Concerning this problem, Albert refers to the so-called "Münchhausen Trilemma", since our search for a conclusive reason allows only the choice between:

1. an infinite recourse, which appears to be given by the need to find first reasons, although this can practically not be achieved and thus supplies no solid foundation,
2. a logical circle of deduction in the argument process caused by using statements which were already used though lacking reasons. This logically erroneous circle also does not supply a foundation. And finally,

3. breaking off the procedure at a particular point, which in principle seems practical, but would involve suspending the principle of sufficient argument arbitrarily /28/.

Since in practical prognosis an infinite recourse is not feasible and a logical circle is inacceptable, the only choice remaining for strict nomological prognoses is to break off the procedure. Of course, the inevitable break-off at particular points of the prognoses' argumentation can be considered to be temporary, but it is not possible to clearly distinguish it from dogmatism.

In the discussion on energy forecasting the break-off point has noticebly shifted in the past years. Criticism of the simple global relationship between primary energy consumption and the gross national product led to an extension and differentiation of this linking hypothesis. The result was an endogeny of variables which were previously held for exogenous or which were not explained by the theoretical approach. Such variables are, for example, the net production values of economic sectors, the actual energy price level or the relation of energy prices to the prices of other production factors. The endogeny of previously exogenous variables substantially improved the strength of prognoses' statements / 9 /. Furthermore, various consumer sectors were improved, for example, private households with their stock of appliances for electricity prognoses.

The endogeny of previously exogenous variables and the improvement of the interwoven structure of energy consumption sectors causes an increase in the number of the model's elements and their relationships. This not only quantitatively, but also qualitatively increases the complexity of prognoses. New exogenous variables make it necessary to assume more theoretical relationships in the model, which often lie in scientific fields lacking empirically secured theories / 29/. In open systems - including the energy sector - it is impossible to achieve complete endogeny.

2.5 The conditionality of prognosis

The pragmatic solution for the conflict of aims between rational and methodical argumentation on the one hand (as shown in the previous sections 2.1 and 2.2) and the complete nomological argumentation on the other (prognostic infinite recourse (2.4)) can be found in the definition of a "sufficiently" advanced break-off point in the argument process. This "degree to which a problem is solved", which means the conditionality of the prognosis, can be drawn upon as an indicator of the scientific nature of a prognosis.

In common usage, a prognosis is a statement formulated with practically no restrictions. In principle, forecasts can be of unconditional or conditional nature. In the second case they are also called if -then statements / 30/. The question of whether a prognosis should be formulated unconditionally or conditionally can be handled depending on whether the occurrence of the prerequisites can be expected with great certainty, or whether their occurrence is of a more hypothetical nature /26 /. In the energy discussion conditional prognoses have been called projections since the early '70s, in order to distinguish them from the more categorical prognoses of the '50s and '60s. (In contrast, Schanz, with reference to Albert /31 /, defines projections as forecasts lacking an explicit reference to theoretical regularities, while Vajna / 32/ uses projections for future developments as they should occur according to political goals.)

Unconditional, categorical prognoses contain statements which can be founded rationally or irrationally (for example: "Energy consumption will increase by x%!). Categorical prognoses not based on laws of succession make it necessary to additionally assume that certain secondary conditions remain stable. This is commonly expressed in the form of a predominantly unspecified ceteris paribus clause, stating for example, that unforeseen disturbances originating outside the system are not considered, if the system is not closed and sufficiently isolated. Actually every categorical forecast depends on hidden, assumed constants and secondary conditions / 33/. An explicit explanation of these assumptions is especially abandoned when the prognosis user desires uncomplicated and binding statements about the future. Strict assumptions of constants, however, often collide with the actual facts found in the social sector.

Thus only the extent to which the conditions of the assumptions can be investigated guarantees that anyone - at least any scientist in the same field - can understand the arguments and evaluate the prognosis. For social problems - and this is particularly true for the energy sector - the lack of empirically secured theories creates the need for additional theoretical assumptions in the model and thus makes the statements considerably hypothetical / 3 /. Categorically formulated prognoses can thus only be scientifically accounted for in exceptional cases, when all antecedent conditions are fulfilled and the necessary laws are known. These conditions are certainly not given in the energy sector.

