JUDGEMENTAL PROGRAMMING

AND

AN EXAMPLE FOR INVESTMENT PLANNING

by

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ABSTRACT

This work presents an attempt towards unstructured interactive methods to find solution to multicriteria real life problems.

The text consists of two parts. In the first part modelling in OR and its inherent gaps, the development in computer technology and solution tools and their limitations including interactive approaches are discussed. The proposed approach, Judgemental Programming (JP), is briefly presented and the expected advantages are stated. JP approach can be summarized as using the computer as a fast work sheet in decision making getting answer to "what if?" type of questions.

In the second part, the electricity investment problem of Turkish Elektricity Authority (TEK) is analyzed and potential approaches are discussed. The JP approach and formulation are presented and discussed in detail within the example. Results of experiments and critiques on the experimental software of Industrial Engineering graduate sudents who performed and reported experiments are also included in the text.

In the experiments, to schedule some projects, knowing specification and marginal contributions of each, to satisfy power and energy "targets" using local and foreign currency investment and operation budgets, over a planning horizon 10-30 years is aimed. The "decision criteria" presented in the text, such as unit cost of energy, value of non depreciated assets at the end of planning horizon and revision modules which were omitted in the 1983 experimental version are included in the final version of the software. Data, program sources and all relevant information with respect to the example and the software are presented in Appendices.

ÖZET

Bu çalışma, gerçek hayatta karşılaşılan çok amaçlı problemlere çözüm bulmak üzere geliştirilen, yapısal olmayan etkileşimli bir yöntem denemesidir.

Konu iki bölüm halinde sunulmuştur. Birinci bölümde, yöneylem araştırması modellerinin yapısal eksiklikleri, bilgisayardaki ve etkileşimli yaklaşımlar da dahil olmak üzere çözüm araçlarındaki gelişmeler ve getirdikleri sınırlamalar tartışılmıştır. Önerilen yaklaşım, muhakemeye dayalı programlama, kısaca anlatılmış ve umulan üstünlükleri belirtilmiştir. Muhakemeye dayalı bu programlama yaklaşımı, bilgisayarın karar verme sürecinde, "eğer şöyle olursa ne olur?" şeklindeki sorulara cevap aramada hızlı bir müsvedde kağıdı olarak kullanılması şeklinde özetlenebilir.

İkinci kısımda ise Türkiye Elektrik Kurumunun elektrik yatırım planlama problemi incelenmiş ve muhtemel yaklaşımlar tartışılmıştır. Sunulan örneğin çerçevesi içerisinde, muhakemeye dayalı programlama yaklaşımı ve formülasyonu detaylı olarak sunulmuş ve tartışılmıştır. Aynı bölümde Endüstri Mühendisliği lisans üstü öğrencilerinin deneme yazılımı ile yaptıkları çalışmaların sonuçları ve eleştirileri de yer almaktadır.

Bu deneylerde, özellikleri ve marjinal katkıları bilinen projelerin, hedeflenen güç ve enerjiye ulaşmak amacıyla, TL ve döviz yatırım ve işletme bütçelerini kullanarak, 10-30 yıllık bir planlama ufku içerisinde projelerin seçimi ve zamanlamasının tesbitine çalışılmıştır. Tez kapsamındaki, 1983 te geliştirilen deneme yazılımında yer almayan enerjinin birim maliyeti, planlama dönemi sonunda tamamı amorti etmemiş tesislerin değeri gibi karar kriterleri ile revizyon modülleri de son yazılıma dahil edilmiştir. Kullanılan data, programlar ve örnekle ve yazılımla ilgili gerekebilecek her türlü bilgi ekler halinde çalışmanın sonunda yer almaktadır.

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I. INTRODUCTION

It seems that, especially following the Second World War, businessmen, governments and other adminstrators are more concentrated on computers and on mathematical tools to solve their problems.

During the recent years the impressive progress in this field reached to such a level that for most people it became very difficult to follow and understand the developments. Despite the knowledge, effort and experience accumulated every day, utilization of these tools did not match the advances. Besides the technical ones, one of the major difficulties in their use has been in communicating with and in gaining confidence of decision maker (dm) and his staff which may be unfamiliar to the presented sophisticated approaches which may reduce their contribution and the chance for fair implementation of solutions.

Because of the sophistication and diversification in solution tools, by the time, even specialists in this field faced with communication problems. Learning, understanding and especially adapting and using a sophisticated tool became very difficult for most of the time even for those with necessary background.

The reason behind this situation seems that by the progress in computer field people are more concentrated on algorithms, mathematical proofs and creation of artificial intelligence while largely omitting the tremendous judgemental ability of the human being and the need for simplicity, accuracy and the absolute necessity of gaining the dm's confidence.

Taking into consideration the inverse relationship between the mathematical and algorihmic development and practicability of the provided tools, new user-friendly approaches seems to be necessary. In the past, the development in solution tools had to follow the path of the developments in computer technology and naturally limited and oriented within this path. Indeed at early stages today's computer technology was not expectable. Solution tools created for early computers are largely revised and dimensions are enlarged up today, but the approach remained mainly the same as being the structuring of the decision making process.

Today, it seems that, instead of using the computer as a decision machine and instead of the effort of structuring the decision making process and trasferring the human judgement and abilities to the computer as made up-today, there is room to use the computer as a work sheet to emphasize the direct use of the human abilities.

Such an approach is tentatively called in this thesis as Judgemental Programming (JP).

JP does not refuse the use and utility of other available techniques but presents itself as a user-friendly tool in decision making giving emphasis to human judgement. Once supported with a reliable data-base, author's belief is towards that the dm won't be afraid to use it and such an approach would be at least a bridge between dm and analysts. This way both dm and analysts would have the occasion to focus their effort on bases for decision making and on reliable information systems rather than on sophisticated solution tools.

II. JUDGEMENTAL PROGRAMMING

II.1. Search for Solution in OR via Modelling

Most of the time, Modelling constitutes the core of the Operational Research (OR) practice. An OR model can be defined as an idealized representation of a real life system. In all modelling attempts the real world system is analyzed for definition of problem and at this stage the real world system is usually transformed to an assumed real world to form a base for the model (1).

The complexity of a real system results from the very large number of elements controlling the behaviour of the system. However, although a real situation may involve a substantial number of factors, a small fraction of these elements assumed to mainly dominate the behaviour of the system. Determination of these elements and formulation of their interrelations constitute the core of the modelling practice.

This stage is quite critical because the model developed according to the determined elements and interrelations may not fairly present the real world system. Because of that risk, the model is usually tested to ensure that there exist no significant deviations between the real life results and behaviour presented by the model, so that the model can be used to achieve certain objectives in the real life. The better is the model, more the results obtained from the model and in the real life are similar.

Usually the elements, which may be controllable or not, and the interrelations between them are expressed as mathematical variables and functions to present the real world, which is called mathematical modelling.

Mathematical modelling assumes that all relevant variables are quantifiable. The variables may be represented by symbols and then related by the appropriate mathematical functions to describe the behaviour of the system. Such models usually permit to reach "best" results through mathematical tools and algorithms. Towards the development of OR, mathematically proven "best" results focused the attention of people in this field, on the development of these tools. The development in computer technology providing higher computational speed and storage-retrieval facility encouraged the concentration of people on mathematical modelling and optimization.

Despite the availability of modern computers, more often mathematical formulations are too complex to allow an exact solution or the computations to achieve proven "best" results, that is optimum solutions, are unsupportable or infeasible. In these cases heuristics appeared to bring acceptable good solutions for most of the time. The heuristic approach relies on the intuitive or empirical rules that, given a current solution to the model, allow the determination of an improved solution. Also in most of the cases simulation models are to be used, which are not limited with a range of mathematical functions to relate variables. This usually provides the possibility of a more accurate representation of the real life (1). However it seems that, heuristics and simulation received less credit with respect to analytical techniques and optimization tools, in the OR world, as they required most of the time special designs and significant efforts to obtain mathematically unproven results.

Returning back to mathematical modelling, once a mathematical model is constructed, which already brings a modification of the real life, it is often necessary to simplify it by converting discrete variables into continuous ones, linearizing the nonlinear functions, eliminating some of the elements affecting the system behaviour, integrating all objectives in a single criterion and so on, until it becomes analitycally solvable or computable.

By nature, in any case modelling deforms the real life situation and mathematically proven "best" result, the optimum solution, remains the best solution for the model but not necessarily for the real life situation. In practice it is very difficult to include all objectives and all elements affecting the system behaviour in a model more often because no solution technique is available for such formulations which could more fairly represent the problem. Usually OR analysts feel themselves restricted by available tools and the real life problems are deformed until they become "solvable" by the available tools. More deformation of the problem results with lesser confidence on the results obtained. An optimum found for the model may not be the best solution even for the model according the dm's criteria. Besides this, one of the major problems inherent to model building is that using most mathematical tools some real life objectives are too intangible to allow acceptable quantifications.

Models, regardless of their sophistication and success to reflect the real life situation, are fed with data. So, obviously, the success in the solutions completely depends on data as the best solution is only the best for the data fed. In most cases providing sufficient and reliable data may not be easy or even possible. Besides that, regardless how accurate and sophisticated is the model, data prepared or found for a model are often aproximate solutions of other models. For example, a unit cost generally includes part of fixed costs and overheads according to the applied cost accounting procedures or a forecasted price for a planning period is the solution of a forecasting model. These data are then used to find for example the optimum product-mix using a mathematical optimization model. In solution models output of various models are used as data for the solution models as in these examples.

Then, the best solution is the solution for solution models plus for the data models and obviously there is no guarantee to prevent occurance of significant gaps between desired and actual results upon application of the model's solutions. More sophisticated the models and the related supporting ones are, one may end up with more uncertainty and bias on the solution found and more risk to fall far away from desirable solutions with respect to the real life situation. Taking the whole problem solving process into consideration, concentration occured on solution tools, and models are developed under the assumption that data can be obtained and the model's results are discussed under the assumption that both model and data fairly represent the real life. Although many algorithms an solution tools are developed no rules suggested for data collection and feed while the end results badly depends on these steps and where the solution model is relatively a small part (2).

II.2. The Gap Between Models and Decision Makers

Because of the approximations and deformations in problem solving and decision process due to complexity of problems in real life situation, it is difficult to explain and gain the confidence of dm and his staff on the models and on solutions unless they are specialized on the proposed tools and approaches. Actually most real life situations do not involve single dm.

Unless the dm and analyst are the same people, in classical tools, usually the analyst has to switch between the tool, ie. the model, and the dm just similar to a mediator between two people never met and speaking different languages can not communicate. Most of the time, search for a solution to most of the real problems becomes a coordinated team's problem, an OR team, including experts on the system and facts about the system and experts on approaches and solution tools. Formation of such a team may not be always easy and possible. The dm and/or those responsible for operations, as well as the analysts may not be available as much as necessary and willing enough to contribute to such a team in most real life situations.

More often people involved in creating mathematical tools and developing analysis and solution techniques are those outside of organization and have little information on organizational and environmental facts and value system of dm(s). Vice versa dm and his experts may have little information on proposed tools, little time or little desire to learn them. They may probably have also little confidence on tools strange to them. Scientist and analyst have usually to invest time to learn about organizational, operational and environmental facts as well as about the dm's value system, dm and his staff has to learn what's going on to be able to evaluate the obtained results. However usually the investment is expected one way from analysts and scientists.

Once the obtained solution is accepted and approved by the dm, implementation of models usually requires "translation" of model's results into operational instructions understandable by the people in the organization. This step also requires cooperation and coordination of analyst and executives, where analyst has to be again a bridge between the solution tools and the executives. As especially potential implementation problems are usually opaque to the analyst, and as usually he does not have enough understanding and knowledge on the system and implementation potential of the prospective solutions, this cooperation and participation should be carried out infact during the whole process.

Besides the other factors inherent to model building, it seems that many solutions found via classical solution tools remain unimplemented due to lack of sufficient cooperation of the people who have authority and responsibility for operations and implementation of the results. Usually both the tools and approaches remain opaque to them. Approaching to dm's value system, organizational and environmental facts results with higher complexity and sophistication in models. Trying to get experience and especially value system of dm is usually very hard more often because stated and unstated factors may be different and even conflicting. Classical approaches in the search of solution do not permit the analyst to withdraw himself between the dm and the solution to the problem and usually do not permit the dm to be able to reach, understand and defend solutions to the problem himself.

II.3. Gaps in Basic Solution Tools

When the well known simplex method was developed in 1947 by the American mathematician George B. Dantzig, this has been a huge step in OR and has been the base for most of mathematical formulations (3). Linear Programming (LP), as a class of mathematical programming models, is concerned with efficient allocation of limited resources to known activities with the objective of meeting a desired goal such as maximizing profit or minimizing cost. The distinct characteristic of LP models is that both the functions representing the objective and the constraints are linear (4).

In the strict sense, Integer Programming (IP), another well known mathematical programming class, defines a nonlinear problem ,since the different functions of the problem are defined only at discrete values of the variables. However a problem is considered linear, if dropping integer restriction the equivalent continuous problem is linear. Then, it may be observed that currently all known integer algorithms are directly or indirectly based on the continuous version of the integer problem (5).

Although very large LP models have been successfully solved in a reasonable amount of time IP computational time drastically increase and becomes practically unsolvable by the current hardwares for many real life problems. Many successful attempts made in this area to develop specialized algorithms for specific problems such as transportation, allocation problems to overcome computational infeasibilities. These computational infeasibilities forced the users to find alternative ways to achieve desirable solutions for integer problems. One of the largely used approach is to solve the continuous version of the problem and then round-off the variables to closest feasible integers. However for many integer and binary problems rounding approach does not bring a meaningful solution. For example, for an investment problem where variables are zero or one meaning to realize or not a project, dealing with fractional values, and the use of rounding as an approximation is logically unacceptable.

Dividing the problems into subproblems and branch and bound techniques are generally proven superior and nearly all available commercial codes are based on this approach. However dimensional infeasibility still remains for many real life problems for available hardwares.

Dynamic Programming (DP) is another mathematical technique designed primarily to improve computational efficiency of certain optimization problems. The idea behind it is to decompose the problem into subproblems or stages which are computationally more manageable and optimize each subproblem over its alternatives only so that it is never necessary to enumerate all combinations in advance. All non-optimal combinations are discarded as optimization applied to each subproblem. Then subproblems are linked together avoiding to optimize over infeasible combinations. But there is no guarantee that such subproblems are easily solvable. In DP an increase in the state variables results an increase in the number of evaluations for the different alternatives at each stage. This presents a serious obstacle in solving even medium size OR problems. This obstacle is knownn as "curse of dimensionality" as called by R Bellmann, or as dimensionality problem (6).

II.4. Recognition of Multicriteria

In OR most of the specialized models such as CPM-PERT, inventory models, simulation or queueing models or decision models usually deal with one goal at a time.

However the goal representing the "major" portion of the system may not be meaningful or suitable for the entire system. It may not be possible to fit models presenting the entire system compatible with the complex nature of the decision process. Most real decision situations are characterized by multiple objectives or goals rather than by single objective. Organizational objectives may vary according to the character, type, phylosophy of the management as well as the environmental conditions which are all time-variant. Profit maximization which is regarded as the sole objective of the business firm in the classical economic theory is one of the most widely accepted objectives but in fact a wide range of political, social, economic and ethical aspects have been quite often received higher priorities as organizational goals by business firms and other organizations. Then it appears that in fact, the rational dm tries to achieve a set of multiobjectives to the fullest extent in an environment of conflicting interests, limited resources, incomplete information and limited time and ability to analyze the problem and the environment, in order to bring a "good" solution.

In recent years OR activities tended towards recognition of multicriteria. However few of them are generally accepted and introduced into text books.

Returning to the single objective mathematical model, it is consisted of two parts; an objective function to be minimized or maximized and a set of constraints for the technological and mathematical limitations. In a feasible problem these constraints form a multidimensional space, or in scientific terms a convex polyhedron where achievement to an extreme point is aimed to obtain the "optimum" while maximizing or minimizing the objective function.

Considering what may be done if there exist in fact more than one objective and if these objectives are conflicting, one way may be to solve the problem for each different objective and present a set of solutions to the dm. These generated efficient extreme points may not make sense for the dm if he may not neglect the solutions achieved for the objectives other than the most important.

Choosing only the solution for one extreme point, neglecting all other objectives seems very much like to single objective approach, and in fact in this case single objective models as much as the number of objectives have been solved. So in this approach the dm has a set of solutions and can choose one of them by means of classical utility theory, as maximize the maximum or minimize the minimum achievement, minimize the maximum regret or others.

Actually, in real life problems selection of a single extreme point achieved by only one of the conflicting objectives is rather a rare case and the dm would prefer to have one solution rather than a set of solutions.

One interesting approach may be to find the center of gravity of the achieved extreme points according to the weights of conflicting objectives where none of them will be neglected. In such an appoach the total regret of not being achieved to any of the objectives will be minimized and at such a point the dm may feel himself disagreable to shift towards any one of the objectives if the weights are well chosen.

Instead of taking the problem as a set of objectives plus a set of constraints, an implication of Kuhn-Tucker approach (7), is that one of the objectives can be taken as the primary one and the others can be treated as constraints where for each of these constraint-objectives, minimum satisfaction levels may be set. Thus the total distance within efficient extreme points will be decreased and to decide on a single solution in this decreased solution space will be easier.

In real life problems the constraints are not as strict as mathematically expressed in constraint sets. That is, a budget constraint in the constraint set for example may be increased or decreased according to the degree of satisfaction of the primary objectives. The usually proposed methodology is to set the preferences of the dm in the constraint set and then sequentially alternate preferences in this set squeezing the convex polyhedron.

Different approaches and solutions are developed since 1950's to obtain a solution to multiobjective problems and researches on this area are still in progress. Several approaches are categorized by Cohon and Marks (8) as follows:

i) A priori articulation of preferences and generating a single relevant solution,

ii) Generating efficient solutions and then selecting the prefered solution among these by subjective evaluation,

iii) Progressive articulation of preferences and arriving at the prefered solution in an interactive manner.

One of the popular approaches in the multicriteria field is directed towards the search for the non dominated solution set or the most efficient set. Such an approach brings into a model with m constraints and Q objectives. Summarizing this approach taken in solving the problem, is first to determine the total set of all non-dominated basic solutions. The set of all non-dominated solutions is then a convex combination of the non-dominated solutions.

Setting:

Zq; (q= 1, 2, ..., Q) to be the achievement value of the qth objective for any solution that satisfies all m constraints;

Z'=(Z1, Z2, ..., ZQ) vector valued achievement function ordered only according to Z1, Z2, ..., ZQ wherein no priorities have been assigned to any of the associated objectives.

Thus, if:

Z'(1) = (Z1(1), Z2(1), ..., ZQ(1)) is a given solution satisfying all the absolute objectives, and;

Z'(2) = (Z1(2), Z2(2), ..., ZQ(2)) is any other solution satisfying all absolute objectives, then it is said that Z'(1) is dominated by Z'(2) if ZQ(2) < ZQ(1) for all q = 1,2, ..., Q otherwise Z'(1) is a non-dominated solution (9).

However little success reported for cases exceeding two criteria (10).

II.5. The Goal Programming Approach

An important technique for solving multiple objective problems involving the multiple allocation of scarce resources is goal programming (GP), which was developed by Charnes and Cooper (11) as a means of resolving infeasible linear programming problems and then extended and refined by Ijiri (12), Jaaskelainen (13), Lee (14) and Ignizio (15).

GP method is based on the minimization of weighted absolute deviations from targets for each objective specified by the dm. These objectives are called as goals and these goals set by the management are often achievable only at the expense of other goals. Furthermore these goals are incommensurable, in other words, non-measurable on the same unit basis. There is also a need to establish a hierarchy of importance among these conflicting goals so that lower priority goals are considered only after the higher priority goals are satisfied or have reached the point beyond which no further improvements are desirable.

GP models seem very much like LP models but the idea behind it and the selection of techniques are different from the LP. In GP, instead of trying to maximize or minimize the objective criterion like in LP, positive and negative deviations from the GP objectives are tried to be minimized as follows:

LP expression	GP equivalent
$a1x1 + a2x2 = b$	min $n+p$ $a1x1 + a2x2 + n - p = b$
$a1x1 + a2x2 > b$	min n $a1x1 + a2x2 + n - p = b$
$a1x1 + a2x2 < b$	min p $a1x1 + a2x2 + n - p = b$

where n's are negative and p's are positive deviations.

Then the objective function becomes the minimization of these deviations based on the relative importance or priority assigned to them. What differs GP from LP is that the targets are sequentially achieved according to these priorities without losing the targets already achieved.

In the presence of incompatible multiple goals the dm needs to exercice his judgement about the importance of the individual goals. In other words, the most important goal must be achieved to the extent desired before the next goal is considered. The most widely used method which is an approach that may be used when a single decision maker is asked to rank objectives is paired comparison. The essence of the procedure is to compare objectives, two at a time, until all possible pairs of objectives have been investigated (15).

The paired comparison test will only work if the dm is consistent in his judgements. If an inconsistency exists as G2 > G1 (that is, second goal is more important than the first), and G1 > G3 but G3 > G2, the problem has to be reviewed by the analyst and dm so as to clarify the situation. Another approach may be to divide the goals into sub-goals or regenerate new goals until all inconsistencies are clarified.

Once the objectives have been ranked, they have to be grouped into a minimum number of priority levels. Again except for the first priority level where all these objectives should strictly be satisfied, all objectives within a given level must be commensurable. As stated by Jeffery L. Ringuest and Thomas R. Gulledge, Jr. (16), this restriction may lead to priority assignments that are purely artificial. That is goals that are of equal importance may be placed in different priority levels only because they are incommensurable. In addition, it may be dificult in practice to assess the goal weights within priority levels. Researches to overcome such restrictions are still in progress and significant improvements have been realized (16).

II.6. Impact of Computer Technology on OR

The progress in the field of OR following the Second World War has been due in large part to the parallel development of the digital computers. The tramendous capabilities in computational speed and information storage and retrival of computers have been the major source of encouragement for OR practice.

Remembering the development curve of computer technology since 1950's starting with Eniac, the first computer generation with size of a large room and a power requirement of around 150 kW is replaced by the first half of 1980's by microprocessors with same capacity and with tramendously higher speeds. The operation speed increased from two or three, to over 10 million operations per second. Trying to compare the development of computer industry to another one is very difficult. However if it would be possible to compare to the otomotive industry for example, it seems that if the development was similar during this period, it would be possible to buy a Rolls-Royce to $1 or 2 and this car would go three million miles with only 4.5 liters, the power would be equal to that of Queen Elizabeth II and it would be possible to reduce the size less than 0.01 mm square. This comparison is made in terms of size, cost, power requirement and so on to give an idea for the development of computers which is often underexpected.

The development in computer technology is very prospective. By the second half of 1970's the elements installed in a single chip increased 100 times and by the end of 1980's a performance over 10 000 times is expected for same costs. The cost of a computer circuit arond $1 Million at 1955 decreased by the beginning of 1980's to lower of $2000 and the decrease expected for better circuits to lower than $10 before 2000's. The size of today's microprocessors is expected to decrease to the size of a salt crystal and 13 picoseconds circuits seems to be available in the near future (17). It seems that in a very near future this expected developments may be considered as underestimated.

Starting from 1975 especially after 1977 the great development observed in microcomputers made available the capacity and speed of mainframes to scientists and businessmen at affordable costs. This development may recall to most of the readers the innovation of the printing machine by Gutenberg which made available and affordable books to a very wide range of people.

