WORKING PAPER

The Value of Oil Price Projections

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ABSTRACT AND SUMMARY

The central theme of this paper is the development of the international price of crude oil. A short overview of oil price history is followed by a discussion of the factors that were responsible for previous, sometimes erratic, changes. We conclude that these factors are likely to maintain their influence in the future, thus giving the forecasts of oil prices a high uncertainty. This uncertainty is reflected in several reports containing oil price projections. We argue, therefore, that a question solely about future oil prices must remain unanswered. This does not render the efforts to examine the future futile; it simply means that the question should be rephrased. We offer one possible problem formulation that explicitly accounts for the high uncertainty. This formulation requires that specific policy problems and options for solving them be specified *before* oil prices are projected – a condition that does not always hold or, at least, that does not seem to be regarded as important enough to be described in many reports on oil price studies.

PREFACE

The international price of crude oil is one of the most visible and most important variables of any energy system. Nonetheless, its future development is highly uncertain. Many energy studies explicitly reflect this uncertainty, but even those that do not implicitly reflect it through comparison with other studies. However, it is an open question whether the theoretical increase of information concomitant with the increase in the number of oil price projections has actually improved the practical knowledge of the consumers of the reports. We argue that "inconclusive" is a more likely initial reaction and have therefore attempted to extract the full information content from a collection of oil price projections. It turns out that this information content could be improved if the authors of energy reports made particular efforts in this direction.

CONTENTS

1 INTRODUCTION

The international price of crude oil is one of the most visible and most important variables of any energy system. Energy planning at many levels is crucially dependent on the expected future development of crude oil prices. The importance of oil price is further amplified by the widespread practice of linking the prices of other fuels to it. It is therefore not surprising that most energy studies include a projection of the international price of oil. However, the information gained by studying a single report is often diminished when unresolvable differences are revealed by comparing it with other studies.

In this paper we report a survey of a number of energy studies that contain projections of the future oil price. After an introductory overview of the history of oil prices we describe the results of an international poll on long-term energy projections. The responses to this poll included 61 different projections of the crude oil price for the year 2000. We then examine in more detail some studies that are representative for the range of all projections. Finally, we try to draw some conclusions that may be helpful in assessing the significance of a wide range of different crude-oil price projections.

Part of this work was done under a contract with Planning Consultants Oy ERG Ltd., Helsinki, Finland.

2 ENERGY PRICES, CONSUMPTION AND ECONOMIC GROWTH

The causal relationship between oil prices and economic growth is two-way. Oil prices affect GDP growth and GDP growth determines energy demand, which in turn influences energy prices. One of the links between the two is energy efficiency, expressed as the amount of energy consumed per unit of GDP. In this section we give an overview of the history of energy efficiency and discuss the interplay between GDP growth and energy prices that has led to the present situation.

During the last two centuries overall energy-use efficiencies have continuously

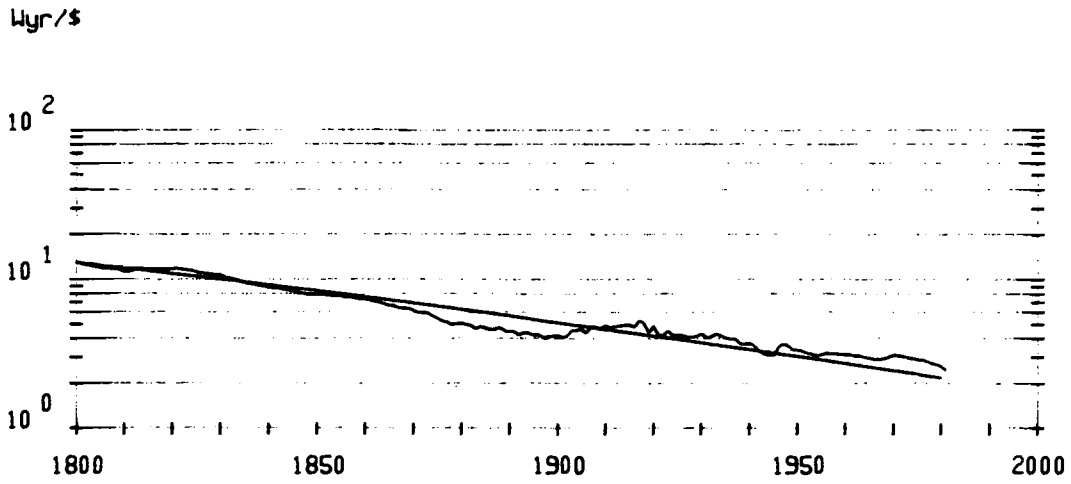

Figure 1. Energy Efficiency in the US.

improved. For example, Figure 1 shows that the amount of energy used to generate a dollar of value added in real terms in the US decreased on average about 1% per year during the last 100 years (including the two abrupt oil price increases in 1973 and 1979). These improvements were partially due to more efficient ways of energy conversion and use, to new conservation measures (e.g., better housing insulation), and also to a continuous shift from old to new energy sources. The latter point is illustrated by Figure 2, which shows the substitution of primary energy sources in the US for the same time period.

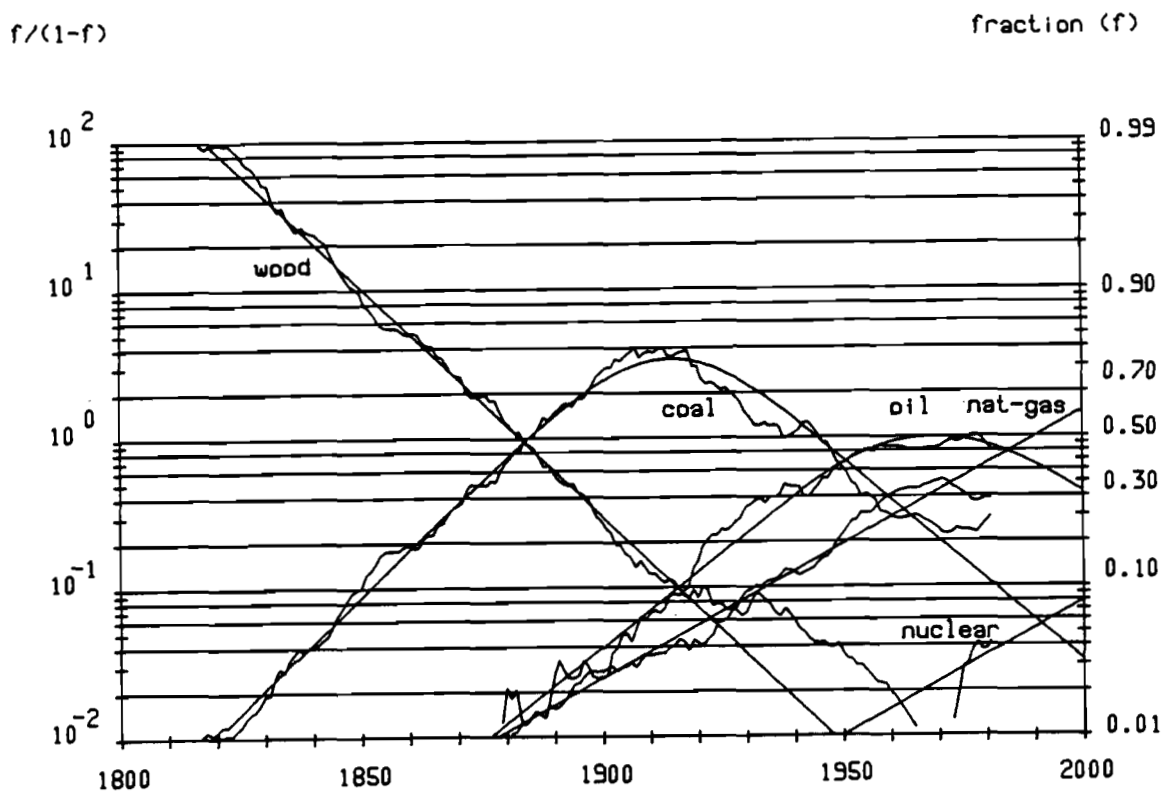

Figure 2. Primary Energy Substitution in the U.S.