The second kind of forecast mentioned at the outset is a conditional prognosis (for example: "Energy consumption will increase by x%, if the gross social product increases by y%!"). It does justice to cropping uncertainties by disclosing its premisses and guarantees that it can be understood. Only the most complete revelation of the argument's premisses will permit an adequate evaluation and criticism of the prognosis. Thus conditionality is the first characteristic of a scientific prognosis as distinguished from pure speculation and prophecy. Particularly in the energy sector, prognoses claiming to be scientific must keep their distance from categorical formulations. They must be much more careful to discover and disclose to which extent results are influenced by uncertainties in conclusion-making, insufficient data or the difficulties in defining real processes and mechanisms /34 /. This also does justice to the experience that many energy prognoses were founded quite "correctly" and solely neglected to consider a secondary effect sufficiently.

Although there is commonly assent, that scientifically serious prognoses must be conditional, conditionality is limited by the requirement of practical application. A prognosis which can be used must be conditional, but its informative value is reduced by each additional condition, so that in an extreme case it degenerates to just a tautology: "Prognoses of energy economics cannot usually get by with one secondary condition, they require several asssumptions, but when first a combination of numerous assumptions must be fulfilled to render the validity of a prognosis, there is the danger that, taken strictly, the prognosis cannot be tested and is thus irrefutable, because the complete particular constellation of assumptions will hardly ever occur /35 /.

Some reflections on method also justify the demand for prognoses which are only partially conditional, to counter protective endeavors: "If the forecaster is not held responsible for the predictive evaluation of exogenous factors, he can greatly simplify his task by drawing the line adeptly, although this also limits the value of the statement to the same degree: By shifting the burden of prognosis to the exogenous variables one can shirk responsibility for false prognoses in an unseemly manner" /36 /.
This objection is superfluous, however, when the user of the prognosis can influence the given conditions himself.

The reciprocality of restrictedness and statement value also brings political implications. As long as prognoses serve the preparation of decisions for action solely, a great amount of empirical information is requisite for their practical application. As the political relevance of these decisions increases, however, this aspect fades and is replaced by the attainment of psychological motivational effects. "Under conditions of scientific politics, the usefulness of analysis and prognoses for politicians and administrators can be measured not only by their contribution to the development or evaluation of political programs, but also by the aid which they offer in daily political business, in the way in which they externally support initiatives, how they can be "sold", and for investigation and criticism (possibly of the political opponent's initiatives which endanger one's own position)" / 2/. For this reason it can be considered a strategy, when political groups defending certain interests partially attempt to formulate their prognoses in such a way as to be irrefutable, and accept a loss of informative value.

2.6 The reflexivity of prognosis

The fact that political implications can also be linked to a prognostic statement draws an important characteristic of prognoses to our attention: their inherent dynamics. Prognoses as decision-making aids are instructions for action in practice, and thus they exert a more or less strong influence on the objects with which they are concerned. This means that forecasts in social systems are social events themselves, which can induce reciprocal effects with the events covered by the prognosis. Via decision rules and procedures the prognosis has an effect on the objects under study at a future point of time. With reference to an ancient example, this phenomenon of reflexivity or inherent dynamics is also called the "Oedipus effect" /27/. The prognostic effects can be understood as feedback mechanisms, as shown in Figure 2.4

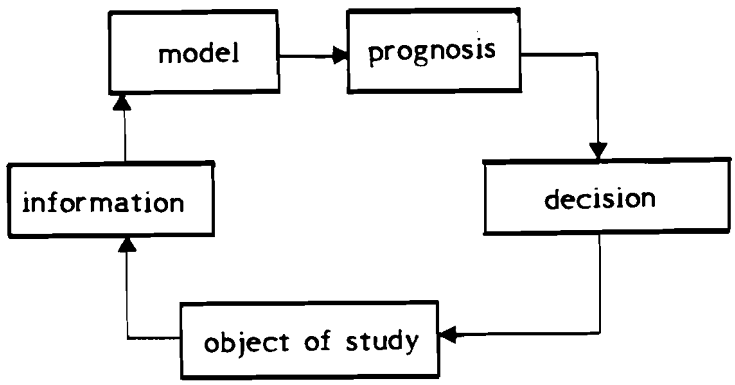

Fig. 2. 4 Prognostic feedback

Since the publication of Merton's classic essay (1948),two different forms of this phenomenon are distinguished: the self-fulfilling prophecy and the self-destroying prophecy. In the first case the prognosis itself contributes to the actual occurrence of the event which it predicted. In the second case, the prognostic statement causes a change in the object of prognosis, so that it refutes itself (see Fig. 2.5).