Observing the development of computers and the OR practice, at the very beginning stage it was the computer being hardly available and very expensive with respect to human time. Hence algorithms had to be developed to efficiently and effectively use the limited and very precious time of computers.

At this stage it was not reasonable and acceptable for people to use alone the very precious time of one of the hardly available mainframes on the World for hours or days to solve a problem by trial and error or a similar approach. That has been the main reason of the development of the batch oriented decision systems and approaches and the emphasis on solution algorithms . The important thing was to achieve the solution at once as quickly as possible without wasting the precious computer time. Despite the development with respect to computers, batch oriented mathematical approaches have not been able to show a parallel development to the computer technology. Even today most people first remember the simplex algorithm and batch oriented formulations while speaking on OR.

By the time, tramendous development of computers made irreasonable the development of algorithms to save the computer time. Today, computer is largely available to most people like books have became available once after Gutenberg. They may be used as an interactive tool for decision production. In today's technology, feasibility studies have to be made between scientist time to develop algorithms and solution tools to solve a specific kind of problem, analyst time to adopt the scientific tool to the real life situation and dm's time for understanding and satisfaction on process and results for final decisions.

II.7. Interactive Optimization Trials

Development and availability of computers and development of mathematical tools towarded attention of OR scientist on the development of interactive decision and optimization tools.

First attempts were made mainly to make easier the process of running batch programs, obtaining results, changing parameters and running them again and again via on line devices. These attempts were very little different from batch problem solving, however by these attempts emphasis on human factor is introduced like the design of screens, interactive messages, emphasis on response time and so on. Other attempts are more often made because of dimensionality problems. Instead of trying to get results at once, problems are tried to be decomposed and each subproblem is tried to be solved interactively before being integrated. This way the data are fed where and when necessary. These kind of interactive optimization attempts mainly aimed better utilization of computer facility.

Sophistication, dimensionality and lack of dm's confidence while approaching to real life in models still remained for most problems. Throughout this development, in approaching to real life in modelling and solution techniques, major steps has been the recognition of multicriteria in interactive decision making and optimization (18). This way the task of interaction between dm and analyst to get the value system of dm has been significantly transfered to computer. DM has been able to obtain results according to his value system interactively using the computer.

A class of methods known as interactive methods rely on the dm's preferences along with the exploration of the objective space. The progressive definition takes place through dm-analyst or dm-computer dialogue at each iteration. At each such dialogue the dm is asked about some trade-off or preference information based upon the current solution or the set of solutions, in order to determine a new solution. The advantage of an interactive approach is that it provides for the dm a learning process about the system and make allowance for psychological convergence for the dm. Some of these interactive methods however are limited by their applicability to specific types of problems or by the difficulty that the dm has in indicating trade-off rates in an iteration.

Among general purpose interactive methods Geoffrian method and the STEP method may be cited. The methods represent different types of approaches for interactive multicriteria optimization (18). In the Geoffrian method (19), the dm is expected to provide at each cycle information concerning his preferences. He should provide an estimate of his marginal rates of substitution between presented criteria and resolve step size problem via direct choice of a numerical display (20). In the STEP method the dm is asked to react to certain compromise solutions obtained by minimizing the distance from an ideal solution. At each cycle the dm is asked to choose the criteria, if any, which he would be willing to worsen to allow the improvement in the unsatisfactory ones, and also to specify the maximal amount of relaxation in their values (21).

Another interesting approach developed by the beginning of 1980's by Masud & Hwang (22), is Interactive Sequential Goal Programming (ISGP). This method combines and extends the attractive features of both Goal Programming and interactive solution approaches for multiobjective decision making. The disadvantage with ISGP is that dm has to choose the goals in an information void. Zeleny and Cochrane (23), show that the "a priori" specification of goals and their ranks can result in a solution which may not be "non-dominated", that is a solution which is at least as good as any other solution in terms of the achievement of objectives.

By ISGP non-dominance of the "best-compromise" solution is assured. Although no mathematical convergence can be proved, it is expected that if the dm is rational and consistent in providing the information required from him, the ISGP termination would take place in a reasonable number of iterations with psychological satisfaction of dm.

Nearly all reported multicriteria solution techniques require a strict cooperation of dm, clear and sincere communication between dm and analyst. The interactive modes considerably shift the communication need from solution phase to design phase. However dimensionality problem still remains for most of decision problems. Deformation of real life situation because of simplifications and modelling, risk of doctrinization of dm and/or need for training of the dm are also the remaining gaps to be considered. Even in interactive optimization, especially the risk of not being able to gain confidence of dm, because of the opaqueness of what's going on for him, is still an important problem.

II.8. Structured Interactive Approaches versus Trial and Error

Actually, today's computer technology made available to each dm hardwares to perform interactive trials and see the potential results of his actions taken. Trial-and-error does not require extensive knowledge on mathematics and sophisticated techniques, then allows direct use of human judgement. Data generation and manipulation in interactive trial-and-error usually do not require complex formulations and may easily be performed by dm's staff or himself. Formulations being created by them the results achieved may be more meaningful and clear to the dm so that he may easily evaluate results obtained in interactive work. It seems that opaqueness of what's going on in problem solving process may be best overcome via simplicity, accuracy and directly providing the dm with the results of his actions taken.

In 1975, Wallenius performed experiments on 18 students and 18 managers from industry to compare the performance of interactive methods of Geoffrion (19) (20), Benayoun's STEP-method (21) and unstructured approach, simple trial-and-error, from a human decision maker's point of view in terms of dm's confidence in the solution obtained, ease of use and understanding of the method, usefulness of the information provided and rapidity of convergence (24). Some experimental research in this field has been done also by Agarwal (25), Dyer (26) and Feinberg (27).

Per Walenius' report, analysis of results showed that the managers gave an overall preference on the unstructured approach over the more sophisticated methods for a variety of reasons, but especially because the method was easy to use, and did not constraint the dm in his search in any way. The students' responses were much more randomly distributed. In overall the unstructured approach, a simple trial-and-error procedure, competed with the more sophisticated methods in terms of most measures. Training and guidance of managers could change preferance of managers. However no such experiments are reported.

II.9. The Judgemental Programming Approach

Judgemental Programming (JP) approach assumes that in all real life decision problems there exist outcomes to which the decision maker aims or expects to achieve via scarce resources expected to be available.

Even in equal degree of resources use, while equally achieving the desired outcomes via different path of actions, there may exist preference criteria that the dm may choose one action instead of another.

First step in JP is to select the main desired outcomes, called as "targets", main resources called as "limits" and other criteria that may affect the preference of a decision, called in JP as "decision criteria". This step requires a good understanding of the problem and of the decision environment.

The next step is to find answer to the question of how an action will affect targets, limits and decision criteria. In this step all possible courses of action should be analyzed to reflect contributions of actions to targets, limits and decision criteria.

The remaining work is to design a monitoring system which will show contribution to or deviations from limits and targets and affects on decision criteria of each action taken.

Finding the desired solutions is left to dm and his experts. The dm will try to achieve targets using available or expected sources according his criteria, his experience, his judgement and the dominant facts that may be quantifiable or not.

The approach and the details would be better understood throughout the example provided.

II.10. Expected Advantages of Judgemental Programming

The most mathematical formulations need that all statements, sequences, logical and judgemental processes be complete and error proof. Additionally, for the problem to be adequately solved all potential shortcomings of the model have to be anticipated in advance so that illogical results are eliminated.

The JP saves the analyst time particularly by reducing the time spent in formulation, data collection and test phases. The JP formulation simply transforms data into the form required for decision making. Thus even the conceptualization and interpretation phases are merged into an evaluation phase, leading to further savings in time and effort. The translation of obtained results into implementation instructions is easier thereafter.

Despite to most of the approaches JP does not require precise and specific structures or commands and does not tend to make expertise or judgement of experts as a part of an algorithm. Instead provides a less formal and more flexible evaluation medium which makes such human abilities more utilizable. At the extreme, JP would simply involve ways of remoulding and evaluating the existing data in order that all relevant decision alternatives be brought to the surface bringing also highest flexibility for consideration of non-quantifiable aspects.

The JP formulation does not bring limitations to reflect all relevant factors in the real life situation if a top to down monitoring is provided to prevent information void and actually there is no limit in formulations to convert actions taken into contributions to limits, targets and decision criteria. The loss of information due to integration, simplifications is expected to be prevented without bringing complexity and dimension problems. Also developed softwares are expected not to need extensive computer memory allocations.

Despite many others, as a solution tool it is expected to be not a black-box for the users but to be easily openable, analyzable and understandable by them. Being an unstructured problem solving process, parallel to the natural decision making,the risk to doctrine or constraint the dm and the need to train him would be at minimum. Solution tool being aimed as simple as possible, JP approach emphasizes data and data manipulation via simple formulations. Due to inherent simplicity of the approach, if data provided is reliable, no significant deviations should be expected between results obtained in the real life and per results of the formulations.

The work of the analyst is concentrated on the design phase. The task of interaction between analyst and dm to get the value system of dm is transfered to computer and the task of obtaining and evaluation of the results to the dm and his experts. User may reach to his best solution per his criteria himself while obtaining answers to his "what if?" type of questions. DM or his expert can see marginal contributions of his actions to the overall results which provides a learning process. Despite most of the solution tools, analyst has not to be a bridge between the problem owner and the solution to the problem. The user can reach, understand and may be able to defend logically his solution to the problem himself. If the user is the dm, this brings greater chance against solutions obtained remaining unimplemented due to lack of confidence on the results of sophisticated solution tools.

III. AN EXAMPLE FOR INVESTMENT PLANNING

III.1. The Selected Problem

In view of the difficulties inherent to model building and implementation, JP is a purely descriptive approach apart from prescriptive mathematical tools. The selected example is the investment planning problem of the Turkish Electricity Authority (TEK).

Actually the TEK information system was not claimed to be suitable to provide reliable data and the author prefered not to spend too much effort to form a better database. However synthetic data provided are closer to the actual and meaningful enough to support the example. So, the scope has not included to establish a reliable data system and generate information through this system to feed the example as such a trial would be infeasible in the situation.

III.1.1. Background Information on the Turkish Electricity System

TEK is primarily responsible for the generation, transmission and distribution of electricity in Turkey, whereas all the distribution utilities are under the responsibility of TEK. Approximately 87 percent of total electricity generation is being provided by TEK and the rest by oto-producers and private companies. Prices are set by government.

For the year 1983 together with 5936 MW installed capacity of TEK, total installed capacity of Turkey is 6935 MW, in which; 3239 MW is hydro and 3696 MW is thermal.

Total domestic generation is 27320 Gwh, imported energy is 2223 Gwh, percapita gross energy is 625 kwh/capita, and peak load is 4731 MW.

75 percent of electricity is consumed by industrial establishments and 16 percent by domestic applications.

Turkey has 110 000 Gwh/year hydro generation capacity of which 11 percent is developed. Although the major hydro resources are generally located in the eastern regions, major consumption centers are in the western regions of country. Lignite based power plants are distributed throughout the country. Other production types are not actually significant.

Electricity distribution losses are about 15 percent and exceeds 20 percent in some province centers. Power cuts and restriction because of shortages is 927 Gwh which directly affects the daily life (28). During last years, people have became more sensitive to pollution and as most of the villages are near to rivers construction of hydropower plants require large expropriations.

III.2. Statement of the Problem

The decision making process in electrical power system investments has become more complex in the world and in Turkey in comparison with recent years. The number of official and non-official organizations and groups that influence power systems decisions has become considerable. That is, the decision making process has become more political. The number of models and number of people involved in modelling have increased considerably however formal models are not much helpful for today's decision environments and model results do not significantly influence the decisions (28).

Presently several factors influence project selection, choice of plant-mix and timing, concerning social factors which appear to be dominant criteria while costs are also considered important. But the primary objective seems not to be minimization of cost or maximization of rate of return as in the near past. The price of electricity is not further determined only by costs but also by the demand/cost structure of other energy sources. The electricity producing is more considered as a vital part of economy. Uncertainty in change of production cost which is reflected to prices significantly affect the demand and leads to uncertainty in load forecasting. The subject is closely related to forecasting and incorporated with national and worldwide economical parameters.

Electrical power system planning has some unique aspects with respect to other infrastructural systems. One of them is the need for long planning horizons usually 10 to 30 years which is mainly due to long construction periods of power plants. Because of long lead times considerable uncertainties may exist in a number of system elements.

Electrical investment decisions, involving choice of plants, locations, timing, plant-mix and operation/maintenance strategies, are mainly based on demand forecasting. The stochastic component of electricity demand is highly significant. Besides that, electricity demand may vary per years, seasons and even per hours. In certain periods it may reach to peak and in certain periods, for example during nights, to very low levels. The fluctuations between peek and lowest levels are by nature very significant. Considering technical infeasibility of energy accumulation in form of electricity, power plants' productions have to follow a path parallel to the load duration curve. Basically economical power plants, that is those with lower operational unit costs, are expected to continuously satisfy the base load and other plants to operate during peak load periods.

In a large interconnected network, load forecasting and decisions based on these forecasts become more complex and difficult. Because of transmission losses between production and consumption nodes, energy production requirement to satisfy peak or base load for far and near consumption centers are different. Besides uncertainties in the determination of load curves over the electrical network in the demand site, stochastic events may alter the supply and the incorporation of supply and demand interaction through energy cost and price, bring further complexity to the investment planning problem.

The decision on selection and timing of projects does not depend only on the decision and timing of resource consumption such as coal or nuclear reserves, land, foreign currency and so on, but also interconnection timing and costs, availability of skilled man power, environmental pollution, opportunities for irrigation or use of by-product heat to serve other demands for thermal energy and other factors.

In the selection of power plant-mix, timing, and distribution over the network, each power plant has to be individually considered with respect to the whole system. Some power plant projects may be interrelated and may not be realized simultaneously because of using same coal reserves or water resources, some projects may not be realized in some regions or in some circumstances due to military, social, economical or other reasons. Also dependence and concentration on a single type of power plant are usually not desired for load management, resource limitations, risk of import unavailability or for similar reasons.

Then, electrical investment problem consist of incorporated investment and operational subproblems. In the light of some of the characteristics stated above, the electrical investment problem of a country is in fact a "super-problem". However, current practice is the use of LP models or some simulation techniques to solve it as simplified subproblems where certain elements are excluded from these models simply because they are not compatible with the analytical approach while, in other instances, they are left out because they are not sufficiently quantifiable.

For the case in Turkey, the electricity investment planning problem is mainly satisfying demand with available sources. However matching supply and demand within very close limits is the major difficulty. Deficiencies in supply lead to highly undesirable social and economical consequences while a surplus leads to economic inefficiency, high costs and bad allocation of scarce resources.

Besides satisfying demands both in terms of energy and power with available or expected budgets, other factors as expropriations, pollution, system reliability, cost of energy generation and use of investments for longer horizons should also be considered.

III.3. Possible Formulations for the Problem

Forgetting many of the stated factors above, a classical electricity investment planning problem may be basically stated as given I power plant projects, with all their characteristics, how should be sequenced from present to year T such that a certain objective is attained ?

This is a typical optimization problem, usually referred as a 0-1 Integer Programming (IP), where each variable x takes on a value either 0 (do not carry out the project), or 1 (undertake the project). In such a problem assuming that the cost of the projects x(i) are presented by c(i), and that the objective is usually to minimize total cost over the planning horizon.

$$z = \min \left(\sum_i \sum_t d(t).c(i).x(i,t) \right) \quad t_0 < t < T \; ; \; i \in I$$

s.t.
- Physical
- Technological
- Environmental
- Financial
- Other constraints,

where d(t) is the appropriate discount factor and I the set of projects.

This discrete optimization problem is combinatoric, and may have, in the unconstrained case as many as (I.T)! feasible solutions. Present computer codes for this problem are unable to find a "proven" optimal solution for I.T > 100, which severely restricts realistic planning that usually requires simultaneous consideration of dozens of projects within a time horizon of about 10 to 30 years (30).

The problem of dimensionality can be circumvented by several means, all of which lead to a certain degree of approximation.

i) The Linear Programming (LP) formulation:

For I.T sufficiently large, the solution for continuous variables can be "rounded-off" to the integer solution. For larger I.T the degree of error is relatively small.

ii) The Mixed Integer Programming (MIP) formulation:

By "grouping" similar projects and expressing them as continuous variables, it is possible to reduce the number of variables considerably, so that a solution can be found within a reasonable period of time.

iii) The Dynamic Programming (DP) formulation:

As a "dynamic" optimization problem, the DP formulation is quite a natural one. However the dimensionality problem still remains and successful experiments have not been reported.

A widely used approach seems to be the "grouping" of projects which leads to significant loss of information. Actually in an investment problem the dm should be more concerned with the marginal contribution of each project to the whole planning process.

However in fact cost minimization can not be considered as the primary and single objective for such a problem. As involved a number of social and economical factor, electrical energy investment planning problem by nature is a multiobjective one as stated in the problem definition (31).

Taking the multiobjective nature of the problem into consideration, it would be possible, for example, to find feasible and desirable trade-offs between conflicting goals such as minimizing costs, maximizing reliability, minimizing resource depletion, pollution and so forth, provided that one had a convenient and efficient "multi-criterion decision model"

(MCDM). Experience to date shows, however, that such general purpose MCDM packages will not be available in the near future (32).

Even assuming that such tools did exist, it is not at all guaranteed that they would necessarily be adopted by actual planners and decision makers. In other words, the fact that such models necessarily involve implicit decision rules which are opaque to the dm discourages their utilization.

Even in the case of single objective, say minimization of the unit cost, obtaining the optimal solution of such a model is extremely difficult (32). Besides the dimensionality problem the solution space is nonconvex. The non linearity may be overcome by piecewise linearization which will result in further increase in dimension. Recognizing multiobjective nature of the problem, the problem is practically unsolvable with available mathematical tools.

Actually all batch oriented decision tools has to consider all factors and alternatives at once which discourages consideration of several factors in model building. Increase in size and content of models, besides dimensionality, brings also lesser confidence on results due to complexity. Involvement of social factors also reduce the time invariance of problems which reduces accumulation of knowledge and experience as in the case of a chess problem for example. Also some of the factors involved may not be quantifiable. Even if such difficulties may be overcame, buit up of super-models may not be feasible and acceptable by dm.

III.4. The Judgemental Programming Formulation

JP formulation requires modelling for computation and monitoring of contributions of each action taken to limits, targets and other decision criteria. However modelling in JP requires by nature simple mathematical operations, more often simple additions which should not be opaque to the user. Such a modelling minimize the deformation of the real life situation as well as provides the dm with a transparent box instead of a black one. That is, what's going on is easily understandable by the dm. There is also no need to consider all alternatives, infeasibilities, undesired results and all combinations during formulation.

In JP formulation it is assumed that the dm is more interested on marginal contribution of each individual action taken to his primary objectives and other criteria, and because of this, artificial integration and artificial simplifications have to be prevented to the highest extent. Despite the classical approaches, inherently JP never attempt to provide the dm with a "decision machine" to replace him but an "evaluation system" or an effective electronic work sheet to assist him in his decision making. Posing the decision-aid problem as such, using JP, dm can communicate with computer to answer his "what if ?" type of questions.

Trying to capture the essential factors involved in the Turkish electricity system the criteria found to be most pertinent in Turkey appeared to be:

i) Meeting the electricity demand in terms of power and energy with budgets in terms of Turkish Lira and foreign currency.

ii) To provide electricity at lower costs.

iii) To benefit from investments for longer horizons.

iv) To prevent electricity short-cuts.

v) To minimize social effects due to pollution and land expropriations.

It appears that no solution tool is available for today to solve such a multicriteria, multidimensional problem for a planning horizon of 10 to 30 years. To decide on whether to start or not a project in a certain year considering all relevant factors related to the project and considering each project as a part of the whole scheduling process requires extensive knowledge on facts about each project, the environment and interdependence of these projects.

Using computer as a decision machine requires transfer of all knowledge, experience, understanding, preferences and judgemental ability of experts and the dm to the computer which is not realizable even in the case of omitted dimensionality problems. JP approach considering computer as a work sheet with a very high response speed, permit the dm and his experts use of their qualifications to the highest extent minimizing the deformation of the real life situation, preventing loss of knowledge and mislead of the user.

The formulation assumes that reliable deterministic data exist for each project about the following factors:

i) power generating capacity, (PC) MW

ii) average availability factor, (AF) %

iii) unit cost of investment, (I) $/kW

iv) foreign cost of investment, (IF) %

v) unit cost of energy generation, (U) TL/kWh

vi) local part of energy generation cost, (LF) %

vii) project construction duration, (CT) years

viii) life time of investment, (LT) years

ix) land used for the project, (L) km.squares

x) annual pollution due to operation, (P) 1000m3 SO2 / year

Synthetic data are produced to support the example based on the ranges specified in Appendix VI, including several types of projects.

Each of the above characteristics of a project will have a marginal contribution to the stated criteria for the whole electricity system.

The developed software simply transforms the characteristics of each project into marginal contributions to limits, targets and other decision criteria, updates and monitors these information to the user.

The JP formulation classifies the criteria for decision making into two groups:

i) Targets and limits, where there exist for dm some expected or definite values which should not be exceeded or which should be achieved.

ii) Other decision criteria, where different factors will affect preference of the dm but where there is no desired or definite value for them.

When limits and targets are introduced these values should usually be forecasted. For this problem limits and targets consisted of, for the case in Turkey, three main categories. These are future demands, investment budgets, operations and maintenance budgets. More precisely :

i) Power demand P(t)

ii) Energy demand E(t)

iii) Investment budget, TL ITL(t)

iv) Investment budget, foreign currency IFC(t)

v) Operation maintenance budget, TL OTL(t)

vi) Operation maintenance budget, foreign currency OFC(t)

Limits and targets appear on the computer screen as follows:

DEVSF	TOTAL	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
*****	*****	****	****	****	****	****	****	****	****	****	****
POWER	-2688.	-51.	-61.	-72.	-75.	-77.	-85.	-95.	-100.	-105.	-117.
ENERG	-6081.	-56.	-88.	-92.	-120.	-140.	-180.	-200.	-220.	-235.	-230.
INTLB	6657.	130.	150.	175.	200.	220.	235.	260.	275.	350.	382.
INFCB	12610.	130.	230.	330.	410.	480.	540.	620.	700.	710.	730.
OMTLB	9622.	21.	31.	43.	55.	85.	115.	150.	180.	220.	280.
OMFCB	3722.	21.	31.	52.	63.	75.	80.	90.	120.	135.	150.

where abbreviations correspond to:

POWER :	P(t)	;	100*MW
ENERG :	E(t)	;	100*GWh
INTLB :	ITL(t)	;	TL Billion
INFCB :	IFC(t)	;	$ Million
OMTLB :	OTL(t)	;	TL Billion
OMFCB :	OFC(t)	;	$ Million

The above data are also produced based on rough estimates to support the example.

Estimated amounts appear for each year through the planning horizon with a reversed sign. That is initially all targets have negative and all limits positive values. DEVSF is the abbreviation of "deviations from". Total deviations also appear for the whole planning horizon under the TOTAL column.

A space is provided for the scheduling of projects. Each scheduled project will have a positive contribution to the targets and a negative contribution to the limits. That is, as all targets are initially negative and all limits are positive, each scheduled project will tend limits and targets' values of related years to nill and after a certain point will tend to reverse them.

This presentation provides information on how actions taken do contribute to the criterion of meeting the electricity demand in terms of power and energy with budgets' in terms of Turkish Lira and foreign currency.