Thus, although there is no doubt that in the long run oil will slowly be replaced by alternative energy forms and that the high oil prices of the last decade have reduced oil demand, it is still an open question as to what share of this reduction is reversible. In fact, some of the largest energy "savings" experienced during recent years have been due to the low level of activity of the more energy-intensive industries, such as steel and shipbuilding. Some of the changes in energy consumption and economic patterns will have a permanent structural character, but others will be reversed when the world economy recovers. An important purpose of energy projections will be to differentiate which changes are which. Figure 3 illustrates that even the shorter term oil consumption variations in the OECD countries during the last decade have been "synchronized" both with the cyclical fluctuations of real

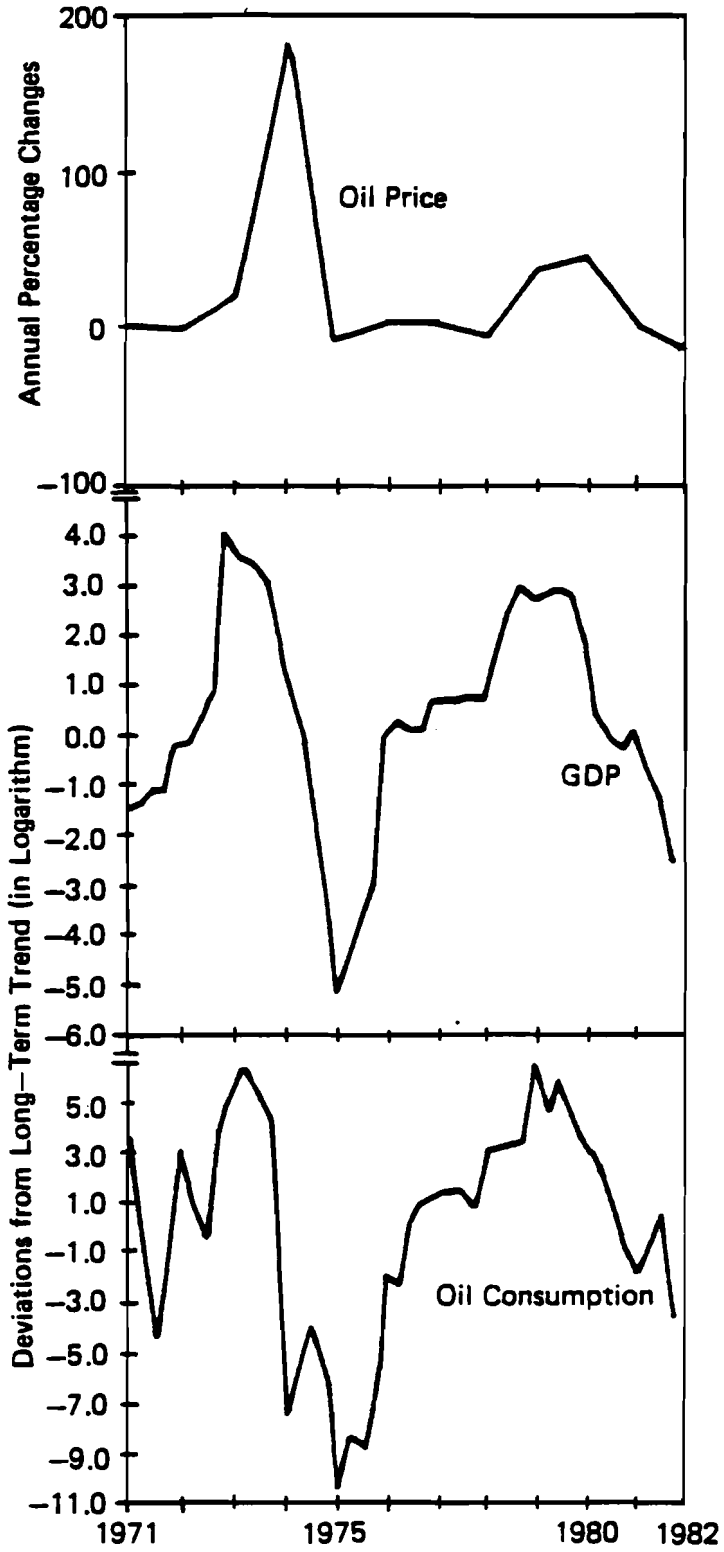

Figure 3. Oil Prices, Consumption, and GDP Growth.

GDP and the oil price changes. It appears that the two major oil price increases, the so-called oil shocks that occurred in 1973-74 and 1979-80, entailed, with a lag of about one year, profound fluctuations in *both* GDP and oil consumption in the OECD countries. The first oil price increase had caused considerable disruption and, before an adequate period for complete adjustment has elapsed, the second increase gave another significant impact. But, more importantly, it established expectations of rapidly rising prices in the future. Consequently, most oil price projections of the last decade envisaged high oil price levels in the future.

These recent developments are in sharp contrast to the situation prior to 1973 when the multinational oil companies regulated oil prices and supply under the pressures of rigorous competition and the regime of incremental production costs. Since the production costs were low and even decreasing, especially in the Persian Gulf area, the oil prices also decreased in constant value terms. Figure 4 shows that oil prices decreased continuously from the end of World War II to the early 1970s, when the decade of market dominance by OPEC began. Despite the sometimes disrupted spirit of unity among member countries, OPEC managed to raise prices and subsequently, through supply regulation, kept them from falling to lower levels.

During this decade of OPEC dominance there was a simultaneous change in the organization of the international oil market. The market became more open and transparent in the sense that more transactions passed through traders and spot markets that were not contained within the major oil companies. These majors lost much of their control of the international market, but also lost was their stabilizing influence on prices through timely supply responses to demand changes. At the same time, the high oil price levels established by OPEC caused a rapid increase in oil production in non-OPEC countries (e.g., Mexico), which further increased the

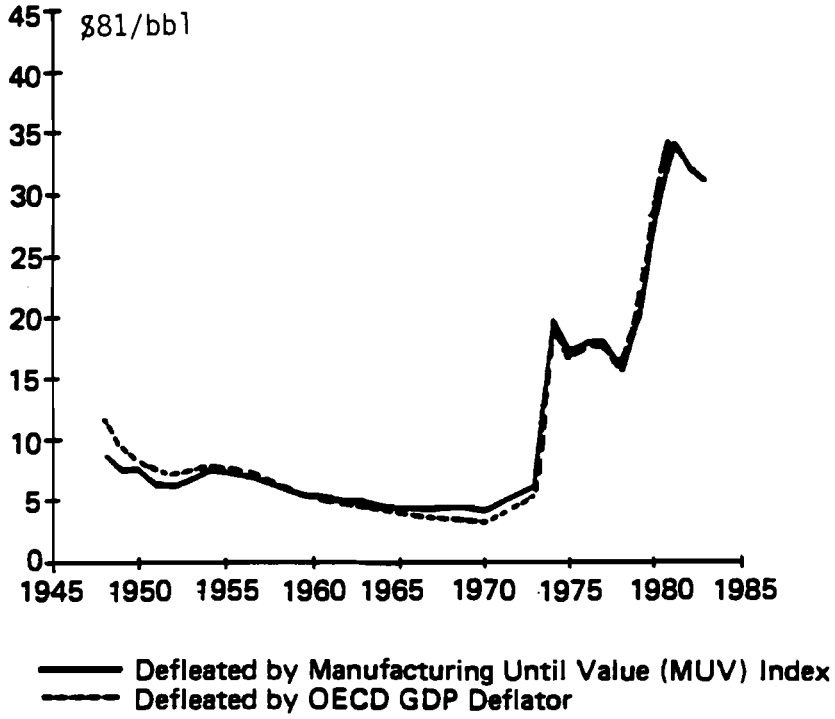

Figure 4. History of Oil Prices

flexibility of the international oil trade. Without the dominating role of the majors to control supply and prices in response to changing demand, the world oil market became more similar to other international commodity markets, such as coffee, sugar, and wheat, in which inventory changes aiso have a strong effect on prices. In fact, inventory accumulation as a result of the fear of rapidly rising prices (or acquisition of strategic reserves, as it is sometimes called) of oil appears to have played a very important role in creating an excess of demand for oil, thus leading to price increases. (An impressive example of self-fulfilling expectations.) This inventory accumulation, perhaps inadvertently, is an additional reason for the softer oil markets that have developed during the last four years, weakening OPEC dominance. After parts of these inventories were unloaded during 1981-82, the oil prices started to fall in 1983 for the first time in ten years. In response to the sudden

threat of an impending oil glut, OPEC has now introduced formal production quotas for its members in an attempt to limit the supply. These quotas are not an easy constraint for all oil-producing countries. The financial difficulties of many of them, notably Nigeria and Venezuela (and Mexico, which apparently attempts to "mirror" OPEC strategies to some extent) can probably be resolved only by increased oil production, since these countries must realize certain minimal revenues because, for them, oil exports are the only possible way to balance their trade deficits. Thus, pressures appear to be strong on the supply side toward increasing production levels and, therefore, also decreasing prices due to lower oil demand.