Prognostic reflexivity		Without publication the prognosis would be	
		true	false
After publication the prognosis becomes	true	neutral	self-fulfilling
	false	self-destroying	neutral

Fig. 2.5 Inherent dynamics of prognoses

Since reflexivity is only of importance in social sectors, the argument of self-refutal is sporadically used to claim that economic and social scientific prognosis is in principle impossible /38/. The majority, however, denies a total agnosticism in the prognostic discussion "even though we must admit that an ... informational feedback makes the analysis more difficult" /39/. Badura even views the reflexivity of prognosis as a potential cause of social change. This means that "(according to the self-understanding of professional forecasters) prognosis can, yes even should refute itself or first generate the prerequisites necessary for their validity" / 2 /. Atteslander /37/ assesses the inherent dynamics of social prognoses similarly.

An objective control of the success of prognostic achievements cannot remain uneffected by this and in relationships arising in practical application the self-destroying power plays the more important role. Since a predicted misdevelopment may be quite avoidable, political or business authorities could use such a prognosis as a reason for (successful) counteractive measures. For such a constellation it would naturally make no sense to interpret the absence of the misdevelopment as a false prognosis. On the other hand, the reality of prognostic effects can be misused as an alibi in order to shield prognoses from errors, whose actual cause lies in the imperfection of the underlying assumptions and rules, by in turn attributing unprovable prognostic effects to their causes /40 /.

Meier /41/ shows empirical proof of prognostic effects for GNP and inflation for the USA, Switzerland and the Federal Republic of Germany. His results confirm the influence which inflation prognoses have not only on inflation, but on economic activity as well. An influence of GNP prognosis on the three output components consumption, investment and public expenditure and thus on the actualized GNP development can be proven at least for the USA.

Many problems of inherent dynamics have been discussed thoroughly, particularly those of the self-destroying effect relevant in practice. A uniform and systematic discussion on this topic has yet to ensue, however, /43/. Strategies have been designed to either prevent the occurrence of self-refutal, through keeping prognoses secret or simulating them, for example /40 / , or to counter the self-destroying effect by including the feedback effects in the prognosis itself /42/. The fundamental possibility of this procedure (so-called x-rational prognosis /41 /), is controversial. Morgenstern (1928) held the opinion, that even in a case where knowledge of the quantitative relationship between the publication and the consequent reaction allows consideration of feedback effects, these effects can still occur, because the intention of the prognosis can be misunderstood and overrun. On the other hand, he did later at least theoretically provide a way to evade scepticism of prognosis based on feedback: To some typical reflexive situations he applied concepts of the game theory which he developed with John von Neumann and thereby solved, or at least weakened the "paradoxical" situation in a decision-oriented context /52,53/.

In the energy sector it is difficult to prove reflexivity. The cause-and-effect relationships existing between energy prognoses and actions or omissions cannot be exposed distinctly. This is due to the extreme complexity of energy economic relationships. Here reality- altering measures are a result of decision-making processes of a large number of decision-makers with partially contrary intentions, in addition.

2.7 Problematics of evaluation criteria

Prognoses intended as aids in decision-making are part of the following causal chain (Fig. 2.6):