The screen design also provides information on other relevant factors stated below:

i) Unit cost of energy generation (UC); for the criterion to provide electricity at lower costs.

ii) Non-depreciated assets following the end of planning horizon (NDA); for the criterion to benefit from investments for longer horizons.

iii) Reliability factor (REL); for the criterion to prevent electricity short cuts.

iv) Land used for the investments (LAND) and pollution factor (PF); for the criteria to minimize social effects due to land expropriations and pollution.

The values are presented in the following units:

UC	:	TL/kWh
NDA	:	1000 Billion Turkish Liras
REL	:	percentage
LAND	:	km squares
PF	:	1000 metercubes of sulfure dioxide

LAND could also be expressed in monetary terms or population affected and PF in terms of other units expressing also nuclear pollution etc. Such alternative presentations do not affect the JP formulation and do not require modifications in the software.

The final version of the screen is as below, where (S:) presents the screen number. The software enables the user sliding the screen in terms of multiples of five periods and the last two lines are used for the software's messages and the input commands.

UC: 40. S:1

NDA : 0. REL: 0. LAND: 0. PF: 0.

DEVSF	TOTAL	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
*****	*****	****	****	****	****	****	****	****	****	****	****
POWER	-2688.	-51.	-61.	-72.	-75.	-77.	-85.	-95.	-100.	-105.	-117.
ENERG	-6081.	-56.	-88.	-92.	-120.	-140.	-180.	-200.	-220.	-235.	-230.
INTLB	6657.	130.	150.	175.	200.	220.	235.	260.	275.	350.	332.
INFCB	12610.	130.	230.	330.	410.	480.	540.	620.	700.	710.	730.
OHTLB	9622.	21.	31.	43.	55.	85.	115.	150.	180.	220.	280.
OHFCB	3722.	21.	31.	52.	63.	75.	80.	90.	120.	135.	150.

SCH. PROJECTS	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
**************	****	****	****	****	****	****	****	****	****	****
1-->										
2-->										
3-->										
4-->										
5-->										
6-->										
7-->										
8-->										
9-->										
10-->										

III.5. Models Used Within the JP Formulation

The JP formulation processes data for each project transforming characteristics of projects into marginal contributions to limits, targets and decision criteria. Project data is presented in a file in the following format:

Code	PC	AF	I	IF	U	LF	CT	LT	L	P
	MW	%	$/kW	%	TL/kWh	%	years	years	km2	km3/y
H004	.	.	.	.						
C008	.	.	.							
N101	.	.								

In this example time variations of all factors between periods related to projects such as diminishing in power capacity, increase in operation and maintenance costs etc. are omitted for simplicity and better understanding of the reader. If such an information could be provided, a time dimension can easily be added to the data and to the arrays in the program for lesser deformation of the real life. This practice would increase both dimension of the data and the program. However the JP approach allows approaching to the real life situation further improving the data manipulation and permits further complex computations without disturbing the understanding and judgemental ability of the user and without providing him with additional load.

The data presenting the characteristics of projects are presented to the dm in a fully sorted list format according to each characteristics via a SORT program presented in Appendix V together with a sample list.

Project data are directly read by the MAIN program and then converted into marginal contribution amounts to limits and targets for corresponding years as follows:

dPOWER = PC / 100

dENERG = PC * (AF / 100) * (365 * 24) / 1000 / 100

dINTLB = PC * I * FC * ((100 - IF) / 100) / CT
/ 1000 000

dINFCB = PC * I * (IF / 100) / CT / 1000

dOMTLB = PC * (AF / 100) * (365 * 24) * U
* (LF / 100) / 1000 000

dOMFCB = PC * (AF / 100) * (365 * 24) * U
* ((100 - LF) / 100) / FC / 1000

where, FC is the foreign currency ($) exchange rate read by the program and some of the divisions to hundreds and thousands are made to specify number of digits that will appear on the screen.

If change of characteristics per time would be introduced, it would be more effective to perform these conversions out of the program and already have in the time dimensioned data set as first year power generating capacity, second year power generating capacity, first year foreign currency requirement for investment, second year requirement and so on. For 6 deviations, 100 projects and a 20 years planning horizon this would require only a 10 Kbyte additional on line memory which may be available even in today's home computers.

Deviations from limits and targets for a specific period (year) is the summation of the stated contributions of all projects affecting the period.

To facilitate the dm's scheduling work, the projects are also converted and sorted according to their yearly contributions to each limit and target on the same unit scale as it appears on the screen. The conversion program and a sample list is provided in Appendix IV.

Each project has contribution to investment budgets during project construction period and to power/energy targets and operation/maintenance budgets during the life time of investment. In the program the contribution values are simply added to limits and targets when a project is started at a year or subtracted from when a scheduled project is omitted.

If a time dimension was included to the projects data set the procedure would be the same. In this case, first year investment cost would affect first year investment budget, following the investment period, first year power capacity would affect first year power demand and so on, even varying according to the period started .

Screening the affects of projects to the targets and limits according to the starting periods constitutes the mainframe of the JP formulation for this problem.

In this example other desision criteria are presented as single values on the screen. Some of these values could also be presented for each period to provide further information in a similar format as presented deviations from limits and targets. In this case as in JP formulation decision criteria is defined as different factors that will affect preference of the dm but where there is no desired or definite value for them, instead of a form of negative and positive deviations they would appear on the screen for each year as they are computed. By this presentation actual unit costs and other factors would appear for each year on the screen. However from ergonomical point of view screening excessive information should be prevented in such formulations.

In this example the five decision criteria are computed as follows (34) (35):

$$UC = \sum_{i,t} c(i,t) + d(i,t) / E(i,t)$$

$$NDA = \sum_{i,t} (I(i,t) - d(i,t))$$

$$REL = \left(\frac{\sum_{t} Dp(t) - \sum_{i,t} P(i,t)}{\sum_{t} Dp(t)} \right)^{n}$$

where;

c : sum of TL and foreign currency op. maintenance costs
d : accrued depreciation by project i at period t
E : energy produced by project i at period t
I : investment costs of project i at period t
P : power generated by project i at period t
Dp: power demand at period t

LAND and PF are direct summations from data.

In JP formulation two points should be considered. Altough values set as limits and targets are simply values to guide the dm, the designer should remind that these are usually estimates and are not deterministic values. Then the variances of these estimates should be considered. Also these values are usually subject to change by the actions taken through the decision process which should also be considered.

In this example besides the point estimates of demands and budgets determined as the nominal values, pessimistic and optimistic limits are also included in the formulation enabling the dm to review the results of his actions taken as the deviations from limits and targets, from pessimistic and optimistic point of views. That is, the deviations are monitored according to optimistic and pessimistic demands and budgets for the whole planning horizon when asked.

Considering the fact that each scheduled project will affect energy produced, the unit cost and price of energy throughout the planning horizon the demand and budgets will also be affected (36) (37). Energy planning of a country will obviously affect the whole economy of that country (38) (39). Energy planning and the economy interface is not within the scope of this work, however as an example for consideration of the fact that usually limits and targets are affected by the previous actions taken, energy demands (targets) are revised according to a preset price elasticity within the program alone or together with optimistic and pessimistic deviations review. Such reviews will provide the dm with valuable information through his decision making process.

For optimistic and pessimistic review, simply differences between nominal and optimistic/pessimistic values are read from files and added to nominal values when asked.

For price elasticity the below formulations are used:

$$UC(t) = \frac{c(0) + \sum_t c(t)}{E(0) + \sum_t E(t)}$$

$$P(t) = m * UC(t)$$

$$Dr(t) = D(t) * \exp\left(-e*(a*P(t-1)+b*P(t-2)+c*P(t-3)\ldots)\right)$$

where;

UC(t)	:	unit energy generating cost at t
P(t)	:	unit price of energy at t
D(t)	:	energy demand at time t
Dr(t)	:	revised energy demand at time t
E(0)	:	initial available energy
E(t)	:	energy generation at time t
c(0)	:	initial energy generating cost
c(t)	:	energy generating cost at time t
m	:	profit margin
e	:	price elasticity
a,b,c	:	parameters

III.6. Software Developed to Support the Example

Being a widely known and used standard high level language, FORTRAN IV is prefered in the development of the programs. Programs are run both in UNIVAC and CDC mainframes at BU with small conversion changes. Taking into consideration that one may be willing to experiment the software in any other computer, the statements that may require changes according to the available compilers and computers are marked within the programs. With the aim that the programs may be run in any computer, standard statements are used to the highest possible extent.

The last state of the program sources are presented in the Appendices II to V. Read-only programs and data files are presently available under the user name un=ULUSOY in the CDC mainframe at BU for free access of users. Also a diskette back-up copy of all files is submitted to the Institute for Graduate Studies in Science and Engineering together with formal copies of the thesis.

Besides the MAIN program, two auxillary programs have been used for the manipulation of the projects file: SORT and CONVERT.

SORT program simply sorts the input file with respect to each column covering all information for each row. During scheduling process to have all projects sorted with respect to their power capacities, average load factors, unit investment costs etc. is very useful for preferences within projects.

The CONVERT program transforms the characteristics of projects into direct contributions to limits and targets. The direct contributions of projects are then sorted by the SORT program. This way the user is able to schedule a project or a group of projects at each stage according to the deviations from limits and targets, that is according to the unsatisfied demands and available budgets.

At the beginning of scheduling process the sorted lists produced by these programs should be available on paper if two terminals are not available to the user. In the case of availability of two terminals it is advisable to develop simple search and list programs to facilitate the user's work.

All programs are presently available in the CDC mainframe at BU. A HELP program is provided to the user which presents names of all files, the necessary commands to start the programs as well as the description and use of the commands and all other necessary information together with print facility. The screens presented by this program is provided in Appendix I. To use the program following log-on just enter:

```
/get,help/un=ULUSOY

/help
```

III.7. Experience With the Formulation

As an experiment to test the formulation a number of graduate students in the IE dept. at BU, they were actually 14 and worked in groups of two, were asked to perform experiments, after about two hours of explanations on the problem and software. In the experimental version decision criteria and review module were not included in order not to confuse them. However they were provided with all other information and data, including the sorted and converted files. They were asked to submit their reports following a three weeks period. By the end of this period they submitted their reports in May 1984 and they are interviewed during and following this time besides analyzing their work performed.

From the reports submitted by the students, which are faced for the first time with the problem and the JP formulation, it was obvious that none of them experienced any difficulty using the software. It appeared however that at least four to five hours of interactive experimenting session was required to arrive at "desirable" solutions.

Per interviews and per the submitted reports, the students understood the problem mainly satisfying demands and avoiding budget deficits. However a small observation of data and some trial runs showed them that the objectives, achieving the targets and not exceeding limits, were conflicting and that the problem was "infeasible". They also noted that a homogenous sacrifice from objectives in scheduling process was not so easy as it was appeared them first.

Noting the infeasibility they first tried to set priorities among objectives and acceptable tolerance levels for them. A group of students gave highest priority to energy demand satisfaction only or together with power demands considering budgets as subordinate levels assuming that sources can be found as energy is a leading factor in the economy. Other students considered demand at subordinate levels assuming that budgets present the maximum amounts of resources that may be available and exceeding them may result with delayed or unrealized projects.

The priorities set by the groups varied from each other. Some of them gave emphasis to short run or long run periods within the planning horizon, some of them gave priorities to some group of projects as hydrolic or coal with acceptable reasons and some introduced also other objectives as using different type of projects from a reliability point of view or trying to install least number of projects to minimize managerial difficulties and so on.

Most of the groups obtained "desirable" results not conflicting with their objectives. Per interviews some of them stated their feelings on possibility of achievement to more preferable results per their utilities which should be most probably true. Because it should be noted that the students were under time pressure to complete their work.

Reports and comments of students pointed out an interesting concept in JP which is not always true in many approaches. This was the inherent learning process. That is, at each interactive session understanding of students on projects and facts were developed and so their solutions. Throughout the whole process they reached to better solutions per their judgements and seing the results of their trials they were able to explain reasons of all of their individual actions. Per their comments, at the end of each session they had more command on the problem and were more able to manage the projects.At the end of each session both the user and results obtained reached to more mature levels which would have not occured if they modelled the problem say with LP and analyzed their solutions. In such a case most of their results and comments would be missed.

Although JP formulation provided a learning process it should be remembered that all students played with numbers with little knowledge about facts on projects and the electricity system, as they were not experts in this field. Such an approach would be most probably more meaningful for an expert with extensive knowledge on real projects and the real system, and his "desired" solution would be more strongly supported with facts and he would be more able to explain and report the reasons of each individual action taken.

III.8. Critiques on the Software

Following their experiments critiques and proposals of the students are also collected via interviews. Most of them complained from lack of a recovery file. They had to use the software usually in one or half an hour sessions and they wanted to restart as they leaved. The PRINT facility of the software provided them the ability to see also the last stage when they leaved. To reset the software say, to reschedule 30 projects, costed them to spend two to four minutes. Considering the remembering effect of this rescheduling and minority of this time spent a recovery file is not considered as necessary by the author in the final version.

Another interesting proposal was related with the design of the software. A group proposed a better command on the screen for add and delete commands. Instead of these commands, they proposed to add and delete the projects using the cursor and to prevent scrolling of the screen. This was exactly what should be done from interactive programming point of view. However this would require design of the software for a specific hardware which was in conflict with author's objective, the example program to be run in any computer with a FORTRAN compiler with a minimum adaptation time.

Another critique by a group was related to the lack of a manual to refer while running the program. A help file was presented to the students to refer how to run the program and the HELP screen within the program was there. However they stated that they prefer all these printed on hand and also to see the units of screened values. This is obviously beneficial for better command on the software. According to this proposals all units are included in the HELP screen providing a facility to have this screen and other relevant information printed on hand via a HELP program as presented in Appendix I. Besides this, all information for better understanding and command on the software are presented in the Appendices which may be referred as a manual.

In this example inflation and non homogeneous distribution of deviations were not considered. Obviously investment in the first and the following years as well as other factors such as energy production won't be the same. Currency requirement in the short and long runs won't be equal due to inflation or change in technology. The omitted time dimension has been noted by most of the students. However the software was not intended to be directly used by TEK planners but to be a relevant example for JP. As mentioned earlier this may be made by adding a time dimension to data and computations. The time dimension was omitted for simplicity and better understanding of the reader. Meanwhile the inflation may be considered while setting up initial deviations in terms of todays currency values. That is one million appearing at the 12th year may be considered as one million in todays values.

Most of the students were disturbed from surplus and deficit in demands and budgets in their solutions. They proposed reflection of import and export possibilities and a facility to better handle the budgets. According to this proposal export and import projects are included as example in the data set but the use of previous years' surplus budgets, shifts and combinations of some budgets etc. are left to the visual and judgemental consideration of the user. In a real life JP trial, such monitoring or formulation changes would be performed per dm's requests until he would be satisfied by the information provided.

These were all reported or discussed critiques of the graduate students. If the experiments were also carried out by TEK planners the critiques would be most probably more numerous. Of course there is no end if the software would be used in actual planning process. But including all possible improvements would lead the example to be too crowded that could result by the missing of the mainframe and main idea of JP in the example.

III.7. Alternative Solution Paths for the Problem

All of the graduate students tried to find a systematic for trial and error in their experiments where in fact there is not a proven one for the time being.

They primarily set their priorities and their tolerance limits for the minimization of deviations from limits and targets. They did not bothered too much about providing surplus energy or budget, as the problem was "infeasible" for the data provided.

The systematic used, mainly consisted of forward and backward scheduling processes. It seems that those conserning more with budgets prefered forward scheduling and those conserning with demands backward scheduling.

Forward and backward scheduling and variations of them usually require a tableau of increments of deviations by periods. That is, if the deviations are say, 100, 120 and 135, the tableau of increments will be 100, 20 and 15 respectively.

For scheduling process the groups were provided with printed lists. The first list consisted of project characteristics, and the other marginal contribution of each project to each limit and target in terms of deviation units. Both lists were fully sorted, according to each characteristic and contribution to each target and limit, to facilitate the scheduling process.

Besides the tableau of increments, analysis of demands and budgets trends may provide very useful information for strategy setting. For example, power energy ratio trends may give idea about suitability of projects scheduling from high load to lower load factor projects or a decreasing trend in operating costs about scheduling long construction period low operating costs projects throughout the planning horizon.

In forward scheduling the user searches a project or group of projects that will satisfy future demands. At this stage the user should also consider the operating costs and budgets for the periods where demands are satisfied. Usually it may be preferable to consider first nearest periods, as the first coming period is directly affected by the projects scheduled in the first period but the second by the projects scheduled in the first and second periods together, and so on. This way the user may go up to the end of the planning horizon according to his preferences.

In many cases backward scheduling may be preferable. Considering the incremental tableau example again, that for deviations say, 100, 120 and 135 the increments were 100, 20 and 15, it is obvious that the last increment will most probably involve less number of projects, which will significantly reduce number of alternatives and combinations to satisfy the last period demand while considering the last period operating budgets. The user starting from the last period searches for projects that may be suitable for available investment budgets. Although backward scheduling is prefered by some groups giving higher priority to demand aspect it may always be preferable in most cases as it decreases the number of alternatives during scheduling.

During scheduling, besides giving priorities to some targets or limits there is always room to consider for example some or all budgets together, in terms of kind and period, as reported also by some of the students. The satisfaction of user on results, besides performing a reasonable approach, mainly depends on time spent during the "tuning" of the results. During this stage projects are changed with "preferable" projects according to the trade-offs between the deviations.

The reader may find sample results in Appendix VI.

III.10. Brief Discussion of the Example

The planning of the electricity investment of Turkey is a real life problem involving multicriteria and multidimension. As discussed before, in today's computer technology there is no way to consider all factors involved and to transfer knowledge, expertise and human abilities to computer via classical optimization and solution tools. Design of super-models to solve such a problem appear to be infeasible with respect to most criteria.

To provide the cooperation of actual TEK planners has not been possible during and after the design of the software. The design is largely based on reported facts, literature and the experience in this field of the thesis advisor. Indeed, in real life, although the designer can escape from being a bridge between the dm or his experts and solution to the problem his work would continue in revising the JP formulation and the software. If the software was used by actual planners, TEK experts would ask for the monitoring of further factors in different formats besides ways of providing actual and reliable data.

Although the students have not been able to bring recommendations that TEK planners would probably could, they reached to solutions where they are "satisfied" per their criteria that they won't be able to reach via other tools without largely omitting some of the factors they considered. It seems that neither they won't be able to defend their solutions as much as when they reached via JP.

IV. CONCLUSION

In general real life decision making problems are complex, multicriterial and multidimensional. Approaching to real life via classical OR solution tools results with difficulties in mathematical manipulations as well as usually needs allocation of expensive resources due to requirement of special designs, more time span to get the solutions, more involvement of people and so on.

Complex mathematical approaches usually bring more bias and uncertainty with respect to real life behaviour and results obtained from tools and bring lesser confidence of problem owners on techniques strange to them.

Because of the difficulties in reflecting the real life, Judgemental Programming is a trial towards unstructured approaches giving emphasis to the judgemental ability and expertise of the human being, in a simple and friendly manner easy to formulate, understand and use for real life problems. Indeed today's computer technology enables further unstructured human involvement.

Judgemental Programming is primarily an approach for formulation and solution. It may be beneficial for a variety of problems alone or together with other tools especially in higher level decision making for unstructured problems involving qualitative dimensions. The major developments should be observed in large scale non-linear or integer programming type of problems, especially involving multicriteria where approaching to real life via other tools do fail. A reduced emphasis on classical model building but a greater emphasis on data manipulation and evaluation should be expected in this development.

Major advances in software, particularly in the development of interactive programming languages specificly designed for this purpose seems to take place in the near future parallel to the Judgemental Programming approach with respect to classical optimization tools in the search of solution to real life problems.

HELP PROGRAM OUTPUT

```
HELP PROGRAM MENU:
------------------------------------
1. LIST OF FILES
2. EXECUTION INSTRUCTIONS
3. MAIN PROGRAM INPUT COMMANDS
4. MAIN PROGRAM SCREEN ABBREVIATIONS
5. PJ FILE EXPLANATIONS
6. INFO FILE EXPLANATIONS
7. TO PRINT ALL SCREENS
8. EXIT
------------------------------------


FOR PRINTOUT ENTER /ROUTE,OUT,DC=PR AFTER EXIT


PLEASE REFER TO THE THESIS ENTITLED
"JUDGEMENTAL PROGRAMMING AND AN EXAMPLE FOR INVESTMENT PLANNING"
SUBMITTED TO THE INSTITUTE FOR GRADUATE STUDIES IN SCIENCE AND ENGINEERING
OF BOSPHORUS UNIVERSITY IN ISTANBUL
IN 1985
```

NAME	EXPLANATION	TYPE	SECURITY
MAIN	MAIN PROGRAM	FORTRAN	READ
M	MAIN PROGRAM CODE	CODE	EXECUTE
DR	DIRECTORY FILE	DATA	READ
PR	PERIODS DEVIATIONS	DATA	READ
OD	OPTIMISTIC DEVIATIONS	DATA	READ
PD	PESSIMISTIC DEVIATIONS	DATA	READ
OUT	OUTPUT FILE	TEMPORARY	USER
PJ	PROJECTS FILE	DATA	READ
SORT	SORT PROGRAM	FORTRAN	READ
S	SORT PROGRAM CODE	CODE	EXECUTE
SORTIN	SORT INPUT FILE	TEMPORARY	USER
SORTOUT	SORT OUTPUT FILE	TEMPORARY	USER
CONVERT	CONVERT PROGRAM	FORTRAN	READ
C	CONVERT PROGRAM CODE	CODE	EXECUTE
INFO	COVERT OUTPUT FILE	TEMPORARY	USER
HELPS	HELP PROGRAM	FORTRAN	READ
HELP	HELP PROGRAM CODE	CODE	EXECUTE