We have already mentioned that a number of long-term "structural" changes could account for lower oil demand. Thus, part of the demand reduction could be due to the substitution of crude oil by other energy sources and another part to genuine energy conservation and better efficiences of energy end-use. A part of the reductions in the total demand for energy, on the other hand, is usually attributed to the overall fall in consumption, due to the worldwide economic recession. Therefore, a number of alternative mechanisms, ranging from energy substitution and conservation to price and income effects, or some combination of them, could account for the recent demand reductions for energy in general and crude oil in particular.

During the last two years the adequate supply of oil and the reduced demand have contributed to fairly steady energy and oil prices, but this stability may be deceptive. For instance, a further escalation of hostilities between Iran and Iraq could eventually result in an oil supply disruption of unprecedented scale. The price of oil could then surge, followed by the prices of other energy sources. In the absence of a serious disruption, however, a continued weakness of oil and energy

prices is conceivable. In this event, OPEC countries would have to absorb most of the decline in demand by reducing production in an effort to stabilize prices. On the other hand, an increase in oil demand would cause higher OPEC oil production and price increases. In this sense, OPEC represents the world's residual source of energy, filling the deficit or absorbing the surplus in energy supply. Thus, even relatively small increases in global energy demand lead to overproportional increases in OPEC oil demand and, presumably, upward pressures on oil prices. The reverse of this phenomenon is demonstrated by recent events, when a 1% decline in global energy consumption (between 1979 and 1982) translated into a 40% decline in OPEC oil production (see, e. g., [1]).

Since OPEC apparently represents the residual supplier of energy at the world level, the price of OPEC oil provides a reference price not only for other crude-oil transactions, but also for other energy sources. Crude oil represents about 80% of internationally traded energy and, as such, its price serves as a marker for all other energy sources that are traded internationally (after quality differentiation is accounted for). Owing to the critical roles of crude oil in the global energy system, as both the main and the residual energy source and the price leader, future oil-price prospects represent one of the most important indicators of the development of the whole energy system.

It is therefore not surprising that most energy studies and projections deal with future oil prices. Unfortunately, crude oil and energy prices are treated (and reported) quite differently in the various studies. The scale ranges from inferences that assumptions on energy prices have occurred somewhere in the analysis to explicit presentations of projected price trajectories. Because of the importance of anticipating future price developments in prudent planning and decision making

and because crude oil prices will be instrumental as an indicator of other changes throughout the energy system and the whole economy, the objective of this paper is to assess and compare price projections published in the literature. In analyzing these projections and the scenarios on which they are based, it is nevertheless very important to be always aware of the fact that the uncertain prospects of actual future events cannot, even in principle, be overcome or predicted by a comparison of different projections. Rather, projections can help to outline the limits and probable ranges of future developments. Furthermore, a comparison of different projections and their underlying assumptions offers the possibility of identifying the importance of various factors and developments connected with oil price changes in these projections. In other words, the structure and the nature of the assumptions and/or the model used in projecting oil prices is at least as important as the actual values of the projected trajectory. In this review of the literature we analyze both the methodology and assumptions, as well as the resultant price trajectories.

3 A COLLECTION OF OIL PRICE PROJECTIONS

A large collection of long-term oil price projections is one of the results of the International Energy Workshop (IEW), an institution that regularly polls projections of crude oil prices, economic growth, primary energy consumption and production,

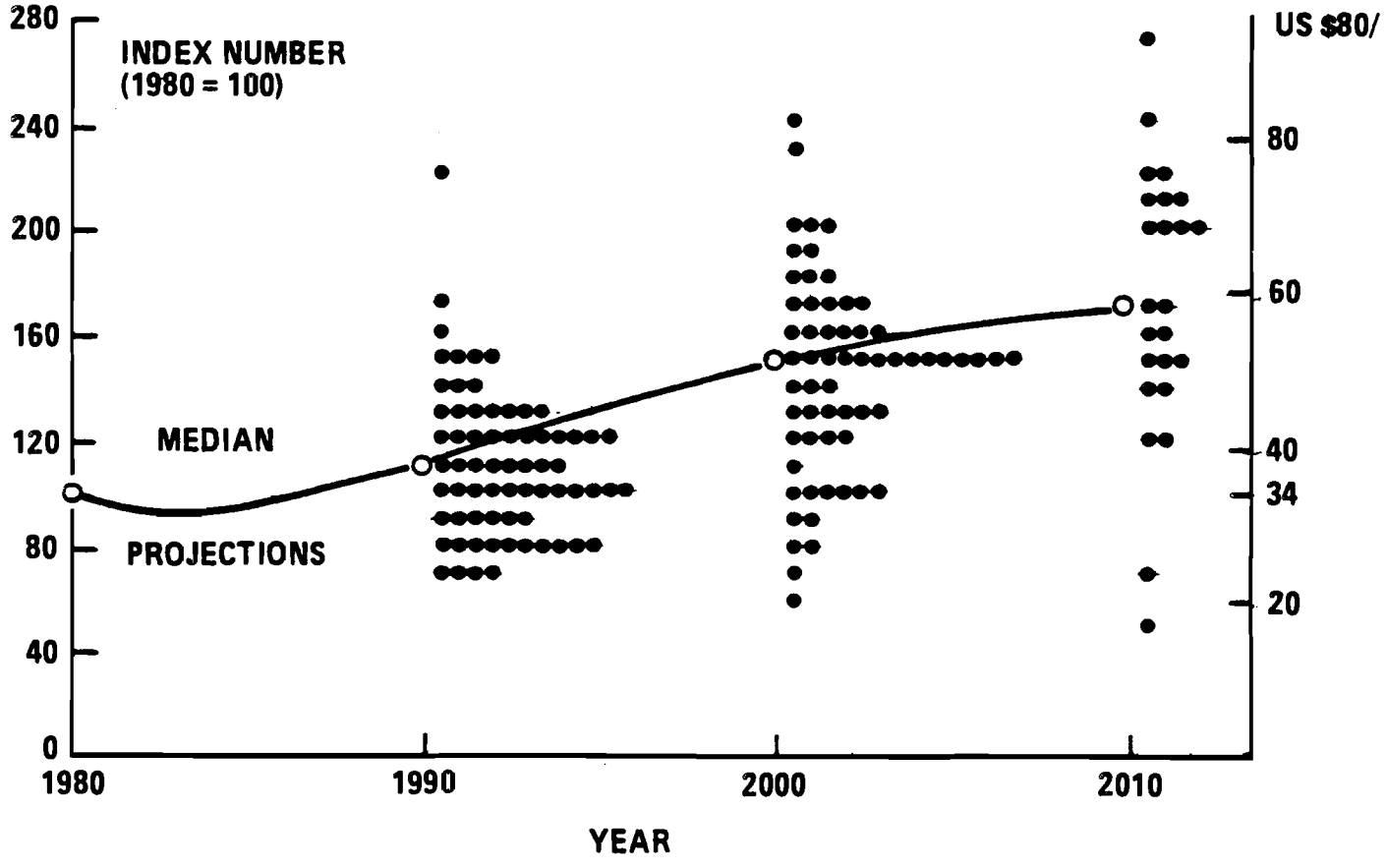

Figure 5. Projections of the International Price of Crude Oil.

and energy trade [2]. Figure 5 is a summary of the 1983 poll results on the international price of crude oil. The figure is in the form of a time series of histograms of

projections with the medians marked separately. The units chosen in the original presentation of the poll results are index numbers with the basis 1980 = 100. Here we have added a scale with absolute numbers using an oil price of $34/bbl for 1980. The median of the 61 independent* poll responses for the year 2000 is 148, corresponding to an annual average price increase (between 1980 and 2000) of almost exactly 2%. A more appropriate statistic is to calculate the average and the variance ($\bar{x}$ and s) of the logarithms of the projections (as if they were distributed log normally). Doing this and retransforming the results yields 139 as an average and the interval [106,184] for $[\bar{x} - s_{\bar{x}}, \bar{x} + s]$.