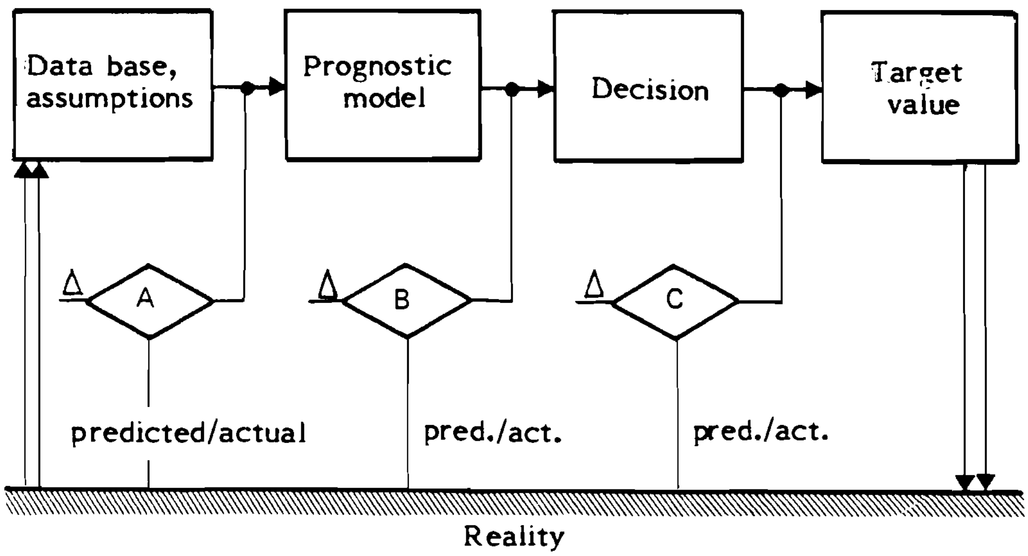

Fig. 2.6 Prognostic causal chain and measurement concepts

In prognosis evaluation two entirely different questions are placed in the foreground, depending on whether the judgment is made before (ex ante) or after (ex post) the occurrence of the predicted event. Desired is either an evaluation of the quality of a prognosis (quality judgment) at the time it is made, or with respect to the development and application of prognostic methods, a judgment concerning the efficiency of past prognoses (success control) / 43/.

The subject of ex post evaluations is usually a comparison of the predicted values with those which actually occured (B in Fig. 2.5), or the determination of suitable statistic characteristic values. The host of feasible prognostic definitions is considerable: variation coefficient, turning point errors, Theil's inequality coefficients, cumulative errors of over- and underestimates, etc. /45 /.

A perusal of the literature available on prognosis evaluation will show that the numerical definition of prediction/actuality deviations can hardly give a complete picture of prognostic method efficiency. Weichhardt / 46/, for example, draws the conclusion that there is no "one" absolute measure for evaluating prognoses, and it is much more important to measure errors in line with the particular question. But Vajna /32 / then finds an objective prognosis evaluation questionable: "The informative value of an analysis of accuracy is largely exhausted after calculating the deviations. The qualitative conclusions drawn from the degree of each deviation rely on personal opinion." Numerically recording errors has proven to be unsuitable for gaining an explanation of the causes for prognostic mistakes.

The limits of the mechanical comparison of forecast to reality are given for several reasons. When forecasts are predicted and compared to the values which actually occur, this can be done for a single prognosis or for an entire time series. In the first case, the forecast-reality comparison completely ignores the conditions under which the the prognosis originated; i.e. to which extent deviations are due to false assumptions at the time of prediction (A in Fig. 2.5). Likewise, a "correct" result could actually have originated in the mutual compensation of erroneous assumptions, which for example was the case with the energy report 1961

/39 /. The supposed "equality" of results for different prognoses must similarly be viewed critically: Congruous prognostic values can originate in completely different, even contradictory constellations of assumptions. An example is the Mesarovic-Pestel world model and the WAES study / 9 /. Furthermore, self-destroying effects can occur or the prognostic values can be falsified by interests flowing into the prognosis.

In the second case of time series analysis a distortion of the prognosis evaluation can be created by the extent of error, by evaluating a relatively "easy" and a relatively "difficult" object of prognosis indiscriminately. This is true for both longitudinal sections and cross sections analysis. Thus the prognosis' degree of difficulty varies in the energy sector on the one hand with respect to new and traditional energy carriers (i.e. small or large market shares / 47 /), on the other hand however also in respect to the period of time covered by the prognosis. In the '60s, in contrast to the '70s, it was comparably simple to set up reliable electricity prognoses through trend extrapolations /48/.