-- PLEASE ENTER -GO- TO RETURN --

```
1. TO GET MAIN PROGRAM FILES
  /GET,M,DR,PR,PJ,OD,PD/UN=ULUSOY
2. TO RUN THE MAIN PROGRAM
  /M
3. TO GET SCREENS AND MESSAGES
  /ROUTE,OUT,DC=PR
4. TO SORT FILE PJ PER COLUMNS
  /GET,S,PJ/UN=ULUSOY
  /SAVE,PJ=SORTIN
  /S
  /SAVE,SORTOUT=FILENAME
5. TO CONVERT FILE PJ INTO CONTRIBUTIONS TO LIMITS AND TARGETS
  /GET,C,PJ/UN=ULUSOY
  /C
  /SAVE,INFO=FILENAME
6. TO SORT FILE INFO PER COLUMNS
  /GET,S,INFO/UN=ULUSOY
  /SAVE,INFO=SORTIN
  /S
  /SAVE,SORTOUT=FILENAME
7. TO CHANGE CONTENTS OF ANY FILE
  /GET,FILENAME
  /FSE,FILENAME.SS721
8. TO PRINTOUT ANY FILE
  /COPYSEF,FILENAME,O
  /ROUTE,O,DC=PR

              -- PLEASE ENTER -GO- TO RETURN --
```

```
INPUT COMMANDS :
A/++++/---- : ADD PROJECT ++++ TO YEAR ---- TO START THE PROJECT AT ----
B OR BEFORE : SHOW THE SCREEN BEFORE THE LAST ONE
C OR CLEAR  : CLEAR ALL SCHEDULED PROJECTS AND REINITIALIZE THE PROGRAM
D/++++/---- : DELETE PROJECT ++++ FROM YEAR ---- TO RETURN TO THE STATE BEFORE
H OR HELP   : DISPLAY THIS SCREEN
M OR MESSAGE: PRINT EACH TIME A MESSAGE OF 80 CHARACTERS ON PAPER
P OR PRINT  : PRINT THE CURRENT SCREEN ON PAPER
R OR REVIEW : REVIEW DEVIATIONS FROM LIMITS AND TARGETS
S OR STOP   : STOP THE PROGRAM
 1,2,3,4,5  : SLIDE THE SCREEN

            -- PLEASE ENTER -GO- TO RETURN --
```

```
SCREEN ABBREVIATIONS :

S            : SCREEN NUMBER
UC           : UNIT COST OF ENERGY GENERATION (TL/KWH)
NDA          : NON DEPRECIATED ASSETS (1000B TL)
REL          : AVERAGE SYSTEM RELIABILITY (%)
LAND         : LAND USED FOR INVESTMENTS (KM2)
PF           : POLLUTION FACTOR (KM CUBES SO2)

DEVSF        : DEVIATIONS FROM LIMITS AND TARGETS
TOTAL        : DEVIATIONS TOTAL

POWER        : DEVIATIONS FROM POWER TARGETS (100MW)
ENERG        : DEVIATIONS FROM ENERGY TARGETS (100GWH)
INTLB        : DEVIATIONS FROM INVESTMENT TL BUDGET LIMITS (TL B)
INFCB        : DEVIATIONS FROM INVESTMENT FOR. CUR. BUDGET LIMITS ($ M)
OMTLB        : DEVIATIONS FROM OP./MAINTENANCE TL BUDGET LIMITS (TL B)
OMFCB        : DEVIATIONS FROM OP./MAINTENANCE FOR.CUR. BUDGET LIMITS ($ M)

SCH.PROJECTS: SCHEDULED PROJECTS STARTED AT THE BEGINNING OF EACH PERIOD


                -- PLEASE ENTER -GO- TO RETURN
```

COLUMN	EXPLANATION
1	PROJECT CODE
2	POWER GENERATION (100MW/YEAR)
3	ENERGY GENERATION (100GWH/YEAR)
4	INVESTMENT BUDGET USED (BTL/YEAR)
5	INVESTMENT BUDGET USED (M$/YEAR)
6	OPERATION BUDGET USED (BTL/YEAR)
7	OPERATION BUDGET USED (M$/YEAR)
8	DEPRECIATION (BTL/YEARS)
9	LIFE TIME OF INVESTMENT (YEARS)
10	LAND USED FOR THE PROJECT (KM3)
11	ANNUAL POLLUTION (1000M3 SO2)

-- PLEASE ENTER -GO- TO RETURN

COLUMN	EXPLANATION
1	PROJECT CODE
2	POWER GENERATING CAPACITY (MW)
3	AVAILABILITY FACTOR (PERCENT)
4	UNIT COST OF INVESTMENT ($/KW)
5	FOREIGN COST OF INVESTMENT (PERCENT)
6	UNIT COST OF GENERATION (TL/KWH)
7	LOCAL PART OF GENERATION COST (PERCENT)
8	PROJECT CONSTRUCTION DURATION (YEARS)
9	LIFE TIME OF INVESTMENT (YEARS)
10	LAND USED FOR THE PROJECT (KM3)
11	ANNUAL POLLUTION (1000M3 SO2)

-- PLEASE ENTER -GO- TO RETURN

MAIN PROGRAM SOURCE

```
      C
            PROGRAM MAIN( INPUT , OUTPUT , OD , PC , DR , PR , PJ , CUT ,        ?
     *                TAPE5=INPUT , TAPE6=OUTPUT )                               ?
      C
      C
      C
      C
      C
      C     ***********************************************************************
      C     ***********************************************************************
      C     **                                                                   **
      C     **        TAHIR ULUSOY          FILE: MAIN      VERSION: MAY  1985   **
      C     **                                                                   **
      C     **        PROGRAMS USED FOR THE MASTER THESIS                         **
      C     **                                                                   **
      C     ***********************************************************************
      C     ***********************************************************************
      C
      C
      C             ************************************************
      C             *                                              *
      C             *             DESCRIPTION OF VARIABLES         *
      C             *                                              *
      C             ************************************************
      C
      C     ASK     ASKING FOR CONTINUATION MESSAGE
      C     CEGC    CUMULATIF ENERGY GENERATION COST INCLUDING DEPRECIATIONS
      C     CGE     CUMULATIF GENERATED ENERGY
      C     DEV     DEVIATIONS FROM LIMITS AND TARGETS
      C     DEVB    DEVIATIONS FROM LIMITS AND TARGETS BEFORE THE LAST CHANGE
      C     DUMMY   DUMMY VARIABLE
      C     FC      FOREIGN CURRENCY RATE
      C     IAE     INITIAL AVAILABLE ENERGY
      C     IC      COLUMN INDEX
      C     IDEV    INITIAL DEVIATIONS
      C     IEGC    INITIAL ENERGY GENERATION COST
      C     INC     INPUT COMMAND
      C     IP      PROJECT FILE INDEX
      C     IR      ROW INDEX
      C     IS      SCREEN INDEX
      C     ITDEV   INITIAL TOTAL DEVIATIONS
      C     J1      STARTING COLUMN INDEX FOR THE SCREEN
      C     J2      ENDING COLUMN INDEX FOR THE SCREEN
      C     LAND    LAND USED FOR INVESTMENTS
      C     LANDB   LAND USED FOR INVESTMENTS BEFORE THE LAST CHANGE
      C     LEAD    LEAD TIME FOR THE PROJECT
      C     LIFE    PROJECT LIFE TIME
      C     LOP     LAST OPERATING PERIOD OF THE PROJECT
      C     LTN     LIMIT-TARGET NAME
      C     MSG     MESSAGE TO PRINT
      C     NDA     NON DEPRECIATED ASSETS
      C     NDAB    NON DEPRECIATED ASSETS BEFORE THE LAST CHANGE
      C     NPJ     NUMBER OF PROJECT
      C     NPR     NUMBER OF PERIODS
      C     ODEV    OPTIMISTIC DEVIATIONS
```

```
C          P          ENERGY PRICE
C          PCODE      PROJECT CODE
C          PDEV       PESSIMISTIC DEVIATIONS
C          PE         PRICE ELASTICITY
C          PF         POLLUTION FACTOR
C          PFB        POLLUTION FACTOR BEFORE THE LAST CHANGE
C          PJDATA     PROJECT DATA INPUT
C          PJINFO     PROJECT INFORMATION
C          PM         PROFIT MARGIN
C          PNI        PROJECT NAME INPUT
C          PP         PROJECT PERIOD
C          PPI        PROJECT PERIOD INPUT
C          RD         REVISED DEMAND ARRAY
C          RDEV       REVISED DEVIATIONS
C          REL        AVERAGE SYSTEM RELIABILITY
C          RELB       AVERAGE SYSTEM RELIABILITY BEFORE THE LAST CHANGE
C          SP         SCHEDULED PROJECTS
C          SPB        SCHEDULED PROJECTS BEFORE THE LAST CHANGE
C          TDEP       TOTAL DEPRECIATION
C          TDEV       TOTAL DEVIATIONS FROM LIMITS AND TARGETS
C          TDEVB      TOTAL DEVIATIONS FROM LIMITS AND TARGETS BEFORE THE LAST CHANG
C          UC         UNIT COST OF ENERGY GENERATION
C          UCB        UNIT COST OF ENERGY GENERATION BEFORE
C
C                     ************************************************
C                     *                                              *
C                     *            VARIABLES DECLARATION             *
C                     *                                              *
C                     ************************************************
C
      COMMON          /CHAR/  PP , SP , LTN                                     ?
      COMMON          IS , J1 , J2 , TDEV , DEV
      COMMON          UC , NDA , LAND , PF , REL
C
      CHARACTER       INC , MSG(80)
      CHARACTER*2     ASK , DUMMY                                               ?
      CHARACTER*4     PP(30) , SP(10,30)                                        ?
      CHARACTER*4     PCODE(120) , SPB(10,30) , PNI , PPI                       ?
      CHARACTER*5     LTN(6)                                                    ?
C
      REAL            TDEV(6) , DEV(6,30)
      REAL            ITDEV(6) , IDEV(6,30)
      REAL            RDEV(6,30) , ODEV(6,30) , PDEV(6,30)
      REAL            FC , TDEP
      REAL            UC , NDA , LAND , PF , REL
      REAL            UCB , NDAB , LANDB , PFB , RELB
      REAL            PJDATA(120,10) , PJINFO(120,10)
      REAL            TDEVB(6) , DEVB(6,30)
      REAL            EGC(30) , CEGC(30) , CGE(30) , RD(30) , P(30)
      REAL            PE , PM
C
      OPEN ( 1 , FILE = 'OD' )                                                  ?
      OPEN ( 3 , FILE = 'PD' )                                                  ?
      OPEN ( 7 , FILE = 'PR' )                                                  ?
      OPEN ( 8 , FILE = 'OUT' )                                                 ?
      OPEN ( 9 , FILE = 'PJ' )                                                  ?
      OPEN (11 , FILE = 'DR' )                                                  ?
```

```
      C
      C                    ***********************************************
      C                    *                                             *
      C                    *            INITIALIZATION MODULE            *
      C                    *                                             *
      C                    ***********************************************
      C
   14    CONTINUE
            WRITE(6,100)
            WRITE(6,101)
            ASK = '**'
            READ(5,1000) ASK
                  IF(ASK.NE.'GO')                        GO TO 14
   15    CONTINUE
      C
         REWIND 1                                                          ?
         REWIND 3                                                          ?
         REWIND 7                                                          ?
         REWIND 9                                                          ?
         REWIND 11                                                         ?
      C
            ASK   = '**'
            IS    = 1
            J1    = 1
            J2    = 10
            IC    = 0
            IR    = 0
            IP    = 0
            INC   = ' '
            PNI   = '     '
            PPI   = '     '
            NPJ   = 0
            LEAD  = 0
            NPR   = 0
      C
            TDEF  = 0.0
            UC    = 0.0
            UCB   = 0.0
            NDA   = 0.0
            NDAB  = 0.0
            LAND  = 0.0
            LANDB = 0.0
            PF    = 0.0
            PFB   = 0.0
            REL   = 0.0
            RELB  = 0.0
      C
                  DO   1  I = 1 , 80
                        MSG(I) = ' '
    1             CONTINUE
      C
                  DO   2  I = 1 , 120
                        PCODE(I) = '     '
                        DO   2  J = 1 , 10
                              PJINFO(I,J) = 0.0
    2             CONTINUE
      C
```

```
                  DO    3  I = 1  ,6
                        LTN(I)    = '      '
                        TDEV(I )  = 0.0
                        ITDEV(I) = 0.0
                        TDEVB(I) = 0.0
                        DO    3  J = 1  , 30
                              IDEV(I,J) = 0.0
                              ODEV(I,J) = 0.0
                              PDEV(I,J) = 0.0
                              RDEV(I,J) = 0.0
                              DEV(I,J)  = 0.0
                              DEVB(I,J) = 0.0
  3               CONTINUE
C
                  DO    4  J = 1  , 30
                        RD(J) = 0.0
                        PP(J) = '    '
                        DC    4  I = 1  , 10
                              SP(I,J)  = '    '
                              SPB(I,J) = '    '
  4               CONTINUE
C
  17    CONTINUE
            WRITE(6,102)
            ASK = '**'
            READ(5,1000) ASK
            IF(ASK.NE.'GO')                            GO TO 17
C
C*****      INPUT DIRECTORY FILE
C
            READ(11,9000) DUMMY
            READ(11,4000) FC , PM , PE , IEGC , IAE
C
C*****      INPUT TARGETS AND LIMITS FILES
C
            READ(7,9000)  DUMMY
            READ(7,1100)  NPR , ( LTN(I) , I = 1,6 )
            READ(7,1200)  ( PP(J) , ( IDEV(I,J) , I = 1,6 ) , J = 1,NPR )
            READ(1,9000)  DUMMY
            READ(1,9000)  DUMMY
            READ(1,1500)  ( ( ODEV(I,J) , I = 1,6 ) , J = 1,NPR )
            READ(3,9000)  DUMMY
            READ(3,9000)  DUMMY
            READ(3,1500)  ( ( PDEV(I,J) , I = 1,6 ) , J = 1,NPR )
                  DO    5  I = 1  , 6
                  DO    5  J = 1  , NPR
                        DEV(I,J) = IDEV(I,J)
                        TDEV(I)  = TDEV(I) + DEV(I,J)
                        ITDEV(I) = TDEV(I)
  5               CONTINUE
C
C*****      INPUT PROJECT FILE
C
            READ(9,9000)  DUMMY
            READ(9,1300)  NPJ
            READ(9,1400) ( PCODE(I),( PJDATA(I,J) , J = 1,10 ), I = 1,NPJ )
                  DO    6  I = 1  , NPJ
```

```
                    PJINFO(I,1) = PJDATA(I,1) / 100
                    PJINFO(I,2) = PJDATA(I,1) * PJDATA(I,2) * 0.000276
                    PJINFO(I,3) = PJDATA(I,1) * PJDATA(I,3) * FC *
     *               ( 100 - PJDATA(I,4) ) / ( 100000000 * PJDATA(I,7) )
                    PJINFO(I,4) = PJDATA(I,1) * PJDATA(I,3) *
     *               PJDATA(I,4) / ( 100000 * PJDATA(I,7) )
                    PJINFO(I,5) = PJDATA(I,1) * PJDATA(I,2) * 8.760 *
     *               PJDATA(I,5) * PJDATA(I,6) / 100 / 1000 / 100
                    PJINFO(I,6) = PJDATA(I,1) * PJDATA(I,2) * 8.760 *
     *               PJDATA(I,5) * ( 100 - PJDATA(I,6) ) / 100 / FC /
     *               100
                    PJINFO(I,7) = PJDATA(I,7)
                    PJINFO(I,8) = PJDATA(I,1) * PJDATA(I,3) * FC /
     *               1000000 / PJDATA(I,8)
                    PJINFO(I,9) = PJDATA(I,9)
                    PJINFO(I,10) = PJDATA(I,10)
    6           CONTINUE
C
   18   CONTINUE
           WRITE(6,103)
           ASK = '**'
           READ(5,1000) ASK
           IF(ASK.NE.'GO')                           GO TO 18
        CALL SCREEN
        WRITE(6,104)
C
C                   ***********************************************
C                   *                                             *
C                   *           THE INPUT RECOGNITION MODULE      *
C                   *                                             *
C                   ***********************************************
C
   20   CONTINUE
           INC = ' '
           PNI = '    '
           PPI = '    '
           READ(5,2000)  INC , PNI , PPI
C
                IF(INC.EQ.'1'.AND.PNI.EQ.'    ')   GO TO 27
                IF(INC.EQ.'2'.AND.PNI.EQ.'    ')   GO TO 27
                IF(INC.EQ.'3'.AND.PNI.EQ.'    ')   GO TO 27
                IF(INC.EQ.'4'.AND.PNI.EQ.'    ')   GO TO 27
                IF(INC.EQ.'5'.AND.PNI.EQ.'    ')   GO TO 27
C
                IF(INC.EQ.'A'.AND.PNI.NE.'    '.AND.PPI.NE.'    ') GOTO 21
                IF(INC.EQ.'D'.AND.PNI.NE.'    '.AND.PPI.NE.'    ') GOTO 22
C
                IF(PNI.EQ.'    ')                  GO TO 12
C
                IF(INC.EQ.'B'.AND.PNI.NE.'FORE')   GO TO 11
                IF(INC.EQ.'H'.AND.PNI.NE.'LP  ')   GO TO 11
                IF(INC.EQ.'P'.AND.PNI.NE.'INT ')   GO TO 11
                IF(INC.EQ.'M'.AND.PNI.NE.'SSAG')   GO TO 11
                IF(INC.EQ.'R'.AND.PNI.NE.'VIEW')   GO TO 11
                IF(INC.EQ.'C'.AND.PNI.NE.'EAR ')   GO TO 11
                IF(INC.EQ.'S'.AND.PNI.NE.'CP  ')   GO TO 11
C
```

```
       12   CONTINUE
                        IF(INC.EQ.'B')                   GO TO 23
                        IF(INC.EQ.'H')                   GO TO 24
                        IF(INC.EQ.'P')                   GO TO 25
                        IF(INC.EQ.'F')                   GO TO 26
                        IF(INC.EQ.'R')                   GO TO 22
      C
                        IF(INC.EQ.'C')                             CALL SCREEN
                        IF(INC.EQ.'C')                             WRITE(6,800)
                        IF(INC.EQ.'C')                             READ(5,1000) ASK
                        IF(INC.EQ.'C'.AND.ASK.NE.'OK')             CALL SCREEN
                        IF(INC.EQ.'C'.AND.ASK.NE.'OK')             WRITE(6,181)
                        IF(INC.EQ.'C'.AND.ASK.NE.'OK')             GO TO 20
                        IF(INC.EQ.'C')                   GO TO 15
      C
                        IF(INC.EQ.'S')                             CALL SCREEN
                        IF(INC.EQ.'S')                             WRITE(6,900)
                        IF(INC.EQ.'S')                             READ(5,1000) ASK
                        IF(INC.EQ.'S'.AND.ASK.NE.'OK')             CALL SCREEN
                        IF(INC.EQ.'S'.AND.ASK.NE.'OK')             WRITE(6,181)
                        IF(INC.EQ.'S'.AND.ASK.NE.'OK')             GO TO 20
                        IF(INC.EQ.'S')                             WRITE(6,901)
                        IF(INC.EQ.'S')                   STOP
      C
       11   CONTINUE
      C
            CALL SCREEN
            WRITE(6,200)
            GO TO 20
      C
      C
      C                 ********************************************
      C                 *                                          *
      C                 *               THE ADD MODULE             *
      C                 *                                          *
      C                 ********************************************
      C
      C*****   CHECK WHETHER THE PROJECT IS ALREADY SCHEDULED
      C
       21   CONTINUE
                    DO  71  I = 1 , 10
                    DO  71  J = 1 , NPR
                        IF ( SP(I,J) .NE. PNI )        GO TO 71
                        CALL SCREEN
                        WRITE(6,210)
                        GO TO 20
       71           CONTINUE
      C
      C*****   CHECK EXISTANCE OF INPUT PROJECT
      C
                    DO  72  I = 1 , NPJ
                        IF ( PCODE(I) .EQ. PNI )       GO TO 31
       72           CONTINUE
            CALL SCREEN
            WRITE(6,211)
            GO TO 20
      C
```

```
C*****    CHECK EXISTANCE OF PERIOD
C
 31    CONTINUE
          IP = I
               DO  73  I = 1 , NPR
                    IF ( PP(I) .EQ. PP1 )         GO TO 32
 73            CONTINUE
       CALL SCREEN
       WRITE(6,212)
       GO TO 20
C
C*****    STORE THE INFORMATION FOR BEFORE COMMAND
C
 32    CONTINUE
          IC = I
               DO  77  I = 1 , 6
                    TDEVB(I) = TDEV(I)
                    DO  77  J = 1 , NPR
                         DEVB(I,J) = DEV(I,J)
 77            CONTINUE
C
               DO  78  I = 1 , 10
                    DO  78  J = 1 , NPR
                         SPB(I,J) = SP(I,J)
 78            CONTINUE
C
          NDAB  = NDA
          UCB   = UC
          LANDB = LAND
          PFB   = PF
          RELB  = REL
C
C*****    SCHEDULE THE PROJECT NAME
C
               DO  79  I = 1 , 10
                    IF ( SP(I,IC) .NE. '    ' )   GO TO 79
                    SP(I,IC) = PCODE(IP)
                    GO TO 33
 79            CONTINUE
       CALL SCREEN
       WRITE(6,213)
       GO TO 20
C
C*****    ADJUST DEVIATIONS FROM INVESTMENT BUDGETS
C
 33    CONTINUE
          LEAD = PJINFO(IP,7)
          IF ( IC + LEAD - 1 .GE. NPR )  LEAD = NPR - IC + 1
               DO  88  J = IC , IC + LEAD - 1
                    DEV(3,J) = DEV(3,J) - PJINFO(IP,3)
                    TDEV(3)  = TDEV(3)  - PJINFO(IP,3)
                    DEV(4,J) = DEV(4,J) - PJINFO(IP,4)
                    TDEV(4)  = TDEV(4)  - PJINFO(IP,4)
 88            CONTINUE
          IF ( IC + LEAD - 1 .EQ. NPR )           GO TO 34
C
C*****    ADJUST DEVIATIONS FROM OTHER LIMITS AND TARGETS
```

```
      C
                LIFE = PJDATA(IP,8)
                IF ( IC + LEAD + LIFE .LT. NPR )  LOP = IC + LEAD + LIFE
                IF ( IC + LEAD + LIFE .GE. NPR )  LOP = NPR
      C
                      DO  89  J = IC + LEAD , LOP
                            DEV(1,J) = DEV(1,J) + PJINFO(IP,1)
                            TDEV(1)  = TDEV(1)  + PJINFO(IP,1)
                            DEV(2,J) = DEV(2,J) + PJINFO(IP,2)
                            TDEV(2)  = TDEV(2)  + PJINFO(IP,2)
                            DEV(5,J) = DEV(5,J) - PJINFO(IP,5)
                            TDEV(5)  = TDEV(5)  - PJINFO(IP,5)
                            DEV(6,J) = DEV(6,J) - PJINFO(IP,6)
                            TDEV(6)  = TDEV(6)  - PJINFO(IP,6)
      C
      C*****    ADJUST OTHER VARIABLES
      C
                            EGC(J)   = EGC(J)    + PJINFO(IP,8) + PJINFO(IP,5) +
           *                             PJINFO(IP,6) * FC / 1000
                            TDEP     = TDEP      + PJINFO(IP,8)
       89             CONTINUE
      C
                NDA   = ( ITDEV(3) - TDEV(3) + ( ITDEV(4) - TDEV(4) ) *
           *               FC / 1000 - TDEP ) / 1000
                UC    = (  ITDEV(5) - TDEV(5) + ( ITDEV(6) - TDEV(6) ) *
           *               FC / 1000 + TDEP ) / ( TDEV(2) - ITDEV(2) ) * 10
                LAND = LAND + PJINFO(IP,9)
                PF    = PF + PJINFO(IP,10)
                REL   = (( TDEV(1) - ITDEV(1)) / (ITDEV(1) * (-1))) ** 10 * 100
      C
      C*****    SCREEN THE RESULTS
      C
       34   CONTINUE
            CALL SCREEN
            WRITE(6,300)  PNI , PPI
            GO TO 20
      C
      C                     *************************************************
      C                     *                                               *
      C                     *                THE DELETE MODULE              *
      C                     *                                               *
      C                     *************************************************
      C
      C*****    CHECK FOR INPUT VALIDITY
      C
       22   CONTINUE
                      DO  74  I = 1 , NPR
                            IF ( PP(I) .NE. PPI )           GO TO 74
                            IC = I
                            DO  74  J = 1 , 10
                                  IF ( SP(J,IC) .NE. PNI ) GO TO 74
                            IR = J
                            GO TO 40
       74             CONTINUE
            CALL SCREEN
            WRITE(6,230)
            GO TO 20
```

```
      C
      C*****   STORE THE INFORMATION FOR BEFORE COMMAND
      C
       40   CONTINUE
                     DO  75  I = 1 , 6
                         TDEVB(I) = TDEV(I)
                         DO  75  J = 1 , NPR
                              DEVB(I,J) = DEV(I,J)
       75            CONTINUE
      C
                     DO  76  I = 1 , 10
                         DO  76  J = 1 , NPR
                              SPB(I,J) = SP(I,J)
       76            CONTINUE
               NDAB  = NDA
               UCB   = UC
               LANDB = LAND
               PFB   = PF
               RELB  = REL
      C
      C*****   FIND PROJECT FILE INDEX
      C
                     DO  91  I = 1 , NPJ
                         IF ( PCODE(I) .NE. FNI )      GO TO 91
                         IP = I
                         GO TO 41
       91            CONTINUE
            CALL SCREEN
            WRITE(6,500)
            GO TO 20
      C
      C*****   UPDATE THE SCHEDULE TABLE
      C
       41   CONTINUE
               IF ( SP(10,IC) .EQ. '     ' )            GO TO 42
               SP(IP,IC) = SP(10,IC)
               SP(10,IC) = '     '
               GO TO 43
      C
       42   CONTINUE
                     DO  92  I = 1 , 10
                         IF ( SP(11-I,IC) .EQ. '     ') GO TO 92
                         SP(IP,IC) = SP(11-I,IC)
                         SP(11-I,IC) = '     '
                         GO TO 43
       92            CONTINUE
      C
      C*****   ADJUST DEVIATIONS FROM INVESTMENT BUDGETS
      C
       43   CONTINUE
               LEAD = PJINFO(IP,7)
               IF ( IC + LEAD - 1 .GE. NPR )  LEAD = NPR - IC + 1
                     DO  93  J = IC , IC + LEAD - 1
                         DEV(3,J) = DEV(3,J) + PJINFO(IP,3)
                         TDEV(3)  = TDEV(3)  + PJINFO(IP,3)
                         DEV(4,J) = DEV(4,J) + PJINFO(IP,4)
                         TDEV(4)  = TDEV(4)  + PJINFO(IP,4)
```

```
 93         CONTINUE
       IF ( IC + LEAD - 1 .EQ. NPR )            GO TO 44
C
C*****  ADJUST DEVIATIONS FROM OTHER LIMITS AND TARGETS
C
       LIFE = PJDATA(I,8)
       IF ( IC + LEAD + LIFE .LT. NPR )  LOP = IC + LEAD + LIFE
       IF ( IC + LEAD + LIFE .GE. NPR )  LOP = NPR
C
            DO  94  J = IC + LEAD , LOP
                DEV(1,J) = DEV(1,J) - PJINFO(IP,1)
                TDEV(1)  = TDEV(1)  - PJINFO(IP,1)
                DEV(2,J) = DEV(2,J) - PJINFO(IP,2)
                TDEV(2)  = TDEV(2)  - PJINFO(IP,2)
                DEV(5,J) = DEV(5,J) + PJINFO(IP,5)
                TDEV(5)  = TDEV(5)  + PJINFO(IP,5)
                DEV(6,J) = DEV(6,J) + PJINFO(IP,6)
                TDEV(6)  = TDEV(6)  + PJINFO(IP,6)
C
C*****  ADJUST OTHER VARIABLES
C
                EGC(J)   = EGC(J)   - PJINFO(IP,8) - PJINFO(IP,5) -
     *                      PJINFO(IP,6) * FC / 1000
                TDEP     = TDEP     - PJINFO(IP,8)
 94         CONTINUE
C
       NDA  = ( ITDEV(3) - TDEV(3) + ( ITDEV(4) - TDEV(4) ) *
     *        FC / 1000 - TDEP ) / 1000
       UC   = (  ITDEV(5) - TDEV(5) + ( ITDEV(6) - TDEV(6) ) *
     *        FC / 1000 + TDEP ) / ( TDEV(2) - ITDEV(2) ) * 10
       LAND = LAND - PJINFO(IP,9)
       PF   = PF - PJINFO(IP,10)
       REL  = (( TDEV(1) - ITDEV(1)) / (ITDEV(1) * (-1))) ** 10 * 100
C
C*****  SCREEN THE RESULTS
C
 44    CONTINUE
       CALL SCREEN
       WRITE(6,400)  PNI , PPI
       GO TO 20
C
C               ***********************************************
C               *                                             *
C               *           THE LAST SCREEN MODULE            *
C               *                                             *
C               ***********************************************
C
 23    CONTINUE
       WRITE(6,190)   UCB , IS ,
     *   NDAB , RELB , LANDB , PFB , ( PP(J) , J = J1,J2 ) ,
     *  ( LTN(I) , TDEVB(I) , ( DEVB(I,J) , J = J1,J2 ) , I = 1,6 ) ,
     *  ( PF(J) , J = J1,J2 ) ,
     *  ( I , ( SPB(I,J) , J = J1,J2 ) , I = 1,10 )
C
       WRITE(6,180)
       ASK = '**'
       READ(5,1000) ASK
```

```
            IF ( ASK .NE. 'GO' )                      GO TO 23
C
         CALL SCREEN
         WRITE(6,181)
         GO TO 20
C
C                  ***********************************************
C                  *                                             *
C                  *               THE HELP MODULE               *
C                  *                                             *
C                  ***********************************************
C
 24      CONTINUE
            WRITE(6,150)
            ASK = '**'
            READ(5,1000) ASK
            IF ( ASK . NE. 'GO' )                     GO TO 24
C
            WRITE(6,151)
            WRITE(6,152)
            ASK = '**'
            READ(5,1000) ASK
            IF ( ASK .NE. 'GO' )                      GO TO 24
C
         CALL SCREEN
         WRITE(6,153)
         GO TO 20
C
C                  ***********************************************
C                  *                                             *
C                  *               THE PRINT MODULE              *
C                  *                                             *
C                  ***********************************************
C
 25      CONTINUE
            WRITE(8,190) UC , IS ,
     *        NDA , REL , LAND , FF , ( PP(J) , J = J1,J2 ) ,
     *      ( LTN(I) , TDEV(I) , ( DEV(I,J) , J = J1,J2 ) , I = 1,6 ) ,
     *      ( PP(J) , J = J1,J2 ) ,
     *      ( I , ( SP(I,J) , J = J1,J2 ) , I = 1,10 )
C
         CALL SCREEN
         WRITE(6,170)
         GO TO 20
C
C                  ***********************************************
C                  *                                             *
C                  *              THE MESSAGE MODULE             *
C                  *                                             *
C                  ***********************************************
C
 26      CONTINUE
            CALL SCREEN
            WRITE(6,160)
                 READ(5,3000)  ( MSG(I) , I = 1,80 )
                 WRITE(8,161)  ( MSG(I) , I = 1,80 )
         CALL SCREEN
```

```
            WRITE(6,162)
            GO TO 20
C
C                  **********************************************************
C                  *                                                        *
C                  *             THE DEVIATIONS REVIEW MODULE               *
C                  *                                                        *
C                  **********************************************************
C
 28     CONTINUE
           CALL SCREEN
           WRITE(6,700)
           ASK = '**'
           READ(5,1000) ASK
                IF ( ASK .EQ. 'OP' )                 GO TO 51
                IF ( ASK .EQ. 'PE' )                 GO TO 52
                IF ( ASK .EQ. 'NC' )                 GO TO 53
           GO TO 28
C
C*****     OPTIMISTIC REVIEW OF DEVIATIONS
C
 51     CONTINUE
           DO  55  I = 1 , 6
           DO  55  J = 1 , NPR
              DEV(I,J)  = DEV(I,J) + ODEV(I,J)
              RDEV(I,J) = ODEV(I,J)
 55        CONTINUE
C
           CALL SCREEN
           WRITE(6,701)
           ASK = '**'
           READ(5,1000) ASK
              IF ( ASK .EQ. 'NE' )                 GO TO 60
              IF ( ASK .EQ. 'GO' )                 GO TO 59
              GO TO 51
C
C*****     PESSIMISTIC REVIEW OF DEVIATIONS
C
 52     CONTINUE
           DO  56  I = 1 , 6
           DO  56  J = 1 , NPR
              DEV(I,J)  = DEV(I,J) + PDEV(I,J)
              RDEV(I,J) = PDEV(I,J)
 56        CONTINUE
C
           CALL SCREEN
           WRITE(6,702)
           ASK = '**'
           READ(5,1000) ASK
              IF ( ASK .EQ. 'NE' )                 GO TO 60
              IF ( ASK .EQ. 'GO' )                 GO TO 59
              GO TO 52
C
C*****     DEMAND REVISION PER PRICE ELASTICITY
C
 53     CONTINUE
           DO  54  I = 1 , 6
```

```
                  DO  54  J = 1 , NPR
                       RDEV(I,J) = 0.0
          54      CONTINUE
      C
          60   CONTINUE
      C
                  CEGC(1) = EGC(1) + IEGC
                  CGE(1)  = IAE + DEV(2,1) - IDEV(2,1)
                  P(1)    = PM * CEGC(1) / CGE(1)
      C
                  DO  58  J = 2 , NPR
                       CEGC(J) = CEGC(J-1) + EGC(J)
                       CGE(J)  = CGE(J-1)  + DEV(2,J) - IDEV(2,J) - RDEV(2,J)
                       P(J)    = PM * CEGC(J) / CGE(J)
                       IF ( J .LT. 4 )                        GO TO 58
                          RD(J) = EXP( -1 * PE *  ( 0.6065 * P(J-1) +
           *                      0.3679 * P(J-2) + 0.0256 * P(J-3) ) ) *
           *                      ( IDEV(2,J) + RDEV(2,J) )
          58      CONTINUE
      C
                  DO  61  J = 1 , NPR
                       RDEV(2,J) = RDEV(2,J) + RD(J)
          61      CONTINUE
      C
          62   CONTINUE
                  CALL SCREEN
                  WRITE(6,703)
                  ASK = '**'
                  READ(5,1000) ASK
                       IF ( ASK .NE. 'GO' )                   GO TO 62
      C
          59   CONTINUE
                  DO  57  I = 1 , 6
                  DO  57  J = 1 , NPR
                       DEV(I,J) = DEV(I,J) -  RDEV(I,J)
          57      CONTINUE
      C
                  CALL SCREEN
                  WRITE(6,181)
                  GO TO 20
      C
      C                   **************************************************
      C                   *                                                *
      C                   *              THE SCREEN SLIDE MODULE           *
      C                   *                                                *
      C                   **************************************************
      C
          27   CONTINUE
                  IF ( INC .EQ. '1' )  IS = 1
                  IF ( INC .EQ. '2' )  IS = 2
                  IF ( INC .EQ. '3' )  IS = 3
                  IF ( INC .EQ. '4' )  IS = 4
                  IF ( INC .EQ. '5' )  IS = 5
                       J1 = IS * 5 - 4
                       J2 = J1 + 9
               CALL SCREEN
               WRITE(6,600)
```

```
         GO TO 20
C
C                    ***********************************************
C                    *                                             *
C                    *                INPUT FORMATS                *
C                    *                                             *
C                    ***********************************************
C
 1000 FORMAT( A2 )
 1100 FORMAT( I4 , 6( 1X , A5 ) )
 1200 FORMAT( A4 , 6F6.0 )
 1300 FORMAT( I4 )
 1400 FORMAT( A4 , 10F5.0 )
 1500 FORMAT( 4X , 6F6.0 )
 2000 FORMAT( A1 , 1X , A4 , 1X , A4 )
 3000 FORMAT( 80A1 )
 4000 FORMAT( 50X , F10.0 )
 9000 FORMAT( A2 )
C
C                    ***********************************************
C                    *                                             *
C                    *                OUTPUT FORMATS               *
C                    *                                             *
C                    ***********************************************
C
 100  FORMAT( '1' ////////////// 24X , '- -   R U N N I N G   - -' ,
     * ////////////// )
C
 101  FORMAT( '1'  ////   1X , 77( '*' ) ,
     * ///      8X , 'THIS PROGRAM IS PREPARED  IN 1983' ,
     *          1X , 'AND REVISED IN 1985' ,
     * //       8X , 'BY  TAHIR ULUSOY' ,
     * //       8X , 'AS A PART OF HIS MASTER THESIS :' ,
     * //       8X , '- JUDGEMENTAL PROGRAMMING AND AN EXAMPLE FOR' ,
     *          1X , 'INVESTMENT PLANNING -' ,
     * //       8X , 'SUPERVISED BY PROF.DR. IBRAHIM KAVRAKOGLU' ,
     * //       8X , 'IN THE INDUSTRIAL ENGINEERING DEPARTMENT' ,
     *          1X , 'OF BOSPHORUS UNIVERSITY' ,
     * //       8X , 'IN ISTANBUL' ,
     * ///      1X , 77( '*' ) ,
     * ///      22X , 'PROGRAM IS IN INITIALIZATION STAGE' ,
     * /////    21X , '-- PLEASE ENTER -GO- TO CONTINUE --' )
C
 102  FORMAT( '1' ////////
     * ////// 26X , 'INITIALIZATION COMPLETED' ,
     * ////// 25X , 'PROGRAM IS IN INPUT STAGE' ,
     * ////// 20X , '-- PLEASE ENTER -GO- TO CONTINUE --' /// )
C
 103  FORMAT( '1' ////
     * /////    32X , 'INPUT STAGE COMPLETED' ,
     * ////     35X , 'PROGRAM IS READY' ,
     * ////     8X , 69( '*' ) ,
     * //       8X , 'PLEASE REMEMBER :' ,
     * /        8X , 'YOU CAN USE RESERVED WORDS -H- OR -HELP-' ,
     * /        8X , 'TO HAVE THE MEANINGS OF ALL RESERVED WORDS ' ,
     *          'AND ABBREVIATIONS' ,
     * /        8X , 'AT ANY TIME DURING THE PROGRAM EXECUTION' ,
```