The extreme projections for the year 2000 are 62 and 240 (on the relative scale), corresponding to absolute values of $23.6 and $91.2/bbl, respectively, thus covering a range of almost 1:4. To understand this wide range it is natural to look for an explanation of these extreme projections. One of the projections for the year 2000 that is near the low end is the High Demand Case by the International Energy Agency (IEA). It represents a "what if?" case in which the demand for oil at a given (low) price is calculated. Since the resultant oil demand in this scenario exceeds the projected supplies, the oil price in this IEA scenario is more accurately a scenario parameter rather than a projection. The projection of 240 (corresponding to an annual average growth rate of 4.4% starting from 1980), on the other side of the spectrum, is the outcome of a disruption scenario that does not contain an inconsistency comparable to the one in the IEA scenario, but which considers a disruption of energy imports, an assumption not made by most of the other respondents.

* We use the term "independent" here quite loosely. All it means at this point is that those responses that belonged to different geographical regions but to the same overall scenario were counted only once.

Starting thus from the extremes may raise the intuitive expectation that this process should converge to single out the median (or any other unambiguous) value as "the best" projection. However, this comfortable and easy picture is grossly disturbed by the inherent uncertainty that surrounds real-world development. The median of the projections is only a description of the current thinking of energy experts and its interpretation as the most likely future value would require some nontrivial assumptions. The purpose of the IEW should not be misinterpreted as to mean the resolution of uncertainty. Rather, the IEW discussions are meant to make differences of opinion explicit, to help make scenarios and assumptions consistent, and to widen points of view through challenging them with different perspectives. This can be called quantification (rather than elimination) of uncertainty.

4 A SURVEY OF ENERGY STUDIES

Whether one wants to extract the information content of a set of oil price projections by formal statistical methods or by direct discussion, the question of the independence of the individual projections arises. And although there is no practical, unambiguous definition of independence, we set out here to evaluate the independence of some oil price projections in qualitative terms. To do this we could only work with those projections that were accompanied by a written report providing context and background. This was more restricting than one might have expected and so we use a somewhat different sample of projections to the one described in the previous section. The new sample is neither a subset nor a superset of the projections shown above, but there is a significant overlap. In any case, we believe that neither the conclusions drawn in this section nor the discussion below is influenced by using two different samples of oil price projections.

Short characterizations of the reports we used are included in the Appendix, in which the abbreviations used in Table 4.1 are defined. Here we summarize the reports' oil price projections for the year 2000 and judgmentally evaluate their degree of independence, dividing them into three categories, i. e., N (for "no"), M (for "maybe"), and Y (for "yes"). We classified as "N" those projections in which it is explicitly stated that they oriented their projection toward others; as "M" those where the projection is characterized either as "expert opinion" or as an assumption that is not discussed further; and as "Y" where the projection was reported as the result of the application of formal tools. Obviously, we do not think that these are particularly strict criteria for the determination of independence, but we think that they serve as an adequate working tool. If there is a systematic bias in these evaluations then it is a shift to the "independent" side. In particular, we do not

think that Odell's arguments [3] concerning the "latter day pessimism" (implying a dependence of all high oil price projections on a joint source) can be dismissed.

Name (IEW Name)	Method	Projection	Independence		
CEC	Assumption	30-33		M	
Chase	Iteration	40-46	Y		
Chevron (CAL)	Exp. Opinion	30-43		M	
Conoco (CON)	Exp. Opinion	34-45[a]		M	
DOE (DOE)	Exp. Opinion	33-67		M	
Eden (CERG)	Trend Extrapol.	50-60			N
EIU	Qualitative	n.a.			
EMF	Analytical	38-82[b]	Y		
ETA-M (EM)	Assumption	46-53		M	
GRI (GRI)	Assumption	40-46		M	
IEA (IEA)	Assumption	28-45		M	
IFP	Assumption	68		M	
Deam	Direct	10-12	Y		
Odell (CIES)	Direct	16-23	Y		
World Bank (WBK)	Take-Over	37[c]		N	

Table 4.1. Oil price projections for the year 2000 (in 1980 US $) and a judgmental evaluation of their independence.

Notes for Table 4.1:

[a] Authors' quantification of a qualitative projection.

[b] Reference case only.

[c] Estimate for 1995.

- Where only relative increases were given, an 1980 oil price of $34/bbl was used as a basis for the calculation of the projected number.

- For a definition of the abbreviations of the studies see the Appendix.

- IEW names are given in parentheses where applicable.

- The entries in the column "Independence" gives our rough judgmental evaluation of the independence of the projections. Y stands for yes, N for no, and M for maybe.

It is interesting to note that the range of future oil prices covered by the four projections that were characterized as "independent" reaches from less than half the current price level (Odell) to well beyond twice the current level (EMF) thus marking the extreme points of the overall range.

The judgmental character of this evaluation and the more detailed discussion of the results below notwithstanding, we argue that the sparseness of the "Y"s is an important result because, even if one were willing to count all "M"s as independent (rather than the other way round), it is worth noting that the authors do not make great efforts to discuss the degree of independence of their oil price projections.* Readers may formulate their own judgment, but we argue that it would be optimistic to assume that the fraction of independent projections is higher than one-half and the possibility of it being as small as one-fourth is quite definite.

It is clear that independence cannot be unambiguously measured in our subject matter, but at least our proxies are observable. Unfortunately, these proxies do not separate the cases clearly. Take, e. g., the distinction between "result of the application of formal tools" and "assumption". The only real difference between the two is that in the former case the assumptions have an indirect effect on the results whereas they lead directly to it in the latter case. This is illustrated by the *World Oil* report of the Energy Modeling Forum. There the projected oil prices are in most cases the result of the application of price reaction functions (which use capacity utilization at time t as one of the determinants of percent change from t to $t+1$) which, in turn, contain assumptions about the speed of adjustment.

The projections labeled as "expert opinion" were put into the middle category mainly because their origin is usually so vague that they could be anything from compietely dependent to completely independent. Their common feature is that they do not lend themselves easily to comparative analyses, as the methodologies used to derive these projections and the assumptions adopted are not described in enough detail to permit an approximate repetition of the process that led to the results,

* The US Anti-Trust Law prescribes that the US oil companies' estimates be independent of each other.

thereby identifying which causes led to which effects.

Although the *World Oil* study is represented as only one entry in our table the underlying results are numerous. The EMF entry in Table 4.1 summarizes more than 100 results of different model runs. Quite obviously, this reflects several areas of uncertainty, both with respect to parameters that are thought to influence the future oil price and to the magnitude of the effects caused by these parameters. The study clearly distinguishes between the two and quantifies them separately. The total range of all results, expressed in 1980 US dollars (the original table uses 1981 dollars), is 30-375. Compared with the IEW results illustrated in Figure 3.1 the EMF study shows some 20 values higher than the IEW highest, but none that is lower than the lowest IEW projection. In particular, not even the "optimistic" EMF scenario shows a value comparable, say, to Odell's projections. In this connection it is interesting to note that the range of EMF's "optimistic" oil prices falls completely within the range of the "reference" cases. (However, the results of those two models that yielded the lowest reference projections are not reported in the summary of the optimistic scenario.) A possible explanation for this rather high bound for optimism could lie in the parameters for the price reaction functions that set limits to downward adjustments. Clearly, if these parameters are set very tightly their price reducing effect is easily offset by other variables (such as trends), thus causing the models to project price increases even in times of underutilized capacity.

5 DISCUSSION

From the discussion in the previous section we conclude that it would be highly speculative to assume that a large sample of oil price projections represents the probable distribution of future oil prices. The interdependence of the single projections is simply too high or, at least, their independence is not demonstrable. We have mentioned Odell's argument [3] that most projections are, indeed, dependent on each other with the effect, expressed in statistical language, that their average is too high. Be this as it may, the influence of statistical dependence on the *variance* is much clearer, i. e., in the case of dependence the sample variance is usually reduced. In our subject matter this implies that the "actual" distribution of independent oil price forecasts would cover an even wider range than the already wide span of the projections presented here. One sound conclusion that can be drawn from all this is that it does not make much sense to think of a unique value (or even a narrow range) when working with uncertain prospects, such as future oil prices.