The problems demonstrated demand new concepts for the evaluation of prognoses. Since they serve in the quantitative preparation of decisions made to attain certain goals, it appears natural to use the degree of attainment as a measure of prognostic success or failure (C in Fig. 2.5). "Assuming that the forecasts have been prepared for some decision purpose, we can say that their quality is determined by the quality of the decision to which they led" /49/. The crucial point in the problem of determining "prognostic success" thus shifts from the question of prognosis quality to the question of an erroneous pronosis' consequences. "A prognosis can be considered correct as long as it provokes no wrong decisions, and it has been false as soon as the measures taken as a result of the prognosis afterwards prove to have been unnecessary" / 32/. This means that it is assumed that the forecaster strives to maximize the usefulness in any way possible and lets quality be expressed in terms of the costs which would arise through wrong decisions. Logical difficulties of interpretation can occur here, however, for example in how to evaluate prognostic success "if an erroneous prognosis is followed by 'wrong decisions' which compensate each other so that no losses occur" /32 /.

Including the prognosis consecutiveness in the evaluation of successfulness is bound to be a failure for practical reasons. The main problem is the definition of a suitable usefulness-function and the corresponding preference structures. An example demonstrating how difficult it is to determine such a function particularly in the energy sector is the so-called asymmetry hypothesis. Since energy- particularly the energy carrier electrical current - is a limitative means of production in many industrial sectors, the assumption is derived therefrom, that the economic costs of underestimating the future demand for electricity should have a greater priority (also through greater environmental pollution due to the further operation of old equipment) than the costs of overestimating, because it implies only isolated economic costs of electricity generating plants whose capacity is not fully exhausted /35 /.

The evaluation of unequal effects of prognostic deviations which are numerically greater, but governed by different aims, is a problem in itself. The problem has become more critical, however, by the fact that the asymmetry thesis has been partially falsified by empirical findings. Asher /50/ describes the effects of an electricity supply shortage in the mid-'60s in the USA as follows: "To meet the unexpected demand, electric utilities have had to make up for the lack of more efficient conventional fossil-fuel or nuclear power plants. Utilities turned to gas turbines because they could be installed rapidly to avert the immediate crisis, while the more efficient plants would have required much longer periods of planning, ligitation and construction." This means that the use of gas turbines reducedenvironmental pollution instead of increasing it, and the asssumed costs of nuclear plants not exhausted to their full capacity are confronted with real costs based on differences in technological efficiency. It is obviously not possible to define a gain or loss function for the complex energy sector.

Having eliminated the concept of prognostic consectutiveness, the question is how to replace or supplement insufficient traditional comparisons of predictions with reality. The weak point was the inability to identify the sources of errors. This is exactly the point where the applied proce dure begins /51 /, which has not yet been used in comparable situations. The impact of assumptions and the prognostic method employed by the forecasters is of particular interest. The main idea is that deviations in the comparison of prognoses with reality comprise assumptions and methodical errors (see Fig. 2.7).

		(law-like) Hypotheses	
		true	false
Prognosis assumption (exegenous)	true	true statement[1]	method error
	false	assumption error	total error

1) without reflexivity: true statement

2) without error compensations: predicted/actual deviation

Fig. 2.7 Prognosis t ruth table

If through ex post analysis the true development of the assumed variables and the "correct" prognostic method can be found, answers will also be found for the following hypothetical questions:

a) What would the prognosis be, if - using the same prognostic method - it were based on the correct assumtion values which were discovered ex post facto?

b) What would the prognosis be, if - using the same prognostic assumptions - the "correct" prognostic method, discovered ex post facto, were used?

The comparison of ex post prognosis values (a) with the actually predicted prognostic values allows a differentiated statement on to which extent the mistakes of prognoses are due to false assumptions concerning the development of the fundamental conditions. The comparison of the ex post prognoses (b) ultimately gives information about the faults of the causal relationships and methods which have been employed.

Using authentic sources, the attempt should be made to reconstrue the causal relationships assumed by the forecasters. The prognoses under study must have clear premisses and methods, however, and it must be possible to follow the prognostic proceedure. In published prognoses this prerequisite has been fulfilled in very varying degrees, which has led to simplifications /51/.

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