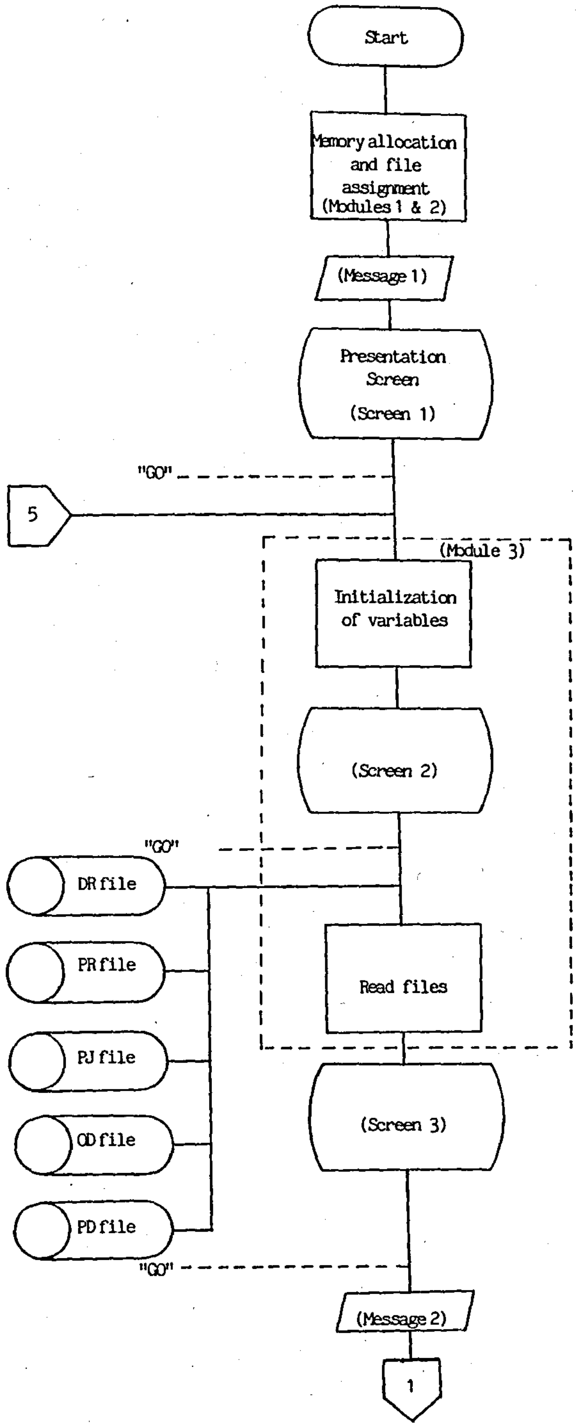
```
     * //     8X , 69( '*' ) ,
     * /////  25X , '-- PLEASE ENTER -GO- TO CONTINUE --' )
C
 104  FORMAT( 28X , '- -   R E A D Y    - -' )
C
 150  FORMAT( '1' //
     * / 1X , 'INPUT COMMANDS :' ,
     * //1X , 'A/++++/---- : ADD PROJECT ++++ TO YEAR ---- ' ,
     *        'TO START THE PROJECT AT ----' ,
     * //1X , 'B OR BEFORE : SHOW THE SCREEN BEFORE THE LAST ONE' ,
     * //1X , 'C OR CLEAR  : CLEAR ALL SCHEDULED PROJECTS AND ' ,
     *        'REINITIALIZE THE PROGRAM' ,
     * //1X , 'D/++++/---- : DELETE PROJECT ++++ FROM YEAR ---- ' ,
     *        'TO RETURN TO THE STATE BEFORE ' ,
     * //1X , 'H OR HELP   : DISPLAY THIS SCREEN' ,
     * //1X , 'M OR MESSAGE: PRINT EACH TIME ' ,
     *        'A MESSAGE OF 80 CHARACTERS ON PAPER' ,
     * //1X , 'P OR PRINT  : PRINT THE CURRENT SCREEN ON PAPER' ,
     * //1X , 'R OR REVIEW : REVIEW DEVIATIONS FROM ' ,
     *        'LIMITS AND TARGETS ' ,
     * //1X , 'S OR STOP   : STOP THE PROGRAM' ,
     * //1X , ' 1,2,3,4,5  : SLIDE THE SCREEN ' ,
     * ////
     * //22X, '-- PLEASE ENTER -GO- FOR THE NEXT PAGE --' )
C
 151   FORMAT( '1'/
     * //1X , 'SCREEN ABBREVIATIONS :' ,
     * //1X , 'S    ',6X, ' : SCREEN NUMBER ' ,
     * / 1X , 'UC   ',6X, ' : UNIT COST OF ENERGY GENERATION (TL/KWH)',
     * / 1X , 'NDA  ',6X, ' : NON DEPRECIATED ASSETS (1000B TL) ' ,
     * / 1X , 'REL  ',6X, ' : AVERAGE SYSTEM RELIABILITY (%) ' ,
     * / 1X , 'LAND ',6X, ' : LAND USED FOR INVESTMENTS (KM2)',
     * / 1X , 'PF   ',6X, ' : POLLUTION FACTOR (KM CUBES SO2) ' ,
     * //1X , 'DEVSF',6X, ' : DEVIATIONS FROM LIMITS AND TARGETS' ,
     * / 1X , 'TOTAL',6X, ' : DEVIATIONS TOTAL ')
 152   FORMAT( /
     *   1X , 'POWER',6X, ' : DEVIATIONS FROM POWER TARGETS (100MW)' ,
     * / 1X , 'ENERG',6X, ' : DEVIATIONS FROM ENERGY TARGETS (100GWH)',
     * / 1X , 'INTLB',6X , ' : DEVIATIONS FROM INVESTMENT ' ,
     *        'TL BUDGET LIMITS (TL B)' ,
     * / 1X , 'INFCB', 6X ,' : DEVIATIONS FROM INVESTMENT ' ,
     *        'FOR. CUR. BUDGET LIMITS ($ M)' ,
     * / 1X , 'OMTLB', 6X , ' : DEVIATIONS FROM OP./MAINTENANCE',
     *        ' TL BUDGET LIMITS (TL B)' ,
     * / 1X , 'OMFCB', 6X , ' : DEVIATIONS FROM OP./MAINTENANCE',
     *        ' FOR.CUR. BUDGET LIMITS ($ M)' ,
     * //1X , 'SCH.PROJECTS: SCHEDULED PROJECTS STARTED ' ,
     *        'AT THE BEGINNING OF EACH PERIOD' ,
     * /////
     * //10X , '-- PLEASE ENTER -GO- TO RETURN ' ,
     *        'TO THE CURRENT SCREEN --' )
C
 153  FORMAT(    8X , '-- YOU CAN REENTER -HELP- TO HAVE AGAIN ' ,
     *        'THE HELP SCREEN --' )
C
 160  FORMAT( 7X , '-- PLEASE ENTER YOUR MESSAGE UP TO 80 CHARACTERS ' ,
     *        'TO BE PRINTED --' )
```