As a general remark, we note that, despite the convenience of using terms and concepts of probability theory for some purposes, it would be inadmissible to use a set of projections as a representation of a probability function in a more rigorous way. Apart from the problem of dependence there is the problem that the premises of probability theory do not apply in an obvious way to forecasts and projections. This has been recognized by psychologists who have therefore introduced the concept of "judgmental probability". This concept may work as a tool for individual decision making, but we think that the low quality of individual probability judgment observed by psychologists (see, e. g., [4] for a number of illustrations), should be a warning against readily using a "collective-judgmental probability" as if it were as

well defined as, say, Brownian motion. Refraining from doing so will also help to avoid futile discussions as to whether a forecast was right under the circumstances and the real-world events took a low-probability course or whether the actual outcome was a reasonably likely outcome of a different model.

Having discussed so far mainly the drawbacks, the reader may wonder whether we see any usefulness in making a comparative study of oil price projections. We certainly do, and by playing down the importance of rigorous tools we emphasize the role of judgment, which is greater than many reports lead their readers to believe. And since judgment is inherently subjective we think that oil price (and many other) forecasts ought to be formulated in a way that leaves room for the judgment of the users of these forecasts. Moreover, where there is any interaction between an analyst and a decision maker, it seems natural for the latter to be at the top of the "judgmental hierarchy". (In the next section we describe a scheme in which this proposal is incorporated.) This implies that both the analyst and the decision maker have (in general different) judgmental probability distributions. The reason why it is the decision maker whose judgment has to guide the analysis (maybe more so than the analysis guiding the decision maker) lies in the fact that the decision maker is (politically) responsible for his decision, which means that it is he who has to carry the burden of explaining decisions and their consequences; and even if the impossible were, in fact, possible and one could formalize all these aspects of decision making and solve the problem analytically it seems hard to imagine that the decision makers would enjoy the idea of being essentially replaced by computer models.

Thus, we see the principal usefulness of projections in their potential to educate the judgment of those who use them. Unfortunately, we have often observed that a report does not fully exploit this potential. There can be many reasons for

this, but a fundamental and recurring one is an imbalance that overemphasizes the rigorous part of an analysis at the expense of a discussion of the many instances where judgment has played a role. It would certainly increase the usefulness of reports if they described the purpose for which an oil price projection was made (thus permitting, at least, a guess as to the kind of judgment that was made) and if a statement of the results included at least some reference to the basic assumptions and their causal connection with the results.

6 DECISION MAKING UNDER UNCERTAINTY

Thus far we have tried to look at a collection of oil price projections in a way that resolves whatever initial confusion may occur in response to a widely scattered set of point projections. But we think that this confusion will be more permanent if mereiy an answer to a simple numerical question is sought. This is because the intrinsic uncertainties of the problem render neither the question nor any single answer appropriate. And even if one settles for an answer consisting of a (reasonably narrow) range of oil prices, it is hard to believe that a satisfactory answer could be obtained. We argue that the question about future oil prices makes sense only if a particular answer is evaluated in terms of its consequences for a decision problem. Here we return to our statement of the previous section that it should be the decision maker whose judgment is the ultimate criterion, and we present now a framework that contains a formal problem description of decision making under uncertainty and a central role for a set of diverging projections. Accordingly, the problem is:

optimize F(D,S)

where: F is an multidimensional function; its elements are "consequences" or "outcomes"

D is a vector of (mutually exclusive) decisions

S is a vector of (mutually exclusive) states-of-the-world

In words: The problem is to depict a decision (d_i) that will lead to an "optimal" set of outcomes $\{F(d_i, s_1), \ldots, F(d_i, s_m)\}$. (In practice, the term "optimal" should be replaced by the more precise "judgmentally optimal" to indicate that judgmental probabilities are combined with a judgmental trade-off between the individual outcomes – and to deter analysts from attempting to solve the decision problem analytically.) Since F is itself a vector, the problem is to compare the matrices $\{f_1(S,D)\}$, ... $\{f_k(S,D)\}$ of consequences and states-of-the-world that are indexed by the decisions considered. (A typical criterion applied to this kind of problem is an "insurance" strategy aiming at a minimization of maximum damage or "regret".)

Tackling the problem described by this paradigm therefore involves the following steps:

1. Selection of the decisions to be considered.
2. Selection of the states-of-the-world to be considered.
3. Selection of the consequences to be considered.
4. Construction of a mapping (model) F(D,S).

Step 1 falls within the domain of the decision makers. And as much as studies are sometimes called academic when they somehow neglect the problem of remaining consistent with the real world, it must be equally said that decision makers often neglect to supply analysts with the decisions at stake. (Wildavsky and Tenenbaum's book [5] on the oil and gas reserve estimates of the US describes an impressive case in point.) Many reports do reflect this lack of "reference decisions", but this is not always perceived as a grave deficiency and is sometimes compensated for by the

formulation of hypothetical decision alternatives. However, the overestimation of the power of analytical tools makes the absence of concretely formulated decisions appear less serious.

Step 2, the selection of a representative set of states-of-the-world, is the stage in which a collection of projections, such as those discussed in this paper, can be of significant use. Moreover, the wide range covered by such a collection becomes a quite natural feature, reflecting the inherent uncertainty of the problem. In our paradigm, this step is a joint effort of decision maker and analyst, probably engaging the latter more than the former.

Step 3, the selection of a representative set of consequences, is again a joint task of decision maker and analyst, this time probably engaging the former more than the latter.

Step 4, the construction of a model that incorporates the results of the previous three steps, is the natural domain of the analyst. However, this domain ought to be much more invaded by decision makers (mainly through their involvement in the basic steps) than is usual. What the participation of the decision maker in the modeling part amounts to is a joint determination of the model size. Choosing the best size of a model requires a trade-off between the clarity of the modeling process (which favors smaller models) and the amount of information contained in the model output (which, taking quantity as a criterion, favors larger models). This trade-off is by no means obvious to resolve. However, we think that in cases where the interaction between modelers and decision makers is weak, it is all too often resolved with a bias toward larger models. The paradigm described here is consistent with the strategy "as small as possible" for the determination of the appropriate model size. By this we mean that (at least the first) selection of model

size should yield the smallest model that gives any meaningful answer to the problem at hand.

The activities and the results of all steps are, of course, intertwined with all other steps, making the whole process a repetitive procedure.

7 CONCLUSIONS

In this report we have summarized the oil price projections of a number of reports and we have tried to summarize and reconcile the possible reasons for the wide range spanned by these projections. Eventually, we have come to recognize the potential usefulness of such a variety of results which had not been so obvious at the outset. This usefulness becomes explicit if the spectrum of different oil price projections is considered in the context of decision making under uncertainty. However, the authors of oil price projections would have to provide more information about the underlying assumptions and objectives if their reports are to be of maximum usefulness for this purpose. This can be done by distributing the emphasis of a study more evenly between scientific rigor and real-world uncertainty. If model results are qualified by a characterization of the uncertainty surrounding them and if they are explained in terms of the underlying assumptions, then users of the results, in particular decision makers, can compare these assumptions with their own, and then estimate what difference in the result they would make. If authors wanted to go even further, they could also make an attempt to explain why differing results, obtained by others, are different from their own findings. This would significantly increase the usability of a report for the solution of a problem described by our paradigm. Although this purpose is not necessarily what authors have in

mind, we think nevertheless that our conclusions are worthy of some deliberation by authors of forthcoming reports on energy studies.

APPENDIX

This appendix contains descriptions of the studies reviewed for the discussion in Section 4 of this paper in a unified format. It also contains the abbreviations of the studies by which they are referred to in the main text.

STUDY NAME: *Energy Scenarios Up to 2000 (EUR 10)*

ABBREVIATION: CEC

REFERENCE: Informal presentation by Chr. Waeterloos (DG XVII, CEC, Brussels) at the International Atomic Energy Agency, Vienna, November 1982 [6].

APPROACH: Scenario writing.

(a) Methodology: Model of final energy demand in physical terms (MEDEE-3) and a linear programming supply model (EFOM 12C).

(b) Base Year: 1980.

(c) Assumptions: Three scenarios: "Free Competition", "International Cooperation", and "European Common Market".

(d) Results: Not yet available in final form.

MAIN OBJECTIVE: Review of energy policy development in the Community and its member states.

SPATIAL AND TEMPORAL COVER: European Community, 1980-2000.

PART OF ENERGY SYSTEM CONSIDERED: Primary to final energy; connection with economy.

PRICE PROJECTIONS: Oil prices in 2000 between $30 and $33/bbl (1981 prices).

COMMENTS: This review is based on a report of a study in its design phase.

STUDY NAME: *The Energy Outlook Through 2000*, a study conducted by the Energy Economics Division.

ABBREVIATION: Chase

REFERENCE: The Chase Manhattan Bank, N.A., March 1983 [7].

APPROACH: Three sets if oil price forecasts were developed, i. e., high, low, and best estimate.

(a) Methodology: Oil price, oil demand, petroleum industry, and OPEC financial pressure models are linked to energy demand and coal demand models, which are primary tools for the iterative long-term forecasts.

(b) Base Year: 1980/82.

(c) Assumptions: A model set is used in an iterative mode starting with an oil price assumption. After iterations natural gas and coal prices can be determined on the basis of crude oil prices. Total energy consumption depends on GDP projections via energy price/GDP elasticities, which are estimated for the base year 1980.

(d) Results: Provides detailed forecasts of the economic growth and energy consumption (based on analysis of supply and demand source) under three different scenarios of future oil prices.

MAIN OBJECTIVE: To analyze major issues affecting the outlook for OPEC oil prices as the focal point of the study, which examines the outlook for the supply, demand, and prices of energy in the market economies.

SPATIAL AND TEMPORAL COVER: From 1980-2000. The world, divided into 42 regions.

PART OF ENERGY SYSTEM CONSIDERED: Whole energy system starting with primary energy and resources going to secondary energy sources and fuel demand.

PRICE PROJECTIONS:

World Crude Oil Price Forecast (1981 US$/bbl)

Year	Low	Best Estimate	High
1980 (actual)	-	34.06	-
1985	24.35	31.60	32.25
1990	31.00	35.00	40.00
2000	40.00	43.00	46.00

COMMENTS: This is a typical independent derivation of oil price projections as described in the main text. Moreover, the derivation of these projections was a central reason for undertaking the study.

STUDY NAME: *World Energy Outlook, June 1983*

ABBREVIATION: Chevron (CAL)

REFERENCE: Standard Oil Company of California (CHEVRON) [8].

APPROACH: Appears to be based on expert opinion and likely trends, but there is no reference to formal models that have been used in the study.

(a) Methodology: Based on recent trends and events. The most likely future developments are evaluated using the information on production capacities, etc.

(b) Base Year: 1982.

(c) Assumptions: Substantial economic growth throughout the world (between 3 and 5% per year) without excessive energy demand increases.

(d) Results: World energy consumption in the year 2000, according to energy source and expected oil prices. Also world demand for refining.

MAIN OBJECTIVE: To outline the energy and especially oil industry's prospects up to the year 2000.

SPATIAL AND TEMPORAL COVER: The market economies with special emphasis on the US. The temporal scope is divided into short-term prospects (up to 1985) and long-term trends (up to 2000).

PART OF ENERGY SYSTEM CONSIDERED: Total energy consumption and consequent demands and production of various energy sources, with emphasis on oil supply, refining capacity, synthetic fuels production, and crude oil prices.

PRICE PROJECTIONS: Crude oil prices under little upward pressure until demand rises in the mid-1990s. OPEC supplies nearly half until 2000. Thus, oil prices will remain flat in the 1980s and will rise slowly in the 1990s reaching a range of $35-50/bbl (1983 dollars). Gas and coal will be priced accordingly to be competitive with equivalent oil products.

COMMENTS: The format of this publication is characteristic for those reports that are labeled "expert opinion" in the main text.

STUDY NAME: *World Energy Outlook Through 2000*

ABBREVIATION: Conoco (CON)

REFERENCE: CONOCO, Stamford, USA, April 1983 [9].

APPROACH: Trend extrapolation to produce one forecast of future energy developments.

(a) Methodology: Undocumented econometric models of the relations between oil price, demand, and GDP. Judgment apparently plays a considerable role.

(b) Base Year: 1981/82.

(c) Assumptions: No explicit assumptions are reported. Since an econometric model is used the number of assumptions (not considering those in methodology-related fields, like the form of the equations for which the parameters are estimated) is small.

(d) Results: Projections of primary energy demand for all market economies together and the US separately.

MAIN OBJECTIVE: The conclusions reported are policy implications for the US. Presumably, other objectives were behind the study as well.

SPATIAL AND TEMPORAL COVER: Market economies, 1980-2000, conclusions for the US.

PART OF ENERGY SYSTEM CONSIDERED: All primary energy.

PRICE PROJECTIONS: Qualitative; constant or even decreasing real oil prices for several years, slight real increase thereafter.

COMMENTS: Another example of the "expert opinion"-type of reports.

STUDY NAME: *1982 Annual Energy Outlook with Projections to 1990*

ABBREVIATION: DOE (DOE)

REFERENCE: US Department of Energy/Energy Information Administration, Washington, DC, April 1983, DOE/EIA-0383 (82) [10].

APPROACH: Projection of energy production, consumption, and price in the US and on international energy markets.

(a) Methodology: Explicit projections and analysis of the domestic and international energy markets are presented through 1990; they are apparently based on trend analysis and expert opinion.

(b) Base Year: 1980/81.

(c) Assumptions: The world oil price will depend on changes in the oil market (i.e., supply and demand); other energy prices are apparently linked to the oil price.

(d) Results: Three oil price projections, the middle one being described as "most realistic", the lower and upper one as safety margins. Based on the middle projection, primary energy and oil balances, and economic growth rates are given.

MAIN OBJECTIVE: No apparent single objective; DOE publishes its projections as a service. In general, this report investigates possible energy futures for the US in the context of all market economies as part (Volume 3) of the *Annual Report to Congress*.

SPATIAL AND TEMPORAL COVER: Time frame: present to 1990/2000; The energy prospects of the US and the market economies as a whole are covered.

PART OF ENERGY SYSTEM CONSIDERED: Oil production, price development, primary energy demand, and consumption.

PRICE PROJECTIONS:

	World Oil Prices in 1982 $/bbl		
	Low	Middle	High
1980	39.32	39.32	39.32
1982	33.59	33.59	33.59
1985	21.00	25.00	34.00
1990	28.00	37.00	48.00

COMMENTS: A hypothetical oil disruption scenario is also analyzed in the report. The calculated consequences on oil supply and price are compared with the most probable, middle price, and supply alternative. The major part of the report deals with US domestic prospects. The methodology and the general approach are not described in much detail.

STUDY NAME: *Energy Projections to the Year 2000*

ABBREVIATION: DOE (DOE)

REFERENCE: US Department of Energy/Division of Analytical Services, Washington, DC, August 1982, DOE/DE-0029/1 [11].

APPROACH: Market approach given OPEC's future pricing behavior.

(a) Methodology: Three econometric models are used: oil market simulation, OECD energy demand model, and non-OPEC demand model.

(b) Base Year: 1981.

(c) Assumptions: Prices remain constant in nominal dollars in 1982 and thus grow slightly slower than inflation.

(d) Results: Economic recovery is assured after 1982. Provided a variety of scenarios in which oil prices and economic growth are varied over a wide range.

MAIN OBJECTIVE: (With respect to non-US prospects.) World oil market scenarios try to reflect uncertainty, from a US vantage point, regarding world oil price, total primary energy consumption, and oil consumption in particular.

SPATIAL AND TEMPORAL COVER: World, with special emphasis on OPEC behavior (US, other OECD, OPEC, rest of market economies, CPE). Historical: 1980, 1981; projected: 1985, 1990, 1995, 2000.

PART OF ENERGY SYSTEM CONSIDERED: Primary energy including oil, coal, gas, nuclear, renewables/other, with special emphasis on the world oil price.

PRICE PROJECTIONS:

Three Basic Price Scenarios (in 1981 $/bbl)

	1980	1981	1985	1990	1995	2000
Low prices	37.0	37.0	27.5	31.5	41.0	51.0
Mid-range prices	37.0	37.0	32.5	42.5	53.5	62.0
High prices	37.0	37.0	37.0	57.0	71.0	74.0

COMMENTS: The assumptions are clearly documented. However, the methodology is not described to the degree of detail that enables the reader to appreciate the linking between assumptions and results. It appears that the prices are determined by the assumed OPEC behavior in the oil market simulation model.

STUDY NAME: *World Energy Outlook to 2020*

ABBREVIATION: Eden (CERG)

REFERENCE: Richard Eden *et al.*, Energy Research Group, Department of Physics, Cavendish Laboratory, University of Cambridge, Cambridge CB3 OHE, U.K., June 1983 [12].