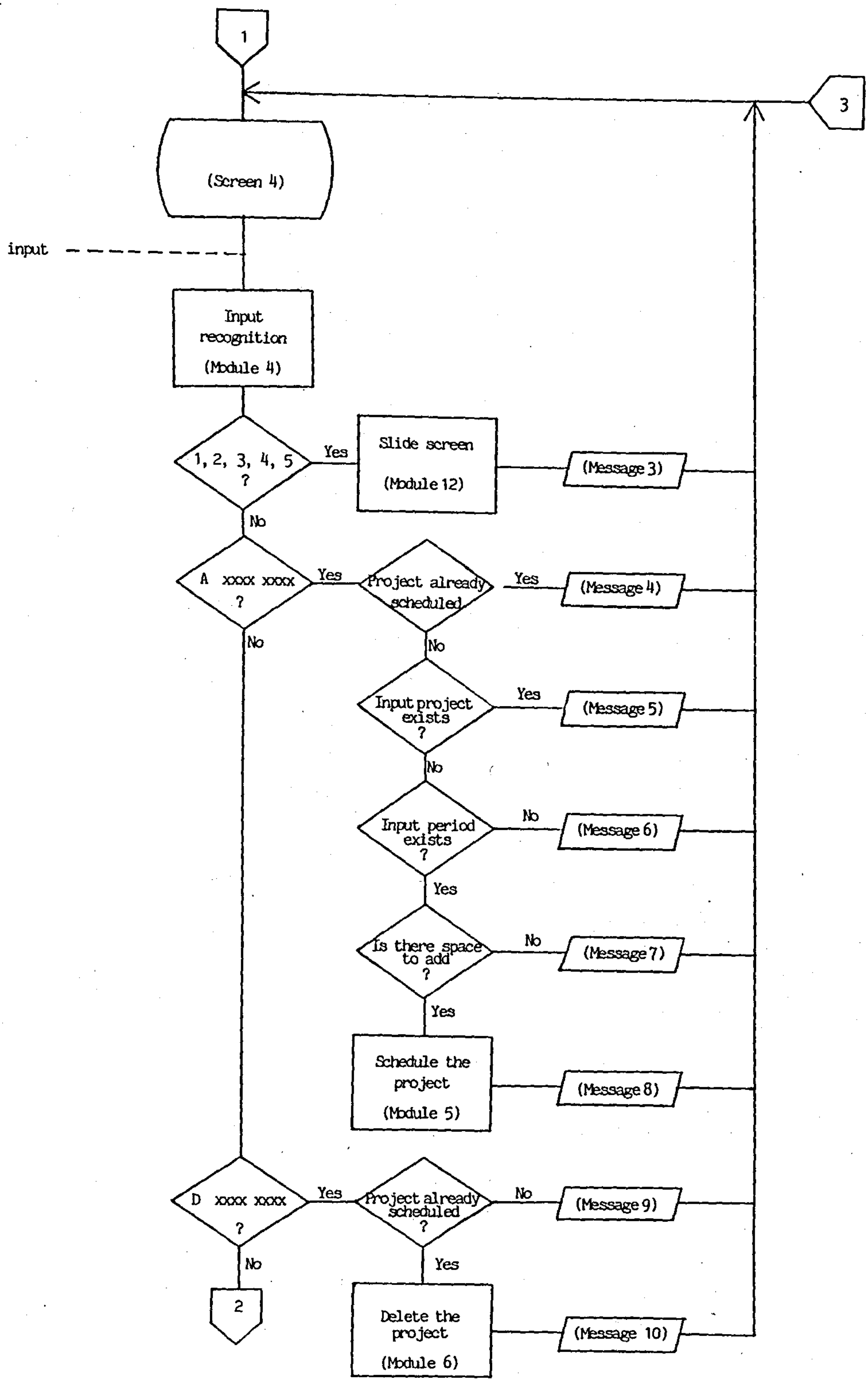
```
C
 161  FORMAT( 1X , 80A1 / )
C
 162  FORMAT( 16X , '-- THE MESSAGE LINE IS PRINTED ON THE PAPER --' )
C
 170  FORMAT( 16X , '-- THE ABOVE SCREEN IS PRINTED ON THE PAPER --' )
C
 180  FORMAT( 1X , '-- THE LAST SCREEN WAS AS ABOVE, ' ,
     *            'PLEASE ENTER -GO- FOR THE CURRENT SCREEN --' )
C
 181  FORMAT( 20X , '-- RETURNED TO THE CURRENT SCREEN --' )
C
 190  FORMAT( '1' , /
     * //     1X , 'UC:', F9.0 , 57X , 'S:' , I1 ,
     * ///    1X , 'NDA :' , F13.0 , 5X , 'REL:' , F6.0 , 5X ,
     *               'LAND:' , F10.0 , 5X , 'PF:' , F12.0 ,
     * ///    1X , 'DEVSF' , 2X , 'TOTAL' , 1X , 10( 2X , A4 ) ,
     * /      1X , '*****  *****' , 1X , 10( 2X , '****' ) ,
     *        6( / 1X , A5 , F8.0 , 10F6.0 ) ,
     * //     1X , 'SCH. PROJECTS' ,   10( 2X , A4 ) ,
     * /      1X , 13( '*' ) , 10( 2X , '****' ) ,
     *        10( / 9X , I2 , '-->' , 10( 2X , A4 ) ) / )
C
 200  FORMAT( 9X , '*** UNRECOGNIZED INPUT; ' ,
     *            'PLEASE WRITE -HELP- OR REENTER CAREFULLY ***' )
C
 210  FORMAT( 9X , '*** THE PROJECT IS ALREADY SCHEDULED; ' ,
     *            'INPUT IS IGNORED ***' )
C
 211  FORMAT( 14X , '*** UNRECOGNIZED PROJECT NAME; ' ,
     *            'PLEASE REENTER ***' )
C
 212  FORMAT( 14X , '*** UNRECOGNIZED PERIOD NAME; PLEASE REENTER ***' )
C
 213  FORMAT( 1X , '*** THERE IS NO PLACE TO SCHEDULE THE PROJECT; ' ,
     *            'PLEASE REVIEW THE PERIOD ***' )
C
 230  FORMAT( 13X , '*** UNRECOGNIZED DELETE COMMAND; ' ,
     *            'PLEASE REENTER ***' )
C
 300  FORMAT( 11X , '-- PROJECT ' , A4 , ' IS STARTED ' ,
     *            'AT THE BEGINNING OF ' , A4 , ' --' )
C
 400  FORMAT( 7X , '-- PROJECT ' , A4 , ' IS DELETED ' ,
     *            'FOR PERIODS BEGINNING FROM ' , A4 , ' --' )
C
 500  FORMAT( 14X , '* * *  U N R E C O G N I Z E D    ' ,
     *            'E R R O R  * * *' )
C
 600  FORMAT( 24X , '-- YOU CHANGED THE SCREEN --' )
C
 700  FORMAT( 13X , '-- PLEASE ENTER -OPT- , -PES- OR -NOR- ' ,
     *            'FOR DEVIATIONS REVIEW --' )
C
 701  FORMAT( 1X , '-- OPTIMISTIC REVIEW PERFORMED, ' ,
     *            '-NEXT- FOR PRICE ELASTICITY, -GO- TO RETURN --' )
C
```

```
  702  FORMAT( 1X , '-- PESSIMISTIC REVIEW PERFORMED, ' ,
     *            '-NEXT- FOR PRICE ELASTICITY, -GO- TO RETURN --' )
C
  703  FORMAT( 1X , '-- DEMAND REVIEWED ' ,
     *            'ACCORDING TO THE PRICE ELASTICITY, ' ,
     *            'ENTER -GO- TO RETURN --' )
C
  800  FORMAT( 4X , '-- YOU WILL CLEAR ALL YOUR WORK, ' ,
     *            'PLEASE ENTER -OK- FOR CONFIRMATION --' )
C
  900  FORMAT( 5X , '-- YOU WILL STOP THE PROGRAM, ' ,
     *            'PLEASE ENTER -OK- FOR CONFIRMATION --' )
C
  901  FORMAT( '1' ///////////// 20X , '-- YOU STOPPED THE PROGRAM --' ,
     *             //////////////// )
C
       END
```

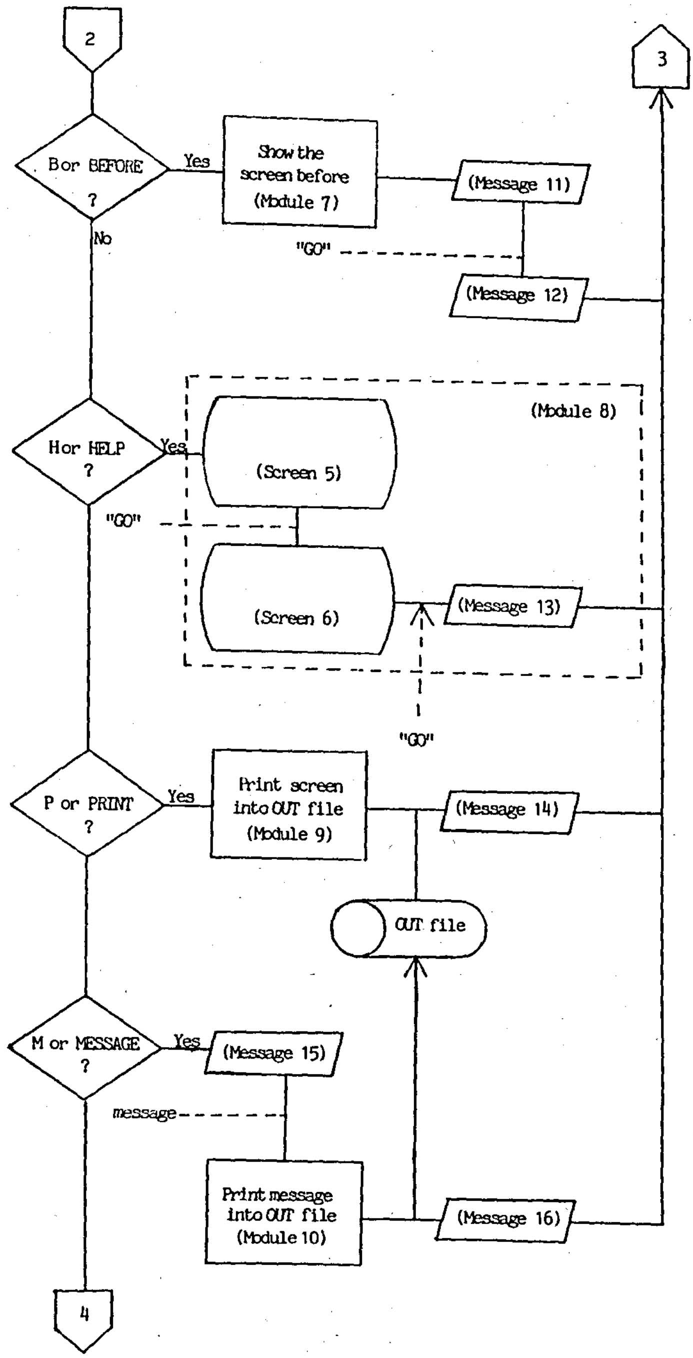
```
C
C
C
C
C                       **************************************************
C                       *                                                *
C                       *              THE SCREEN SUBROUTINE             *
C                       *                                                *
C                       **************************************************
C
        SUBROUTINE SCREEN
        COMMON        /CHAR/  PP , SP , LTN
        COMMON        IS , J1 , J2 , TDEV , DEV
        COMMON        UC , NDA , LAND , PF , REL
        CHARACTER*4   PF(30) , SP(10,30)
        CHARACTER*5   LTN(6)
        REAL          TDEV(6) , DEV(6,30)
        REAL          UC , NDA , LAND , PF , REL
C
           WRITE(6,190) UC , IS ,
     *       NDA , REL , LAND , PF , ( PF(J) , J = J1,J2 ) ,
     *     ( LTN(I) , TDEV(I) , ( DEV(I,J) , J = J1,J2 ) , I = 1,6 ) ,
     *     ( PP(J) , J = J1,J2 ) ,
     *     ( I , ( SP(I,J) , J = J1,J2 ) , I = 1,10 )
C
  190   FORMAT( '1' , /
     * //       1X , 'UC:', F9.0 , 57X , 'S:' , I1 ,
     * ///      1X , 'NDA :' , F13.0 , 5X , 'REL:' , F6.0 , 5X ,
     *               'LAND:' , F10.0 , 5X , 'PF:' , F12.0 ,
     * ///      1X , 'DEVSF' , 2X , 'TOTAL' , 1X , 10( 2X , A4 ) ,
     * /        1X , '*****  *****' , 1X , 10( 2X , '****' ) ,
     *          6( / 1X , A5 , F8.0 , 10F6.0 ) ,
     * //       1X , 'SCH. PROJECTS' ,    10( 2X , A4 ) ,
     * /        1X , 13( '*' ) , 10( 2X , '****' ) ,
     *          10( / 9X , I2 , '-->' , 10( 2X , A4 ) ) / )
        RETURN
        END
```

MAIN PROGRAM FLOW CHARTS

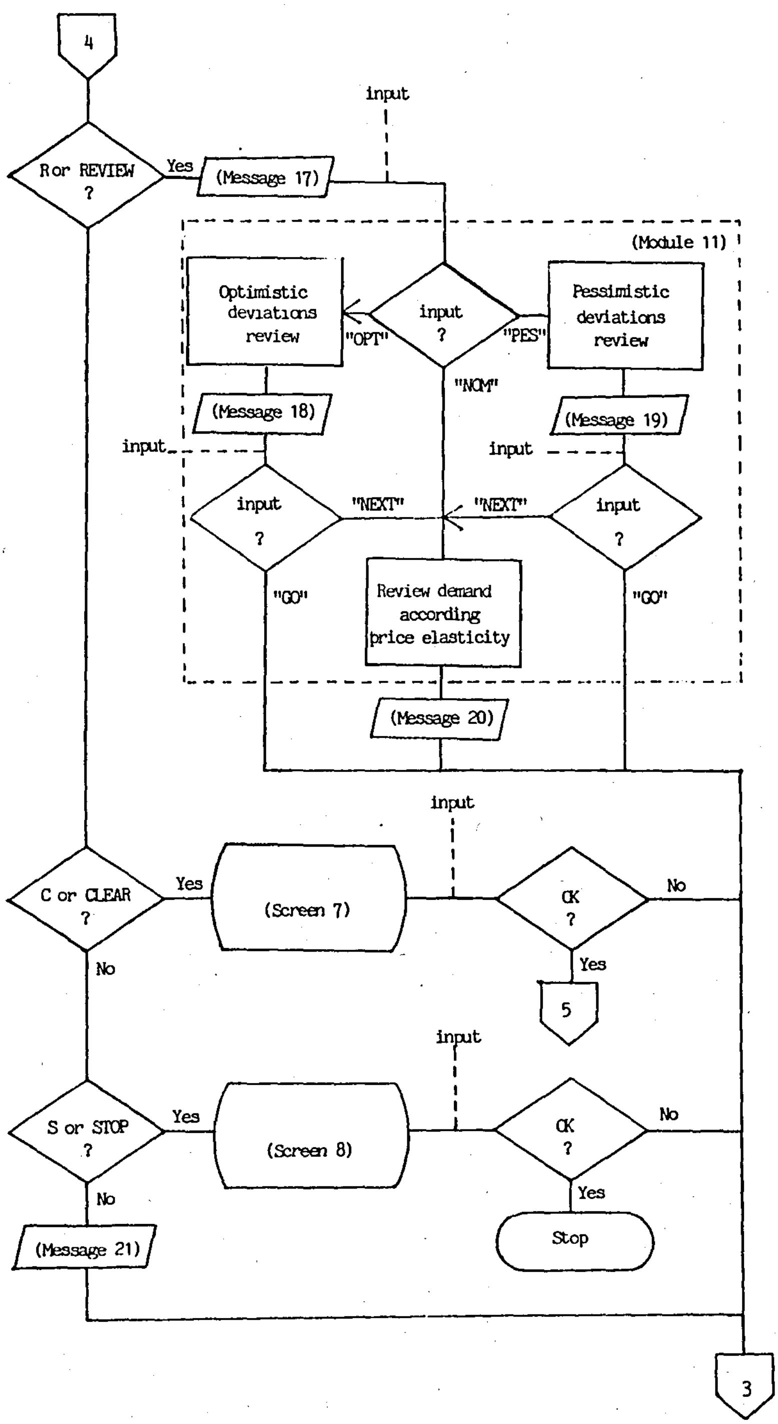

Start
Memory allocation and file assignment (Modules 1 & 2)
(Message 1)
Presentation Screen
(Screen 1)
"GO"
5
(Module 3)
Initialization of variables
(Screen 2)
"GO"
DR file
PR file
PJ file
OD file
PD file
Read files
(Screen 3)
"GO"
(Message 2)
1



1
3
(Screen 4)
input
Input recognition (Module 4)
1, 2, 3, 4, 5 ?
Yes
Slide screen (Module 12)
(Message 3)
No
A xxxx xxxx ?
Yes
Project already scheduled
Yes
(Message 4)
No
No
Input project exists ?
Yes
(Message 5)
No
Input period exists ?
No
(Message 6)
Yes
Is there space to add ?
No
(Message 7)
Yes
Schedule the project (Module 5)
(Message 8)
D xxxx xxxx ?
Yes
Project already scheduled ?
No
(Message 9)
Yes
Delete the project (Module 6)
(Message 10)
No
2



2
B or BEFORE ?
Yes
No
Show the screen before (Module 7)
(Message 11)
"GO"
(Message 12)
3
(Module 8)
H or HELP ?
Yes
(Screen 5)
"GO"
(Screen 6)
(Message 13)
"GO"
P or PRINT ?
Yes
Print screen into OUT file (Module 9)
(Message 14)
OUT file
M or MESSAGE ?
Yes
(Message 15)
message
Print message into OUT file (Module 10)
(Message 16)
4



4
R or REVIEW ?
Yes
(Message 17)
input
(Module 11)
Optimistic deviations review
input ?
"OPT"
"PES"
Pessimistic deviations review
"NOM"
(Message 18)
(Message 19)
input
input
input ?
"NEXT"
"NEXT"
input ?
"GO"
Review demand according price elasticity
"GO"
(Message 20)
input
C or CLEAR ?
Yes
(Screen 7)
OK ?
No
No
Yes
5
input
S or STOP ?
Yes
(Screen 8)
OK ?
No
No
Yes
(Message 21)
Stop
3

MAIN PROGRAM MODULES AND WORK PERFORMED

1. Description of variables

   - Explain meanings of all variables used in the program

2. Variables Declaration

   - Describe nature of all variables excluding integers
   - Specify dimensions and common blocks
   - Open files

3. Initialization Module

   - Present the program
   - Initialize all variables, reset files and prepare the program for input stage
   - Input all files
   - Perform initial computations

4. The Input Recognition Module

   - Read input, check input validity and assign the proper module

5. The Add Module

   - Check whether the project is already scheduled
   - Check for validity of project name and period
   - Store the actual screen for BEFORE command
   - Check whether there is place for screening the name
   - Schedule the project name on the scheduling area
   - Adjust periodical and total deviations from investment budgets without exceeding the planning horizon
   - For operating period adjust other periodical and total deviations as well as total electricity generating cost and total accumulated depreciation without exceeding the life time of the project and the planning horizon
   - Computes non depreciated assets remaining after the end of the planning horizon
   - Computes unit cost of energy generation, used land, pollution factor and overall system reliability

6. The Delete Module

- Check whether the stated project exist at the stated period
- Store the actual screen for BEFORE command
- Remove the project name from the scheduling area pushing up other names below
- Adjust all deviations reversing work performed by the add module and recompute other variables

7. The Last Screen Module

- Show the screen before the last add or delete command

8. The Help Module

- Show the meaning and use of all input commands and all screen abbreviations excluding interactively explained input requests

9. The Print Module

- Print the actual screen into OUT file to be output via printer or stored into magnetic media for further analysis or reference

10. The Message Module

- Print each time a full line message into OUT file to be output via printer or stored into magnetic media together with the printed screens for comments and explanations

11. The Deviations Review Module

- Ask for nominal, optimistic or pessimistic review
- Adjust the actual deviations according optimistic or pessimistic variances, show results, ask for price elasticity adjustment

- If nominal review entered or price elasticity adjustment is required together with pessimistic or optimistic review; compute actual price at each period according initial conditions and projects scheduled, then revise the energy demands according to the preset price elasticity.
- Show results
- Reverse deviations review adjustments to return to the current status.

12. The Screen Slide Module

. Slide the screen window over the planning horizon in multiples of five periods.

13. Input Formats

14. Output Formats

15. The Screen Subroutine

. Display the screens

MAIN PROGRAM SCREENS AND MESSAGES

```
*****************************************************************************

      THIS PROGRAM IS PREPARED  IN 1983 AND REVISED IN 1985
      BY  TAHIR ULUSOY
      AS A PART OF HIS MASTER THESIS :
      - JUDGEMENTAL PROGRAMMING AND AN EXAMPLE FOR INVESTMENT PLANNING -
      SUPERVISED BY PROF.DR. IBRAHIM KAVRAKOGLU
      IN THE INDUSTRIAL ENGINEERING DEPARTMENT OF BOSPHORUS UNIVERSITY
      IN ISTANBUL

*****************************************************************************

                    PROGRAM IS IN INITIALIZATION STAGE

                   -- PLEASE ENTER -GO- TO CONTINUE --
```

1

```
                        INITIALIZATION COMPLETED

                       PROGRAM IS IN INPUT STAGE

                   -- PLEASE ENTER -GO- TO CONTINUE --
```

2

INPUT STAGE COMPLETED

PROGRAM IS READY

`************************************************************************`

PLEASE REMEMBER :
YOU CAN USE RESERVED WORDS -H- OR -HELP-
TO HAVE THE MEANINGS OF ALL RESERVED WORDS AND ABBREVIATIONS
AT ANY TIME DURING THE PROGRAM EXECUTION

`************************************************************************`

-- PLEASE ENTER -GO- TO CONTINUE --

3

JC: 0.   S:1

NDA : 0.   REL: 0.   LAND: 0.   PF: 0.

DEVSF	TOTAL	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
*****	*****	****	****	****	****	****	****	****	****	****	****
POWER	-2688.	-51.	-61.	-72.	-75.	-77.	-85.	-95.	-100.	-105.	-117.
ENERG	-8081.	-56.	-88.	-92.	-120.	-140.	-180.	-200.	-220.	-235.	[illegible]
INTLB	6657.	130.	150.	175.	200.	220.	235.	260.	275.	[illegible]	332.
INFCB	12610.	130.	230.	330.	410.	480.	540.	620.	700.	710.	730.
DPTLB	9622.	21.	31.	43.	55.	85.	115.	150.	180.	220.	280.
DPFCB	3722.	21.	31.	52.	63.	75.	80.	90.	120.	135.	150.

SCH. PROJECTS	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
*************	****	****	****	****	****	****	****	****	****	****
1-->										
2-->										
3-->										
4-->										
5-->										
6-->										
7-->										
8-->										
9-->										
10-->										

4

```
INPUT COMMANDS :

A/++++/---- : ADD PROJECT ++++ TO YEAR ---- TO START THE PROJECT AT ----

B OR BEFORE : SHOW THE SCREEN BEFORE THE LAST ONE

C OR CLEAR  : CLEAR ALL SCHEDULED PROJECTS AND REINITIALIZE THE PROGRAM

D/++++/---- : DELETE PROJECT ++++ FROM YEAR ---- TO RETURN TO THE STATE BEFORE

H OR HELP   : DISPLAY THIS SCREEN

M OR MESSAGE: PRINT EACH TIME A MESSAGE OF 80 CHARACTERS ON PAPER

P OR PRINT  : PRINT THE CURRENT SCREEN ON PAPER

R OR REVIEW : REVIEW DEVIATIONS FROM LIMITS AND TARGETS

S OR STOP   : STOP THE PROGRAM

 1,2,3,4,5  : SLIDE THE SCREEN


                 -- PLEASE ENTER -GO- FOR THE NEXT PAGE --
```

5

```
SCREEN ABBREVIATIONS :

S             : SCREEN NUMBER
UC            : UNIT COST OF ENERGY GENERATION (TL/KWH)
NDA           : NON DEPRECIATED ASSETS (1000B TL)
REL           : AVERAGE SYSTEM RELIABILITY (%)
LAND          : LAND USED FOR INVESTMENTS (KM2)
PF            : POLLUTION FACTOR (KM CUBES SO2)

DEVSF         : DEVIATIONS FROM LIMITS AND TARGETS
TOTAL         : DEVIATIONS TOTAL

POWER         : DEVIATIONS FROM POWER TARGETS (100MW)
ENERG         : DEVIATIONS FROM ENERGY TARGETS (100GWH)
INTLB         : DEVIATIONS FROM INVESTMENT TL BUDGET LIMITS (TL B)
INFCB         : DEVIATIONS FROM INVESTMENT FOR. CUR. BUDGET LIMITS ($ M)
OMTLB         : DEVIATIONS FROM OP./MAINTENANCE TL BUDGET LIMITS (TL B)
OMFCB         : DEVIATIONS FROM OP./MAINTENANCE FOR.CUR. BUDGET LIMITS ($ M)

SCH.PROJECTS: SCHEDULED PROJECTS STARTED AT THE BEGINNING OF EACH PERIOD


        -- PLEASE ENTER -GO- TO RETURN TO THE CURRENT SCREEN --
```