APPROACH: Trend projections; scenario writing.

(a) Methodology: "Supply-demand integration" – iterative balancing of demand and supply projections, including consistency checks and feedback.

(b) Base Year: 1980, 1983 (not the same for all variables).

(c) Assumptions: Main scenario, economic growth: 2.7% per annum (1980-2000), 2.4% per annum (2000-2020).

(d) Results: Dominating role of oil to continue through 2020; investments in new energy forms crucial. Procedural result: four consistent scenarios. Main scenario variable: GNP growth patterns.

MAIN OBJECTIVE: To investigate the investment problems arising from a transition away from oil.

SPATIAL AND TEMPORAL COVER: Market economies, disaggregated into nine regions; 1980-2020.

PART OF ENERGY SYSTEM CONSIDERED: Primary energy,. emphasis on oil; demand analysis disaggregated into economic sectors.

PRICE PROJECTIONS: Projected oil price in the year 2000: $40-60/bbl (1980 dollars).

COMMENTS: Assumptions stay deliberately near the consensus of energy analysts, apparently for the purpose of exploring "common ground". The procedure leading to the reported results do not appear to be repeatable for readers.

STUDY NAME: *Prix de Revient des Energies de Substitution: Elements de Strategie pour un Group Petrolier (Cost Prices for Substitution Energy: Strategy Elements for an Oil Company).*

ABBREVIATION: IFP

REFERENCE: A. Brion, Seminaire i.f.p., Nice (France), March 1981 [13].

APPROACH: Analysis and estimation of cost data for different energy chains.

(a) Methodology: Data collection and return-on-investment calculations.

(b) Base Year: 1980.

(c) Assumptions: 12 % per annum return on invested capital for nonelectric, 9 % for electric power plants.

(d) Results: Investments ought to at least double if the stability of the non-OPEC energy production situation is to be achieved.

MAIN OBJECTIVE: To establish a basis for decisions on strategic investments by an oil company (TOTAL).

SPATIAL AND TEMPORAL COVER: With regard to the origins: global, elsewhere: France; the immediate future.

PART OF ENERGY SYSTEM CONSIDERED: Primary energy (oil, gas, coal, nuclear).

PRICE PROJECTIONS: Derivation of CIF costs of various fuels. To estimate the potential profitability of their production, the average annual growth rate of the international oil price is assumed to be 3.5%.

COMMENTS: Not directly a study on the future oil prices which, however, play a crucial role in application of the results. Also, the prospective costs of oil competitors have an influence on future oil prices.

STUDY NAME: *OPEC and the World Oil Outlook*

ABBREVIATION: EIU

REFERENCE: The Economist Intelligence Unit, February 1983, Special Report No. 140, by B. Mossavar-Rahmani and F. Fesharaki [1].

APPROACH: Informal scenario about the nature of demand for OPEC oil in relation to global economic growth.

(a) Methodology: Assessment of the market "rules" by a former member of OPEC ministerial conferences.

(b) Base Year: 1981.

(c) Assumptions: None in the usual sense of the word. A hypothesis is formed on the basis of observations.

(d) Results: The same forces that drove down demand for OPEC oil in the early 1980s will probably drive it back up over the next three years because OPEC is the world's "swing producer" of crude oil, which multiplies any percentage of change in global oil consumption into a much higher percentage change of OPEC's oil production.

MAIN OBJECTIVE: To analyze short- to medium-term developments of the world oil market.

SPATIAL AND TEMPORAL COVER: World demand for oil and OPEC production, scenario for 1985-1990.

PART OF ENERGY SYSTEM CONSIDERED: OPEC production capacity and world demand for OPEC oil.

PRICE PROJECTIONS: Only qualitative estimates are given, with the conclusion that the volatile mixture of oil and politics will lead again to a disruption of supplies and higher prices (and further oscillations).

COMMENTS: No quantitative forecasts are given. However, the mere description of the so-called "OPEC multiplier" amounts to a projection of further oscillations of the future oil price.

STUDY NAME: *World Oil, Summary Report*

ABBREVIATION: EMF

REFERENCE: Energy Modeling Forum (EMF), Stanford University, Stanford, USA, February 1982 [14].

APPROACH: "Pooling" of different models: a standardized set of input data is used by different models, the results of which are then compared.

(a) Methodology: Obviously, different methods are used by the different models. Many, however, use price reaction functions to determine oil prices.

(b) Base Year: 1980 (81).

(c) Assumptions: The standard set of input data consist of 12 scenarios on economic growth, price elasticities, OPEC production capacities, and other variables. These 12 scenarios are used to define input data for the ten models used.

(d) Results: Future oil prices are highly uncertain, but there is an unmistakable upward trend.

MAIN OBJECTIVE: To project the possible future evolution of the "world" (only the market economies are considered) oil market under a range of plausible situations.

SPATIAL AND TEMPORAL COVER: Market economies, 1980-2000.

PART OF ENERGY SYSTEM CONSIDERED: Crude oil as primary energy carrier and unspecified "backstops".

PRICE PROJECTIONS: The 2000 oil price range for the reference case is $42-90/bbl (1981 dollars), dependent on the model. In the "disruption-low demand elasticity" scenario, oil prices go as high as $417/bbl (1981 dollars).

COMMENTS: The EMF study examines many variables that influence future oil prices and assesses their impacts separately, thus distinguishing between the uncertainties of the variables themselves and the uncertain effects of their change. The overall result is a large number of "point forecasts", with no unambiguous pattern other than that practically all of them represent an increase of the real price of oil.

STUDY NAME: *ETA-MACRO: A User's Guide*

ABBREVIATION: ETA-M (EM)

REFERENCE: EA-1724 Electric Power Research Institute, Palo Alto, February 1981 [15].

APPROACH: A combination of a macroeconomic growth model and a process analysis for energy technology assessment.

(a) Methodology: The market economy is simulated over time. Energy supply, demand, and prices are matched through a dynamic linear programming model.

(b) Base Year: 1980.

(c) Assumptions: Potential GNP growth, elasticity of energy demand substitution, price of imported oil, data on energy conversion technologies, and availability of natural resources.

(d) Results: Realized GNP growth, energy demand, and energy supply by fuel.

MAIN OBJECTIVE: Check the logical consistency of competing assumptions about energy futures.

SPATIAL AND TEMPORAL COVER: 1980-2000; Canada; China. (See also the comment below.)

PART OF ENERGY SYSTEM CONSIDERED: All primary energy.

PRICE PROJECTIONS: $46-53/bbl (1980 dollars) for the oil price in the year 2000.

COMMENTS: This description refers to the user's guide of a model that can be applied to a variety of geographical regions and for a variety of assumptions. The figures reported in this paper refer to a run of ETA-MACRO for Canada by J.S. Rogers and T.F. Wilson (University of Toronto) and to *ETA-MACRO Projections for China* by A.S. Manne, November 1982.

STUDY NAME: *The Future of Oil: A Reevaluation*

ABBREVIATION: Odell (CIES)

REFERENCE: K.E. Rosing and P.R. Odell, Eurices Paper nr. 83-1A, Erasmus Universiteit Rotterdam, 1983 [3].

APPROACH: Pre-1973 estimates of the then-economic oil reserves and contemporary oil demand estimates are combined.

(a) Methodology: Determination of "long-run supply prices" as a function of cumulative oil consumption.

(b) Base Year: 1982/83.

(c) Assumptions: The rapid growth of pre-1972 oil consumption was based on unique conditions.

(d) Results: There is growth potential for the global oil industry until at least 2015.

MAIN OBJECTIVE: To show that the near-consensus view that oil resources are seriously limited is too pessimistic and inappropriate.

SPATIAL AND TEMPORAL COVER: World, 1948-2080.

PART OF ENERGY SYSTEM CONSIDERED: Conventional and unconventional oil.

PRICE PROJECTIONS: In the main scenario the oil price is projected to be below $25/bbl (1980 dollars) in the year 2000.

COMMENTS: This study represents a "heretical" view of the future of oil, backed with extensive reasoning. It makes one wonder why none of the more than 100 projections by the EMF (which can be viewed as representing the "conventional wisdom") comes anywhere near the Odell/Rosing scenario. It would seem most interesting to investigate this discrepancy in more detail.

STUDY NAME: *The Outlook for Primary Commodities*

ABBREVIATION: World Bank (WBK)

REFERENCE: World Bank Staff Commodity Working Paper Number 9. The World Bank, Washington, DC, U.S.A., January 1983 [16].

APPROACH: Global energy demand and supply are projected by country and/or by region. A world market price of primary commodities links the models for the countries/regions. Prices are the result of a balancing procedure of demand and supply equations.

(a) Methodology: Econometric models for each country/region with a common structure, including a supply block, a demand block, and an inventory demand equation, normalized on price. Longer-term prices are derived in a less formalized way.

(b) Base-Year: Historical data up to 1982.

(c) Assumptions: Competitive conditions, i. e., utility maximization on the demand side and profit maximization on the supply side.

(d) Results: Short- and long-term price outlooks for major commodities, including energy. Quantities are also derived.

MAIN OBJECTIVE: The study is mainly designed to help estimate future balances of payments and appraise investment prospects.

SPATIAL AND TEMPORAL COVER: Whole world, disaggregated into countries/regions, which are grouped into industrialized, centrally planned, and developing regions. Time horizon: 1995.

PART OF ENERGY SYSTEM CONSIDERED: Energy demand (including structural changes and conservation and rate of economic growth), production capacities of each major energy source (oil, coal, gas, nuclear, hydro).

PRICE PROJECTIONS:

Price (in 1981 $/bbl)

	1981	1985	1990	1995
OPEC Petroleum	34.3	32.0	37.0	41.0

COMMENTS: A large number of variables interacting in a system not smaller than the world economy are estimated, yielding a single projection. This has the virtue of describing a consistent picture, but questions arise as to the sensitivity of the results and their uncertainty range.

STUDY NAME: *The Energy Transition in Developing Countries*

ABBREVIATION: World Bank (WBK)

REFERENCE: The World Bank, August 1983, Washington, DC [17]

APPROACH: Base year 1980 with historical data for 1970. Also, some references are made to the actual 1982 situation. The methodology is not described explicitly, but it is stated that energy supply and demand prices do depend on the future pace of world economic growth.

(a) Methodology: Projections are obviously based on scenarios of future economic development and other factors determining energy prices and consumption, but no reference is made as to whether formal models were used.

(b) Base Year: 1980.

(c) Assumptions: A major assumption is that the current softening of oil prices will not cause any fundamental changes in the long-run trend of rising energy prices.

(d) Results: Primary energy consumption scenarios by energy source with a discussion of possible policy and price consequences.

MAIN OBJECTIVE: To examine strategic issues concerning the assurance of economic growth and development, despite higher costs of energy, mainly from a developing country's perspective.

SPATIAL AND TEMPORAL COVER: The report deals with developing countries, while Chapter 1 gives the global energy outlook. The spatial disaggregation of the world is limited to developing countries and the rest of the world. The time horizon is 1995.

PART OF ENERGY SYSTEM CONSIDERED: Only primary energy consumption is considered explicitly and is projected to grow at 2.3% per year during the 1980-1995 period, with the oil share decreasing and the share of coal and nuclear power increasing.

PRICE PROJECTIONS: The report discusses the considerable uncertainty about the precise rate of price increases during the next decade. It is maintained that it is extremely unlikely that the price of oil in the mid-1990s will be below its current level in real terms and that a price range of, say, $20-25/bbl would not be sustainable in the longer run in any case.

COMMENTS: The global outlook represents only a short commentary (the first chapter in a voluminous report) on the energy prospects and financing requirements in developing countries. The analysis of oil prices is very brief and represents the "common wisdom" of softer prospects in the short run and increasing real prices in the long run.

STUDY NAME: *The Price of Crude Can be Controlled by the Cost of Methanol*

ABBREVIATION: Deam

REFERENCE: R.J. Deam and C. Giesecke, Programme Group on Systems Research and Technological Development, Jülich Nuclear Research Centre (KFA), April 1983 [18].

APPROACH: A somewhat extreme scenario is described to demonstrate the potential usefulness of a particular technology (i.e., the methanol route).

(a) Methodology: Hand calculations, supported by a large linear programming model with a price-elastic demand function. (A model description was published in 1976.)

(b) Base Year: 1983

(c) Assumptions: Methanol will be available in large quantities at total FOB costs of $52/t if produced from natural gas or at $135/t if produced from coal. The end-use technologies for methanol will be available.

(d) Results: Crude oil prices can be limited to $10-12/bbl in real terms for more than 40 years and to $24/bbl for at least another 40 years. Governments of oil consuming countries could (by proper taxation) reduce the producer price to even $4/bbl.

MAIN OBJECTIVE: To increase the number of options being considered by describing an "unconventional" system of liquid fuel supply, which could be highly competitive if there existed an appropriate infrastructure and if the raw materials for the methanol production (primarily natural gas) were available at prices that do not include a high profit margin.

SPATIAL AND TEMPORAL COVER: Global, next 80 years.

PART OF ENERGY SYSTEM CONSIDERED: Mainly liquid and gaseous fuels (also from coal). Consequences described in all main parts of the energy system.

PRICE PROJECTIONS: Maximum crude oil price $10-12/bbl for more than 40 years, thereafter $24/bbl for at least another 40 years. During the shift period OPEC will go to maximum production.

COMMENTS: A target scenario is described, the likelihood of which is not discussed. A path to the target is not described either. Nevertheless, the study marks a characteristic point in the set of *all* possibilities.

STUDY NAME: *Gas Research Institute Baseline Projection of US Energy Supply and Demand, 1980-2000*

ABBREVIATION: GRI (GRI)

REFERENCE: Prepared by T.J. Woods, R.H. Holt, J.T. Rasmussen, D.A. Dreyfus. Gas Research Institute (GRI), January 1982 and October 1982. [19].

APPROACH: Economic and energy modeling supplemented by judgmental considerations.

(a) Methodology: A macroeconomic model by DRI (Data Resources Inc.) to generate a detailed economic projection; a second (modified) DRI model to develop a preliminary energy projection; and an EEA (Energy and Environmental Analysis Inc.) model to study the industrial sector fuel demand. Preliminary model results were finalized through some iterations of judgmental modifications (e.g., for macroeconomic effects of economic growth assumptions and sectoral energy demand as a function of macroeconomic indicators).

(b) Base Year: 1982.

(c) Assumptions: GNP growth and major fuel prices; no technological breakthrough is assumed. Also, a cost-based determination of natural gas prices in a free market is assumed.

(d) Results: Consistent and "comprehensive baseline projection of future energy supply and demand" with price projections of gaseous fuels.

MAIN OBJECTIVE: To provide a baseline from which the potential impacts of GRI's research and development program can be evaluated.

SPATIAL AND TEMPORAL COVER: The United States; 1980 to 2000.

PART OF ENERGY SYSTEM CONSIDERED: Primary energy with emphasis on gas supply and demand. Prices, production, and import of various gaseous fuels are also considered in greater detail.

PRICE PROJECTIONS: Crude oil price assumptions result in a price of $43/bbl (1980 dollars) in 2000. GNP growth is 1.85% per year for the US. These values represent rough averages of the January and October reports.

COMMENTS: The oil price is not the focus of the work described. However, it is a crucial parameter for the results obtained.

STUDY NAME: *World Energy Outlook by the International Energy Agency*

ABBREVIATION: IEA (IEA)

REFERENCE: International Energy Agency, OECD, Paris, 1982 [20].

APPROACH: Global oil demand and supply are estimated to assess the vulnerability of OECD economies to oil supply disruptions.

(a) Methodology: Econometric energy demand models are used to derive demand for major end-use sectors. Judgmental projections of future energy supply.

(b) Base Year: 1980.

(c) Assumptions: Two main scenarios; one with a constant real oil price, and one with a higher oil price and a lower demand.

(d) Results: "Tight" oil markets after the mid-1980s; energy demand in 2000 much lower than 1979 projections.

MAIN OBJECTIVE: To assist OECD governments in their role of minimizing the damage of hypothetical oil supply disruptions.

SPATIAL AND TEMPORAL COVER: World, 1980-2000; policy conclusions for OECD countries.

PART OF ENERGY SYSTEM CONSIDERED: Energy chain from primary to final energy with an emphasis on primary energy.

PRICE PROJECTIONS: An oil price of $28-45/bbl (1981 dollars) in 2000.

COMMENTS: The IEA does not project consistent scenarios but leaves gaps between oil demand and supply.

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