6

-- YOU WILL CLEAR ALL YOUR WORK, PLEASE ENTER -OK- FOR CONFIRMATION --

7

-- YOU WILL STOP THE PROGRAM, PLEASE ENTER -OK- FOR CONFIRMATION --

8

MESSAGES

1 -- R U N N I N G --

2 -- R E A D Y --

3 -- YOU CHANGED THE SCREEN --

4 *** THE PROJECT IS ALREADY SCHEDULED; INPUT IS IGNORED ***

5 *** UNRECOGNIZED PROJECT NAME; PLEASE REENTER ***

6 *** UNRECOGNIZED PERIOD NAME; PLEASE REENTER ***

7 *** THERE IS NO PLACE TO SCHEDULE THE PROJECT; PLEASE REVIEW THE PERIOD ***

8 -- PROJECT H001 IS STARTED AT THE BEGINNING OF 1984 --

9 *** UNRECOGNIZED DELETE COMMAND; PLEASE REENTER ***

10 -- PROJECT H005 IS DELETED FOR PERIODS BEGINNING FROM 1984 --

11 -- THE LAST SCREEN WAS AS ABOVE, PLEASE ENTER -GO- FOR THE CURRENT SCREEN --

12 -- RETURNED TO THE CURRENT SCREEN --

13 -- YOU CAN REENTER -HELP- TO HAVE AGAIN THE HELP SCREEN --

14 -- THE ABOVE SCREEN IS PRINTED ON THE PAPER --

15 -- PLEASE ENTER YOUR MESSAGE UP TO 80 CHARACTERS TO BE PRINTED --

16 -- THE MESSAGE LINE IS PRINTED ON THE PAPER --

17 -- PLEASE ENTER -OPT- , -PES- OR -NOR- FOR DEVIATIONS REVIEW --

18 -- OPTIMISTIC REVIEW PERFORMED, -NEXT- FOR PRICE ELASTICITY, -GO- TO RETURN --

19 -- PESSIMISTIC REVIEW PERFORMED, -NEXT- FOR PRICE ELASTICITY, -GO- TO RETURN --

20 -- DEMAND REVIEWED ACCORDING TO THE PRICE ELASTICITY, ENTER -GO- TO RETURN --

21 *** UNRECOGNIZED INPUT; PLEASE WRITE -HELP- OR REENTER CAREFULLY ***

HELP PROGRAM SOURCE

```
      C
            PROGRAM HELP( INPUT , OUTPUT , TAPE5=INPUT , TAPE6=OUTPUT ,          ?
     *               OUT )                                                        ?
      C
      C     **********************************************************************
      C     **********************************************************************
      C     **                                                                  **
      C     **         TAHIR ULUSOY          FILE: HELP      VERSION: MAY  1965  **
      C     **                                                                  **
      C     **         PROGRAMS USED FOR THE MASTER THESIS                      **
      C     **                                                                  **
      C     **********************************************************************
      C     **********************************************************************
      C
      C
            CHARACTER A
            OPEN( 8 , FILE='OUT')
            REWIND 8
      C
       1       WRITE(6,100)
               WRITE(6,101)
               READ(5,1000) A
               IF(A.EQ.'1') WRITE(6,102)
               IF(A.EQ.'1') WRITE(6,103)
               IF(A.EQ.'2') WRITE(6,104)
               IF(A.EQ.'2') WRITE(6,105)
               IF(A.EQ.'3') WRITE(6,106)
               IF(A.EQ.'4') WRITE(6,107)
               IF(A.EQ.'4') WRITE(6,108)
               IF(A.EQ.'5') WRITE(6,109)
               IF(A.EQ.'6') WRITE(6,110)
      C
               IF(A.EQ.'7') WRITE(8,100)
               IF(A.EQ.'7') WRITE(8,101)
               IF(A.EQ.'7') WRITE(8,102)
               IF(A.EQ.'7') WRITE(8,103)
               IF(A.EQ.'7') WRITE(8,104)
               IF(A.EQ.'7') WRITE(8,105)
               IF(A.EQ.'7') WRITE(8,106)
               IF(A.EQ.'7') WRITE(8,107)
               IF(A.EQ.'7') WRITE(8,108)
               IF(A.EQ.'7') WRITE(8,109)
               IF(A.EQ.'7') WRITE(8,110)
               IF(A.EQ.'7') GO TO 1
      C
               IF(A.EQ.'8') STOP
               IF(A.GT.'8') GO TO 1
               READ(5,1000) A
               GO TO 1
      C
       1000  FORMAT(A1)
       100   FORMAT( '1' /////
            * / 3X , 'HELP PROGRAM MENU:',
            * / 3X , '----------------------------------',
            * / 3X , '1. LIST OF FILES',
```

```
     * / 3X , '2. EXECUTION INSTRUCTIONS',
     * / 3X , '3. MAIN PROGRAM INPUT COMMANDS',
     * / 3X , '4. MAIN PROGRAM SCREEN ABBREVIATIONS',
     * / 3X , '5. PJ FILE EXPLANATIONS'
     * / 3X , '6. INFO FILE EXPLANATIONS'
     * / 3X , '7. TO PRINT ALL SCREENS',
     * / 3X , '8. EXIT'
     * / 3X , '-----------------------------------')
 101  FORMAT ( ///
     * / 3X , 'FOR PRINTOUT ENTER /ROUTE,OUT,DC=PR AFTER EXIT ',
     * ///
     * / 3X , 'PLEASE REFER TO THE THESIS ENTITLED',
     * / 3X , '"JUDGEMENTAL PROGRAMMING ',
     *        'AND AN EXAMPLE FOR INVESTMENT PLANNING"',
     * / 3X , 'SUBMITTED TO THE INSTITUTE FOR ',
     *        'GRADUATE STUDIES IN SCIENCE AND ENGINEERING',
     * / 3X , 'OF BOSPHORUS UNIVERSITY IN ISTANBUL',
     * / 3X , 'IN 1985' // )
C
 102  FORMAT( '1' //
     * / 3X , 'NAME      EXPLANATION                TYPE       SECURITY',
     * / 3X , '--------  -------------------------  -------    --------',
     * / 3X , 'MAIN      MAIN PROGRAM               FORTRAN    READ    ',
     * / 3X , 'M         MAIN PROGRAM CODE          CODE       EXECUTE ',
     * / 3X , 'DR        DIRECTORY FILE             DATA       READ    ',
     * / 3X , 'PR        PERIODS DEVIATIONS         DATA       READ    ',
     * / 3X , 'OD        OPTIMISTIC DEVIATIONS      DATA       READ    ',
     * / 3X , 'PD        PESSIMISTIC DEVIATIONS     DATA       READ    ',
     * / 3X , 'OUT       OUTPUT FILE                TEMPORARY  USER    ',
     * / 3X , 'PJ        PROJECTS FILE              DATA       READ    ',
     * / 3X , 'SORT      SORT PROGRAM               FORTRAN    READ    ',
     * / 3X , 'S         SORT PROGRAM CODE          CODE       EXECUTE ')
 103  FORMAT(
     *   3X , 'SORTIN    SORT INPUT FILE            TEMPORARY  USER    ',
     * / 3X , 'SORTOUT   SORT OUTPUT FILE           TEMPORARY  USER    ',
     * / 3X , 'CONVERT   CONVERT PROGRAM            FORTRAN    READ    ',
     * / 3X , 'C         CONVERT PROGRAM CODE       CODE       EXECUTE ',
     * / 3X , 'INFO      COVERT OUTPUT FILE         TEMPORARY  USER    ',
     * / 3X , 'HELPS     HELP PROGRAM               FORTRAN    READ    ',
     * / 3X , 'HELP      HELP PROGRAM CODE          CODE       EXECUTE ',
     * ///////
     * //22X, '-- PLEASE ENTER -GO- TO RETURN --' )
 104  FORMAT( '1'
     * / 3X , '1. TO GET MAIN PROGRAM FILES',
     * / 5X , '/GET,M,DR,PR,PJ,OD,PD/UN=ULUSOY',
     * / 3X , '2. TO RUN THE MAIN PROGRAM ',
     * / 5X , '/M',
     * / 3X , '3. TO GET SCREENS AND MESSAGES',
     * / 5X , '/ROUTE,OUT,DC=PR',
     * / 3X , '4. TO SORT FILE PJ PER COLUMNS' ,
     * / 5X , '/GET,S,PJ/UN=ULUSOY',
     * / 5X , '/SAVE,PJ=SORTIN',
     * / 5X , '/S',
     * / 5X , '/SAVE,SORTOUT=FILENAME',
     * / 3X , '5. TO CONVERT FILE PJ INTO CONTRIBUTIONS TO',
     *        ' LIMITS AND TARGETS',
     * / 5X , '/GET,C,PJ/UN=ULUSOY',
```

```
     * / 5X , '/C',
     * / 5X , '/SAVE,INFO=FILENAME')
 105  FORMAT(
     *   3X , '6. TO SORT FILE INFO PER COLUMNS',
     * / 5X , '/GET,S,INFO/UN=ULUSCY',
     * / 5X , '/SAVE,INFO=SORTIN',
     * / 5X , '/S',
     * / 5X , '/SAVE,SORTOUT=FILENAME',
     * / 3X , '7. TO CHANGE CONTENTS OF ANY FILE',
     * / 5X , '/GET,FILENAME',
     * / 5X , '/FSE,FILENAME.SS721',
     * / 3X , '8. TO PRINTOUT ANY FILE',
     * / 5X , '/COPYSBF,FILENAME,O',
     * / 5X , '/ROUTE,O,DC=PR',
     *///22X, '-- PLEASE ENTER -GO- TO RETURN --' )
 106 FORMAT( '1' //
     * / 1X , 'INPUT COMMANDS :' ,
     * //1X , 'A/++++/---- : ADD PROJECT ++++ TO YEAR ---- ' ,
     *         'TO START THE PROJECT AT ----' ,
     * //1X , 'B OR BEFORE : SHOW THE SCREEN BEFORE THE LAST ONE' ,
     * //1X , 'C OR CLEAR  : CLEAR ALL SCHEDULED PROJECTS AND ' ,
     *         'REINITIALIZE THE PROGRAM' ,
     * //1X , 'D/++++/---- : DELETE PROJECT ++++ FROM YEAR ---- ' ,
     *         'TO RETURN TO THE STATE BEFORE ' ,
     * //1X , 'H OR HELP   : DISPLAY THIS SCREEN' ,
     * //1X , 'M OR MESSAGE: PRINT EACH TIME ' ,
     *         'A MESSAGE OF 80 CHARACTERS ON PAPER' ,
     * //1X , 'P OR PRINT  : PRINT THE CURRENT SCREEN ON PAPER' ,
     * //1X , 'R OR REVIEW : REVIEW DEVIATIONS FROM ' ,
     *         'LIMITS AND TARGETS ' ,
     * //1X , 'S OR STOP   : STOP THE PROGRAM' ,
     * //1X , ' 1,2,3,4,5  : SLIDE THE SCREEN ' ,
     * ////
     * //22X, '-- PLEASE ENTER -GO- TO RETURN --' )
C
 107  FORMAT( '1'/
     * //1X , 'SCREEN ABBREVIATIONS :' ,
     * //1X , 'S    ',6X, ' : SCREEN NUMBER ' ,
     * / 1X , 'UC   ',6X, ' : UNIT COST OF ENERGY GENERATION (TL/KWH)',
     * / 1X , 'NDA  ',6X, ' : NON DEPRECIATED ASSETS (1000B TL) ' ,
     * / 1X , 'REL  ',6X, ' : AVERAGE SYSTEM RELIABILITY (%) ' ,
     * / 1X , 'LAND ',6X, ' : LAND USED FOR INVESTMENTS (KM2)',
     * / 1X , 'PF   ',6X, ' : POLLUTION FACTOR (KM CUBES SO2) ' ,
     * //1X , 'DEVSF',6X, ' : DEVIATIONS FROM LIMITS AND TARGETS' ,
     * / 1X , 'TOTAL',6X, ' : DEVIATIONS TOTAL ')
 108  FORMAT( /
     *   1X , 'POWER',6X, ' : DEVIATIONS FROM POWER TARGETS (100MW)' ,
     * / 1X , 'ENERG',6X, ' : DEVIATIONS FROM ENERGY TARGETS (100GWH)',
     * / 1X , 'INTLB',6X , ' : DEVIATIONS FROM INVESTMENT ' ,
     *         'TL BUDGET LIMITS (TL B)' ,
     * / 1X , 'INFCB', 6X ,' : DEVIATIONS FROM INVESTMENT ' ,
     *         'FOR. CUR. BUDGET LIMITS ($ M)' ,
     * / 1X , 'OMTLB', 6X , ' : DEVIATIONS FROM OP./MAINTENANCE',
     *         ' TL BUDGET LIMITS (TL B)' ,
     * / 1X , 'OMFCB', 6X , ' : DEVIATIONS FROM OP./MAINTENANCE',
     *         ' FOR.CUR. BUDGET LIMITS ($ M)' ,
     * //1X , 'SCH.PROJECTS: SCHEDULED PROJECTS STARTED ' ,
```

```
     *          'AT THE BEGINNING OF EACH PERIOD' ,
     * /////
     * //22X , '-- PLEASE ENTER -GO- TO RETURN ' )
 109  FORMAT( '1' //////
     * / 3X , 'COLUMN EXPLANATION    ',
     * / 3X , '------ -------------------------------------',
     * / 3X , '  1     PROJECT CODE  ',
     * / 3X , '  2     POWER GENERATING CAPACITY (MW)      ',
     * / 3X , '  3     AVAILABILITY FACTOR (PERCENT)',
     * / 3X , '  4     UNIT COST OF INVESTMENT ($/KW)   ',
     * / 3X , '  5     FOREIGN COST OF INVESTMENT (PERCENT)',
     * / 3X , '  6     UNIT COST OF GENERATION (TL/KWH)',
     * / 3X , '  7     LOCAL PART OF GENERATION COST (PERCENT)',
     * / 3X , '  8     PROJECT CONSTRUCTION DURATION (YEARS)',
     * / 3X , '  9     LIFE TIME OF INVESTMENT (YEARS)',
     * / 3X , '  10    LAND USED FOR THE PROJECT (KM3)',
     * / 3X , '  11    ANNUAL POLLUTION (1000M3 SO2)',
     * /////////
     * //22X , '-- PLEASE ENTER -GO- TO RETURN ' )
 110  FORMAT( '1' //////
     * / 3X , 'COLUMN EXPLANATION    ',
     * / 3X , '------ -------------------------------------',
     * / 3X , '  1     PROJECT CODE  ',
     * / 3X , '  2     POWER GENERATION (1000KW/YEAR)',
     * / 3X , '  3     ENERGY GENERATION (1000GWH/YEAR)',
     * / 3X , '  4     INVESTMENT BUDGET USED (BTL/YEAR)',
     * / 3X , '  5     INVESTMENT BUDGET USED (M$/YEAR)',
     * / 3X , '  6     OPERATION BUDGET USED (BTL/YEAR)',
     * / 3X , '  7     OPERATION BUDGET USED (M$/YEAR)',
     * / 3X , '  8     DEPRECIATION (BTL/YEARS)',
     * / 3X , '  9     LIFE TIME OF INVESTMENT (YEARS)',
     * / 3X , '  10    LAND USED FOR THE PROJECT (KM3)',
     * / 3X , '  11    ANNUAL POLLUTION (1000M3 SO2)',
     * /////////
     * //22X , '-- PLEASE ENTER -GO- TO RETURN ' )
      END
```

CONVERT PROGRAM SOURCE

```
      C
            PROGRAM CONVERT( INFO , DR , PJ , OUTPUT , TAPE6=OUTPUT )          ?
      C
      C
      C
      C     ***************************************************************************
      C     ***************************************************************************
      C     **                                                                       **
      C     **        TAHIR ULUSOY              FILE: CONVERT     VERSION MAY 1965   **
      C     **                                                                       **
      C     **        PROGRAMS USED FOR THE MASTER THESIS                            **
      C     **                                                                       **
      C     ***************************************************************************
      C     ***************************************************************************
      C
      C
      C*****    DESCRIPTION OF VARIABLES
      C
      C         DUMMY       DUMMY VARIABLE
      C         FC          FOREIGN CURRENCY RATE
      C         NPJ         NUMBER OF PROJECT
      C         PCODE       PROJECT CODE
      C         PJDATA      PROJECT DATA INPUT
      C         PJINFO      PROJECT INFORMATION
      C
      C*****    VARIABLES DECLARATION
      C
            CHARACTER*4   PCODE(120)                                           ?
            CHARACTER*2   DUMMY                                                ?
            REAL          PJDATA(120,10) , PJINFO(120,10) , FC
            INTEGER       NPJ
      C                                                                        ?
            OPEN ( 8 , FILE = 'INFO' )                                         ?
            OPEN ( 9 , FILE = 'PJ' )                                           ?
            OPEN (11 , FILE = 'DR' )
      C                                                                        ?
            REWIND 8                                                           ?
            REWIND 9                                                           ?
            REWIND 11
      C
      C*****    INPUT DIRECTORY FILE
      C
              READ(11,9000) DUMMY
              READ(11,4000) FC
      C
      C*****    INPUT PROJECT FILE
      C
              READ(9,9000)  DUMMY
              READ(9,1300)  NPJ
              READ(9,1400) ( PCODE(I),( PJDATA(I,J) , J = 1,10 ), I = 1,NPJ )
                  DO    6  I = 1 , NPJ
                        PJINFO(I,1) = PJDATA(I,3) / 100
                        PJINFO(I,2) = PJDATA(I,1) * PJDATA(I,2) * 0.000876
                        PJINFO(I,3) = PJDATA(I,1) * PJDATA(I,3) * FC *
```

```
     *          ( 100 - PJDATA(I,4) ) / ( 100000000 * PJDATA(I,7) )
                PJINFO(I,4) = PJDATA(I,1) * PJDATA(I,3) *
     *           PJDATA(I,4) / ( 100000 * PJDATA(I,7) )
                PJINFO(I,5) = PJDATA(I,1) * PJDATA(I,2) * 8.760 *
     *           PJDATA(I,5) * PJDATA (I,6) / 100 / 1000 / 100
                PJINFO(I,6) = PJDATA(I,1) * PJDATA(I,2) * 8.760 *
     *           PJDATA(I,5) * ( 100 - PJDATA(I,5) ) / 100 / FC /
     *           100
                PJINFO(I,7) = PJDATA(I,7)
                PJINFO(I,8) = PJDATA(I,1) * PJDATA(I,3) * FC /
     *           1000000 / PJDATA(I,8)
                PJINFO(I,9) = PJDATA(I,9)
                PJINFO(I,10) = PJDATA(I,10)
 6          CONTINUE
C
      WRITE(8,900)  DUMMY
      WRITE(8,300)  NPJ
      WRITE(8,400) ( PCODE(I),( PJINFO(I,J) , J = 1,10 ), I = 1,NPJ )
C
      WRITE(8,500)
C
C     INPUT FORMATS
C
 1300 FORMAT( I4 )
 1400 FORMAT( A4 , 10F5.0 )
 4000 FORMAT( 50X , F10.0 )
 9000 FORMAT( A2 )
C
C     OUTPUT FORMATS
C
  300 FORMAT( I4 )
  400 FORMAT( A4 , 10F5.0 )
  500 FORMAT( ////////// 15X,'--- CONVERSION TERMINATED ---'////////// )
  900 FORMAT( A2 )
C
C
C
      STOP
      END
```

CONVERT PROGRAM SAMPLE OUTPUT

110										
CC01	2.	9.	9.	17.	3.	5.	4.	3.	10.	45.
CC02	2.	10.	9.	15.	3.	6.	5.	3.	12.	40.
CC03	2.	11.	11.	23.	4.	5.	4.	4.	12.	46.
CC04	2.	10.	11.	25.	3.	5.	4.	4.	14.	55.
CC05	2.	10.	7.	21.	3.	6.	5.	4.	12.	62.
CC06	2.	12.	11.	22.	4.	9.	5.	4.	12.	70.
CC07	2.	13.	9.	20.	3.	7.	6.	5.	14.	80.
CC08	3.	20.	13.	22.	4.	7.	7.	6.	13.	85.
CC09	4.	22.	16.	34.	6.	15.	6.	8.	14.	80.
CC10	6.	29.	21.	49.	9.	16.	6.	10.	15.	95.
CC11	6.	39.	20.	40.	11.	25.	8.	13.	12.	100.
CC12	7.	41.	23.	51.	12.	25.	7.	13.	14.	105.
CC13	8.	50.	22.	57.	16.	25.	8.	16.	13.	105.
CC14	8.	49.	23.	64.	17.	30.	7.	14.	15.	120.
CC15	8.	50.	24.	54.	19.	36.	8.	14.	10.	110.
CC16	9.	51.	27.	42.	18.	33.	9.	16.	12.	130.
CC17	8.	50.	25.	50.	19.	30.	8.	14.	11.	115.
CC18	8.	47.	28.	67.	15.	25.	8.	17.	14.	130.
CC19	9.	52.	26.	57.	20.	33.	9.	17.	12.	120.
CC20	9.	57.	31.	62.	19.	27.	9.	19.	15.	140.
FC01	2.	10.	6.	18.	2.	38.	4.	3.	5.	5.
FC02	2.	12.	8.	21.	3.	45.	4.	3.	6.	8.
FC03	2.	13.	9.	22.	3.	49.	4.	4.	7.	4.
FC04	3.	18.	9.	27.	4.	71.	5.	4.	5.	2.
FC05	3.	21.	16.	33.	5.	74.	4.	5.	6.	5.
FC06	3.	19.	10.	28.	4.	75.	5.	5.	7.	7.
FC07	4.	23.	14.	42.	4.	75.	4.	5.	9.	7.
FC08	4.	26.	18.	45.	5.	95.	4.	7.	4.	8.
FC09	5.	30.	19.	51.	5.	93.	4.	6.	8.	6.
FC10	5.	29.	15.	42.	7.	114.	5.	7.	9.	9.
FC11	6.	36.	25.	57.	10.	150.	4.	9.	10.	10.
FC12	5.	34.	14.	36.	7.	117.	6.	7.	12.	8.
FC13	6.	38.	28.	58.	8.	145.	4.	12.	11.	6.
FC14	7.	42.	23.	51.	9.	150.	5.	9.	14.	8.
FC15	7.	42.	20.	42.	7.	127.	6.	9.	12.	7.
FC16	7.	45.	35.	66.	9.	143.	4.	13.	11.	9.
FC17	8.	51.	25.	48.	9.	174.	6.	10.	15.	6.
FC18	8.	52.	24.	54.	9.	160.	6.	11.	12.	8.
FC19	9.	58.	25.	57.	10.	188.	6.	11.	12.	9.
FC20	10.	63.	30.	61.	10.	195.	6.	13.	15.	10.
GC01	1.	0.	6.	19.	0.	1.	1.	2.	3.	1.
GC02	1.	0.	7.	22.	0.	3.	1.	2.	4.	2.
GC03	1.	0.	3.	9.	0.	1.	2.	1.	6.	2.
GC04	1.	0.	4.	12.	0.	5.	2.	2.	5.	1.
GC05	1.	0.	4.	12.	0.	3.	2.	1.	5.	2.
GC06	1.	0.	3.	10.	0.	4.	2.	2.	4.	3.
GC07	1.	0.	4.	12.	0.	3.	2.	2.	6.	2.
GC08	1.	1.	5.	14.	0.	7.	2.	3.	8.	1.
GC09	1.	0.	4.	12.	0.	5.	2.	1.	5.	2.
GC10	1.	1.	5.	25.	0.	7.	2.	2.	7.	3.
GC11	2.	1.	4.	20.	1.	9.	3.	4.	7.	3.
GC12	1.	1.	4.	29.	0.	7.	2.	4.	5.	2.
GC13	1.	1.	6.	26.	1.	11.	2.	4.	7.	4.
GC14	2.	2.	8.	35.	1.	13.	2.	3.	5.	3.
GC15	2.	1.	6.	39.	1.	10.	2.	4.	8.	2.
GC16	2.	2.	5.	25.	1.	15.	3.	5.	5.	4.
GC17	2.	2.	6.	41.	1.	14.	2.	4.	7.	3.
GC18	2.	2.	4.	26.	1.	12.	3.	4.	5.	2.
GC19	2.	3.	9.	39.	1.	17.	2.	5.	7.	4.
GC20	2.	2.	4.	28.	1.	11.	3.	4.	4.	3.
GC21	2.	3.	10.	42.	1.	19.	2.	5.	8.	2.
GC22	3.	3.	8.	53.	1.	19.	2.	6.	6.	3.
GC23	3.	3.	7.	50.	1.	22.	2.	5.	5.	4.

GC24	2.	3.	10.	45.	1.	19.	2.	7.	8.	3.
GC25	3.	3.	8.	55.	1.	19.	2.	6.	5.	2.
GC26	3.	3.	5.	35.	1.	21.	3.	6.	7.	2.
GC27	3.	4.	8.	58.	1.	24.	2.	8.	9.	3.
GC28	3.	3.	6.	39.	1.	22.	3.	5.	10.	3.
GC29	3.	4.	5.	38.	1.	25.	3.	6.	8.	2.
GC30	3.	4.	6.	39.	2.	26.	3.	6.	10.	4.
HC01	1.	5.	11.	17.	5.	2.	4.	2.	10.	0.
HC02	2.	9.	19.	27.	9.	4.	4.	3.	20.	0.
HC03	2.	11.	18.	23.	9.	4.	5.	3.	25.	0.
HC04	3.	13.	24.	32.	11.	5.	5.	4.	30.	0.
HC05	3.	14.	22.	30.	12.	4.	6.	4.	32.	0.
HC06	3.	14.	29.	43.	12.	5.	4.	4.	35.	0.
H007	4.	15.	36.	51.	12.	5.	4.	5.	38.	0.
HC08	4.	17.	26.	36.	13.	5.	6.	5.	40.	0.
HC09	5.	20.	29.	35.	11.	5.	7.	6.	45.	0.
HC10	5.	19.	25.	31.	12.	5.	7.	5.	48.	0.
HC11	5.	19.	22.	28.	15.	4.	8.	4.	50.	0.
HC12	5.	22.	25.	33.	15.	5.	8.	5.	52.	0.
HC13	6.	24.	31.	37.	18.	7.	7.	6.	56.	0.
HC14	7.	24.	25.	32.	16.	7.	9.	6.	60.	0.
HC15	6.	26.	22.	27.	18.	5.	9.	5.	55.	0.
HC16	7.	26.	21.	27.	19.	8.	10.	5.	65.	0.
HC17	8.	28.	17.	21.	19.	7.	12.	5.	60.	0.
HC18	8.	27.	20.	24.	14.	4.	12.	5.	70.	0.
HC19	8.	25.	20.	24.	16.	8.	11.	5.	75.	0.
HC20	9.	25.	25.	27.	14.	6.	10.	5.	70.	0.
HC21	9.	22.	20.	23.	12.	5.	12.	5.	80.	0.
HC22	10.	25.	20.	22.	16.	6.	13.	5.	75.	0.
HC23	12.	25.	22.	25.	17.	6.	12.	5.	85.	0.
HC24	12.	24.	26.	30.	14.	5.	11.	6.	88.	0.
HC25	14.	26.	32.	35.	17.	7.	10.	6.	85.	0.
HC26	16.	27.	27.	32.	13.	5.	12.	6.	90.	0.
HC27	17.	25.	25.	27.	8.	3.	13.	5.	95.	0.
HC28	20.	26.	28.	33.	11.	4.	14.	6.	100.	0.
NC01	3.	19.	8.	62.	2.	4.	8.	16.	20.	0.
NC02	4.	23.	7.	58.	3.	5.	10.	17.	30.	0.
NC03	4.	23.	8.	67.	3.	7.	9.	16.	35.	0.
NC04	5.	27.	10.	93.	3.	5.	8.	18.	40.	0.
NC05	6.	33.	10.	105.	3.	5.	8.	19.	35.	0.
NC06	6.	34.	7.	74.	3.	7.	11.	17.	40.	0.
NC07	7.	36.	12.	93.	4.	7.	10.	23.	45.	0.
NC08	7.	38.	12.	107.	4.	8.	9.	22.	40.	0.
NC09	7.	37.	10.	68.	4.	8.	13.	24.	45.	0.
NC10	9.	41.	11.	97.	5.	9.	12.	25.	50.	0.
IC01	0.	0.	0.	0.	0.	0.	1.	0.	0.	0.
EC01	0.	0.	0.	-0.	0.	0.	1.	-0.	0.	0.

SORT PROGRAM SOURCE

```
C
      PROGRAM SORT( SORTIN , SORTOUT , OUTPUT , TAPE6=OUTPUT )
C
C
C
C
C     ******************************************************************
C     ******************************************************************
C     **                                                              **
C     **      TARIK ULUSOY           FILE: SORT         VERSION MAY 1985 **
C     **                                                              **
C     **      PROGRAMS USED FOR THE MASTER THESIS                     **
C     **                                                              **
C     ******************************************************************
C     ******************************************************************
C
C
C*****    DESCRIPTION OF VARIABLES
C
C         DUMMY    DUMMY VARIABLE
C         IN       INPUT ARRAY
C         TEMP     TEMPORARY STORAGE ARRAY
C         NPJ      NUMBER OF PROJECT
C
C*****    VARIABLES DECLARATION
C
      CHARACTER*2  DUMMY
      CHARACTER*5  IN( 15,120 ), TEMP( 15 )
C
      OPEN(  9 , FILE = 'SORTIN' )
      OPEN( 10 , FILE = 'SORTOUT' )
C
      REWIND  9
      REWIND 10
C
      WRITE(6,400)
C
C*****    INPUT DATA TO BE SORTED
C
          READ(9,9000) DUMMY
          READ(9,1000) NPJ
          READ(9,2000) ( ( IN(I,J) , I = 1,15 ) , J = 1,NPJ )
C
C*****    SORT THE DATA
C
          NN = NPJ - 1
C
          DO  1  II = 1 , 15
             IF( IN(II,1) .EQ. '     ' )           GO TO  1
             WRITE(10,100) II
C
             DO  10  I = 1 , NN
             J = I
             JJ = I + 1
C
```

```
                    DO  20  K = JJ , NPJ
                    IF( IN( II,K ) .GT. IN( II,J ) )  J = K
       20           CONTINUE
C
                    DO  30  L = 1 , 15
                    TEMP(L) = IN(L,I)
                    IN(L,I) = IN(L,J)
                    IN(L,J) = TEMP(L)
       30           CONTINUE
C
       10       CONTINUE

                WRITE(30,200)  ( ( IN(I,J) , I = 1,15 ) , J = 1,NPJ )
C
       1    CONTINUE
C
            WRITE(6,300)
C
C*****      INPUT FORMATS
C
 1000       FORMAT( I4 )
 2000       FORMAT( A4 , 14A5 )
 9000       FORMAT( A2 )
C
C*****      OUTPUT FORMATS
C
  100       FORMAT('1'/1X , ' SORTED WITH RESPECT TO COLUMN ' , I2 / )
  200       FORMAT( 15( 2X , A5 ) / )
  300       FORMAT( /// 15X,'--- FILE SORTIN SORTED INTO FILE SORTOUT ---')
  400       FORMAT( /// 15X,'--- SORT PROGRAM RUNNING ---')
C
            STOP
            END
```

SORT PROGRAM SAMPLE OUTPUT

SORTED WITH RESPECT TO COLUMN 6

CO19	9.	52.	26.	57.	20.	33.	9.	17.	12.	120.
CO20	9.	57.	31.	62.	19.	27.	9.	19.	15.	140.
CO15	8.	50.	24.	54.	19.	36.	8.	14.	10.	110.
CO17	8.	50.	25.	50.	19.	30.	8.	14.	11.	115.
HO16	7.	26.	21.	27.	19.	8.	10.	5.	65.	0.
HO17	8.	28.	17.	21.	19.	7.	12.	5.	60.	0.
CO16	9.	51.	27.	42.	18.	33.	9.	16.	12.	130.
HO13	6.	24.	31.	37.	18.	7.	7.	6.	56.	0.
HO15	6.	26.	22.	27.	18.	5.	9.	5.	55.	0.
CO14	8.	49.	23.	64.	17.	30.	7.	14.	15.	120.
HO25	14.	26.	32.	35.	17.	7.	10.	6.	85.	0.
HO23	12.	25.	22.	25.	17.	6.	12.	5.	85.	0.
CO13	8.	50.	22.	57.	16.	25.	8.	16.	13.	105.
HO14	7.	24.	25.	32.	16.	7.	9.	6.	60.	0.
HO19	8.	25.	20.	24.	16.	8.	11.	5.	75.	0.
HO22	10.	25.	20.	22.	16.	6.	13.	5.	75.	0.
CO18	8.	47.	28.	67.	15.	25.	8.	17.	14.	130.
HO12	5.	22.	25.	33.	15.	5.	8.	5.	52.	0.
HO11	5.	19.	22.	28.	15.	4.	8.	4.	50.	0.
HO24	12.	24.	26.	30.	14.	5.	11.	6.	88.	0.
HO20	9.	25.	25.	27.	14.	6.	10.	5.	70.	0.
HO18	8.	27.	20.	24.	14.	4.	12.	5.	70.	0.
HO08	4.	17.	26.	36.	13.	5.	6.	5.	40.	0.
HO26	16.	27.	27.	32.	13.	5.	12.	6.	90.	0.
CO12	7.	41.	23.	51.	12.	25.	7.	13.	14.	105.
HO07	4.	15.	36.	51.	12.	5.	4.	5.	38.	0.
HO06	3.	14.	29.	43.	12.	5.	4.	4.	35.	0.
HO10	5.	19.	25.	31.	12.	5.	7.	5.	48.	0.
HO05	3.	14.	22.	30.	12.	4.	6.	4.	32.	0.
HO21	9.	22.	20.	23.	12.	5.	12.	5.	80.	0.
CO11	6.	39.	20.	40.	11.	25.	8.	13.	12.	100.
HO09	5.	20.	29.	35.	11.	5.	7.	6.	45.	0.
HO28	20.	26.	28.	33.	11.	4.	14.	6.	100.	0.
HO04	3.	13.	24.	32.	11.	5.	5.	4.	30.	0.
FO19	9.	58.	25.	57.	10.	188.	6.	11.	12.	9.
FO20	10.	63.	30.	61.	10.	195.	6.	13.	15.	10.
FO11	6.	36.	25.	57.	10.	150.	4.	9.	10.	10.

DATA GENERATION TABLE

Data	Projects				
(units)	Hydro	Coal	Nuclear	Gas	Fuel
PC (MW)	100-2000	150-900	300-1500	50-300	150-1000
AF (%)	15-60	60-75	55-70	3-15	70-80
I ($/kW)	550-1500	900-1200	1000-2000	500-600	700-800
IF (%)	35-45	45-60	75-85	60-80	50-65
U (TL/kWh)	4-12	5-7.5	2-3.5	35-65	15-25
LF (%)	80-90	40-60	45-55	9-11	9-11
CT (years)	4-14	4-9	8-14	1-3	4-6
LT (years)	50-100	25-30	20-30	10-15	20-30
L (km2)	50-100	10-50	20-50	3-10	5-15
P (km3/y)	0	20-140	0	1-4	2-10

DATA FILES

FILE: DR - DIRECTORY FILE
FOREIGN CURRENCY RATE .... : 530.
PROFIT MARGIN .... : 1.08
PRICE ELASTICITY .... : 0.5
INITIAL ENERGY GENERATION COST (TL E) .... : 1092.800
INITIAL AVAILABLE ENERGY (100GWH) ....: 273.20

FILE: PR - PERIODS NOMINAL DEVIATIONS FILE

20	POWER	ENERG	INTLB	INFCB	CMTLB	CMFCB
1984	-51	-56	130	130	21	21
1985	-61	-88	150	230	31	31
1986	-72	-92	175	330	43	52
1987	-75	-120	200	410	55	63
1988	-77	-140	220	480	85	75
1989	-85	-180	235	540	115	80
1990	-95	-200	260	620	150	90
1991	-100	-220	275	700	180	120
1992	-105	-235	350	710	220	135
1993	-117	-280	382	730	280	150
1994	-130	-350	385	750	322	165
1995	-145	-410	390	755	550	170
1996	-155	-550	393	760	680	180
1997	-165	-600	397	765	720	225
1998	-185	-650	400	770	860	260
1999	-190	-650	425	775	980	290
2000	-200	-760	440	780	1060	310
2001	-215	-780	460	785	1080	370
2002	-220	-820	480	790	1090	435
2003	-245	-900	510	800	1100	500

FILE: OD - OPTIMISTIC DEVIATIONS FILE

20	POWER	ENERG	INTLB	INFCB	CMTLB	CMFCB
1984	5	5	13	13	2	2
1985	6	9	15	23	3	3
1986	7	9	18	33	5	5
1987	7	12	20	41	8	6
1988	8	14	22	48	11	8
1989	9	18	24	54	15	10
1990	10	20	26	62	18	12
1991	11	22	27	70	22	13
1992	12	24	35	71	28	15
1993	13	28	38	73	32	17
1994	15	35	39	75	55	17
1995	16	41	40	76	68	18
1996	17	55	41	77	72	22
1997	19	60	42	78	86	26
1998	20	65	44	79	98	29
1999	21	68	46	80	106	31
2000	22	76	48	82	108	37
2001	24	78	51	85	109	42
2002	26	82	53	90	110	45
2003	28	90	55	95	120	50

FILE: PD - PESSIMISTIC DEVIATIONS FILE

20	POWER	ENERG	INTLB	INFCB	CMTLB	CMFCB
1984	-5	-5	-13	-13	-2	-2
1985	-6	-9	-15	-23	-3	-3
1986	-7	-9	-18	-33	-5	-5
1987	-7	-12	-20	-41	-8	-6
1988	-8	-14	-22	-48	-11	-8
1989	-9	-18	-24	-54	-15	-10
1990	-10	-20	-26	-62	-18	-12
1991	-11	-22	-27	-70	-22	-13
1992	-12	-24	-35	-71	-28	-15
1993	-13	-28	-38	-73	-32	-17
1994	-15	-35	-39	-75	-55	-17
1995	-16	-41	-40	-76	-68	-18
1996	-17	-55	-41	-77	-72	-22
1997	-19	-60	-42	-78	-86	-26
1998	-20	-65	-44	-79	-98	-29
1999	-21	-68	-46	-80	-106	-31
2000	-22	-76	-48	-82	-108	-37
2001	-24	-78	-51	-85	-109	-42
2002	-26	-82	-53	-90	-110	-45
2003	-28	-90	-55	-95	-120	-50

FILE: PJ - PROJECTS FILE

110

CC01	150	70	900	50	6.0	50	4	25	10	45
CC02	170	68	920	48	6.5	52	5	25	12	40
CC03	190	67	950	52	5.8	55	4	25	12	46
CC04	185	64	980	55	5.4	51	4	25	14	55
CC05	180	65	960	61	6.5	50	5	26	12	62
CC06	220	62	970	52	7.2	45	5	27	12	70
CC07	230	65	980	54	5.2	48	6	26	14	80
CC08	340	68	960	48	4.0	52	7	27	13	85
CC09	400	62	970	52	6.5	43	6	27	14	80
CC10	550	60	975	55	6.0	52	6	28	15	95
CC11	630	70	985	51	6.4	46	8	26	12	100
CC12	680	68	980	54	6.2	48	7	28	14	105
CC13	800	72	990	58	5.8	54	8	27	13	105
CC14	760	74	985	60	6.8	53	7	29	15	120
CC15	820	70	975	54	7.5	50	8	30	10	110
CC16	850	68	980	45	7.0	51	9	28	12	130
CC17	800	72	965	52	6.8	54	8	30	11	115
CC18	830	64	1150	56	6.0	52	8	30	14	130
CC19	870	68	1100	54	7.2	53	9	30	12	120
CC20	900	72	1200	52	5.8	57	9	30	15	140
FC01	150	75	800	60	23	11	4	20	5	5
FC02	180	74	820	58	23	11	4	25	6	8
FC03	200	75	785	57	22	10	4	22	7	4
FC04	280	74	790	61	23	10	5	30	5	2
FC05	320	75	780	53	21	11	4	26	6	5
FC06	300	73	785	60	23	10	5	23	7	7
FC07	360	74	760	61	19	10	4	28	9	7
FC08	400	75	785	57	21	9	4	24	4	8
FC09	480	72	730	53	13	10	4	30	8	6
FC10	450	74	780	60	23	10	5	27	9	9
FC11	550	74	760	55	25	11	4	24	10	10
FC12	530	74	720	57	20	10	6	30	12	8
FC13	600	73	740	52	22	9	4	20	11	6
FC14	650	74	730	54	21	10	5	27	14	8
FC15	660	72	720	53	18	10	6	28	12	7
FC16	700	73	750	50	19	11	4	22	11	9
FC17	780	74	730	51	20	9	6	30	15	6
FC18	830	72	720	54	18	10	6	30	12	8
FC19	900	73	690	55	19	9	6	30	12	9
FC20	1000	72	700	52	18	9	6	28	15	10
GC01	50	3	600	62	63	11	1	10	3	1
GC02	60	5	600	62	62	11	1	10	4	2
GC03	52	3	595	61	61	10	2	13	6	2
GC04	68	8	590	62	63	10	2	10	5	1
GC05	65	5	600	61	62	11	2	14	5	2
GC06	54	8	595	62	61	10	2	11	4	3
GC07	70	5	580	60	62	10	2	13	6	2
GC08	80	9	590	61	62	9	2	10	8	1
GC09	68	8	570	60	60	10	2	15	5	2
GC10	120	9	580	71	42	10	2	15	7	3
GC11	150	10	560	70	42	11	3	12	7	3
GC12	130	9	570	79	40	10	2	11	5	2
GC13	140	12	540	70	42	9	2	10	7	4
GC14	175	12	560	71	41	10	2	15	5	3
GC15	185	9	535	79	39	10	2	12	8	2
GC16	190	13	560	71	40	11	3	11	5	4
GC17	190	12	540	79	41	9	2	14	7	3
GC18	195	10	520	73	41	10	3	14	5	2
GC19	210	14	535	70	39	9	2	13	7	4
GC20	200	9	530	79	41	9	3	15	4	3
GC21	230	14	520	70	40	11	2	13	8	2
GC22	255	12	530	78	41	10	2	12	6	3
GC23	250	15	510	79	39	9	2	15	5	4

GC24	240	13	530	70	41	10	2	10	8	3
GC25	260	12	535	79	40	10	2	13	5	2
GC26	265	13	510	78	41	11	3	12	7	2
GC27	275	15	530	79	39	10	2	10	9	3
GC28	285	13	520	78	40	11	3	15	10	3
GC29	280	15	510	79	40	9	3	12	8	2
GC30	300	15	500	78	39	10	3	14	10	4
HC01	100	60	1500	44	12	81	4	50	10	0
HC02	180	57	1420	43	12	81	4	53	20	0
HC03	200	61	1450	40	10	82	5	53	25	0
HC04	280	53	1380	41	11	80	5	54	30	0
HC05	320	50	1330	42	10	83	6	58	32	0
HC06	300	52	1300	44	11	82	4	59	35	0
HC07	360	43	1320	43	10	82	4	52	38	0
HC08	400	49	1280	42	9	84	6	55	40	0
HC09	480	47	1300	39	7	80	7	57	45	0
HC10	450	48	1220	40	8	82	7	60	48	0
HC11	500	43	1100	40	9	88	8	69	50	0
HC12	530	47	1200	41	8	84	8	64	52	0
HC13	600	45	1120	39	9	83	7	63	56	0
HC14	650	43	1100	40	8	82	9	68	60	0
HC15	620	47	1000	39	8	86	9	64	55	0
HC16	700	42	950	40	9	82	10	70	65	0
HC17	780	41	820	39	8	84	12	75	60	0
HC18	800	39	930	38	6	86	12	78	70	0
HC19	830	35	830	39	8	80	11	74	75	0
HC20	900	32	820	37	7	82	10	76	70	0
HC21	920	27	790	38	7	82	12	75	80	0
HC22	1000	28	780	37	8	83	13	80	75	0
HC23	1150	25	700	38	8	84	12	82	85	0
HC24	1200	23	730	38	7	85	11	84	88	0
HC25	1400	21	680	37	8	82	10	85	85	0
HC26	1600	19	620	39	6	83	12	89	90	0
HC27	1650	17	580	37	4	86	13	95	95	0
HC28	2000	15	600	38	5	84	14	100	100	0
NC01	310	70	2000	80	2.0	50	8	20	20	0
NC02	380	68	1900	81	2.5	52	10	23	30	0
NC03	410	64	1800	82	3.1	48	9	24	35	0
NC04	530	58	1700	83	2.0	53	8	26	40	0
NC05	600	62	1650	85	1.9	55	8	27	35	0
NC06	610	64	1570	85	2.1	48	11	30	40	0
NC07	680	60	1680	81	2.3	52	10	26	45	0
NC08	700	62	1650	83	2.1	45	9	23	40	0
NC09	720	58	1580	78	2.4	51	13	25	45	0
NC10	890	53	1600	82	2.5	52	12	30	50	0
IC01	1	100	.50	100	0.0	0	1	1	0	0
EC01	1	100	-0.5	100	0.0	0	1	1	0	0

SAMPLE RESULTS

```
UC:      16.                                                                        S:1

NDA :          6.     REL:     0.    LAND:          924.       PF:              414.

DEVSF   TOTAL    1984  1985  1986  1987  1988  1989  1990  1991  1992  1993
*****   *****    ****  ****  ****  ****  ****  ****  ****  ****  ****  ****
POWER   -1496.   -51.  -60.  -69.  -71.  -68.  -67.  -73.  -77.  -70.  -77.
ENERG   -3057.   -56.  -88.  -91. -114. -107. -112. -111. -125.  -68.  -98.
INTLB    2829.    66.   20.   -7.  -46.  -34.  -76.  -77. -110.  -25.   30.
INFCB    6163.   -24.  -23.  -43.  -78.  -35.  -16.  -11.  -36.   35.  147.
OPTLB    7508.    21.   31.   42.   54.   75.   79.  102.  127.  152.  208.
OPFCB   -4450.    21.   27.   39.   43.   39.   10.   10.   38. -194. -247.

SCH. PROJECTS    1984  1985  1986  1987  1988  1989  1990  1991  1992  1993
**************   ****  ****  ****  ****  ****  ****  ****  ****  ****  ****
          1--->  G002  C005  H028  H001  F009  H012  C012  G019  H007
          2--->  G001  H002  H027  G024  F015  H015  F011  G014
          3--->  G003  H003  H004  F014        H005  G006  H023
          4--->  G005  H006        H020        H004        H022
          5--->  G009  G010                    H014
          6--->  C001                          F001
          7--->  C002
          8--->  C003
          9--->  C004
         10--->
```

```
UC:      16.                                                                        S:3

NDA :          6.     REL:     0.    LAND:          924.       PF:              414.

DEVSF   TOTAL    1994  1995  1996  1997  1998  1999  2000  2001  2002  2003
*****   *****    ****  ****  ****  ****  ****  ****  ****  ****  ****  ****
POWER   -1496.   -70.  -81.  -89.  -78.  -85.  -74.  -66.  -82.  -88. -102.
ENERG   -3057.   -51.  -97. -222. -185. -185. -160. -247. -267. -306. -363.
INTLB    2829.   112.  139.  178.  255.  305.  355.  398.  418.  436.  490.
INFCB    6163.   392.  420.  483.  599.  662.  695.  732.  737.  742.  778.
OPTLB    7508.   219.  435.  553.  552.  658.  769.  840.  860.  870.  864.
OPFCB   -4450.  -519. -519. -510. -500. -478. -450. -414. -351. -261. -215.

SCH. PROJECTS    1994  1995  1996  1997  1998  1999  2000  2001  2002  2003
**************   ****  ****  ****  ****  ****  ****  ****  ****  ****  ****
          1--->
          2--->
          3--->
          4--->
          5--->
          6--->
          7--->
          8--->
          9--->
         10--->
```

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