This is an Excerpt from **Group Decision Making: Drawing Out and Reconciling Differences** by Thomas L. Saaty, Kirti Peniwati

Chapter 8

Planning the Future with Risk and Uncertainty The Forward Backward Processes of Planning

Serious planning is almost always a group activity in the same way that governments and corporations have to plan the future. This involves many people working together to structure the plan and provide judgments as in any decision.

There is no better way to think about the complexity and uncertainty of the future than through the eyes of creative thinking. In all this there is no better substitute to expert knowledge and understanding except the use of the prioritization process that is not amenable to spontaneous thinking and the use of imagination in guessing what should be included and where in the elaborate structure. Our representation of the relationship between decision making and creative thinking is roughly represented by Figure 8.1.

Risk, Uncertainty and the Unknown

To deal with complexity our mind must model it by creating a structure and providing observations, measurements, and judgments and of course hopefully rigorous analysis to study the influences of the various factors included in the model. How well the model works out depends on several factors having to do with its form or structure whose meaning and purpose are identified and described with language and words and the functions and flows within the structure to serve the goals and purpose of the model. In general the structure is fixed for a given analysis. However, the flows are dynamic and are mostly studied with logic and mathematics. Smets [1] very aptly addresses issues having to do with the goodness of the logical and mathematical aspect of models in terms of three forms of "ignorance": incompleteness, imprecision and uncertainty. Although he does not decompose his discussion about ignorance by making a distinction between structure and flow, we believe that his scheme is useful for that purpose. With his idea of incompleteness we associate the absence of factors such as criteria and alternatives in the structure of a model (the subject of this paper) and perhaps due to insufficient understanding or in an effort to save time not providing a full set of judgments in a decision. With imprecision we associate the fact that we cannot pinpoint exactly the names and identity of the criteria and alternatives or the precise numerical values of variables that in the case of decision-making take the form of numerical judgments. With uncertainty we associate probabilities with the different factors used in the model and with the likelihood that the judgments are what we think they are.

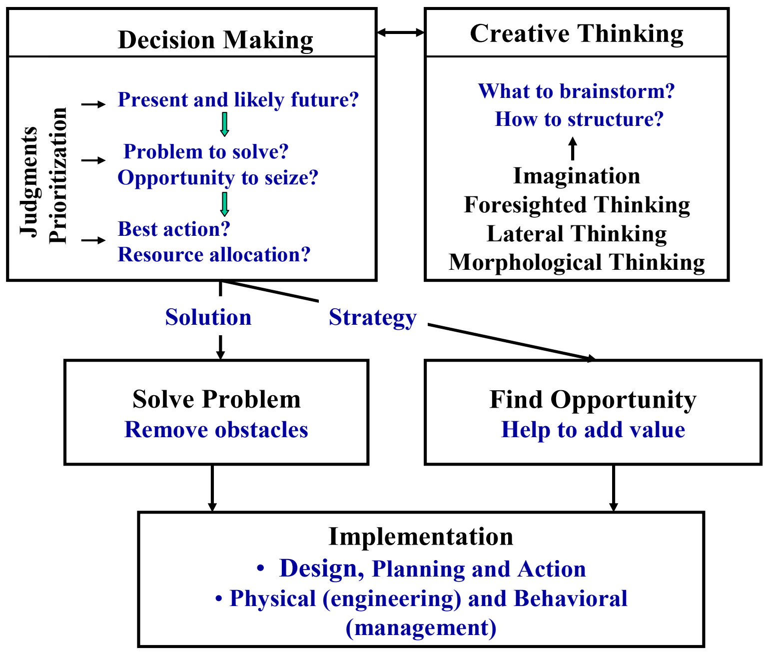


Figure 8.1 Relationships between Decision Making and Creative Thinking

The unknown or "other" [2] that affects our lives is what we usually very much want to know about to cope with uncertainty. We often suspect that it affects us with partial and indefinite evidence that it exists but we only have uncertain feelings about it. Even when we do not know what it is we would like to allow for its influence in our explaining the outcome of a decision. One way to deal with the many factors of a decision is to include the unknown as one of them and then determine its priority of influence on the outcome by comparing it with other factors. We are able to do that to the extent that we are sure of what we know and of the residual that remains outside our understanding that may also have some effect on what we do. Confidence from good understanding and past success are what we need in order to judge the potential significance of what we don't know on the outcome. We can then perform sensitivity analysis to see how much effect unknown factors can have on the stability of the choice we make.

There is concern in the literature about all these three forms of ignorance. O'Connor et al [3] described problems in maintenance arising from imprecision by not having clear criteria and not having robust decisions with which to maintain failing equipment. The object of this work was to develop a dynamic and adaptive maintenance decision-making system using the AHP that utilizes existing data and supports decisions accordingly. Faults identified as others or unknown were approximately 30 percent of the total faults. The maintenance tradesmen decided to examine the faults in greater detail and classify them. In the end unidentified faults became less than 5 percent of the total faults for any machine.

To deal with incompleteness, we show how to include unknown influences as an intangible whose effect is determined through relative measurement. Instead of assigning (guessing) probabilities to the unknown, we derive priorities by performing the more general operation of paired comparisons that involves systematic and reasoned redundancies in all the judgments about the likelihood of influence which then helps improve the validity of the numbers assigned. The unknown is simply a measure of the confidence an expert has about covering all the important criteria that influence the outcome of the decision. This enables one to capture the relative effect of what one "feels" the unknown to have on the outcome of the decision as one of the factors. The process itself diminishes uncertainty about the values of these probabilities. This says nothing about the naiveté and ignorance of the judge. It simply provides a means to remove doubt about the factors and their influence on the decision. With the unknown included as a criterion, the decision maker should no longer have any doubt about the factors included. They are all there. One caveat is that the unknown cannot be too important in priority for then one would be making a decision based on ignorance about other important criteria that should be involved. The main advantage of including a factor called "other" or the "unknown" is that it makes it possible for the decision maker to do sensitivity analysis to test the potential stability of the outcome with respect to the "unknown" according to his belief. It is an alternative that involves the use of uncertain knowledge instead of statistical methods of projection to determine the degree of confidence in the outcome of a decision under uncertainty. It is likely to be of value to an expert known for his care and accuracy in making decisions.

There are two kinds of "other" we can think of. One is to think of "other" as miscellaneous diverse criteria not considered in the decision. Such criteria we believe can and should be included as sub-criteria of a parent criterion designated as for example "miscellaneous". But that is not what we have in mind. We are thinking of residual criteria that one may suspect are there but cannot articulate them explicitly. Residual does not mean central in the sense that they would serve as an alibi for ignorance. Their relative priorities must be commensurate with those of the criteria that are known.

Planning

For the long range planner the important question is not what we should do tomorrow, but what we should do today to prepare for an uncertain future. Some factors of the future, however, need to be converged with various time spans into a decision in the present. Decision making is, in essence, an attempt to synthesize into the present a great number of divergent time spans.

To deal with the future we need to plan ahead. Planning is thinking and a social process of aligning what is deduced to be a likely outcome of a situation, given current actions, policies, and environmental influences, with what is perceived as a desirable outcome that requires new policies and new actions. How to do planning in a scientific way has always been the first author's area of interest having introduced the idea of forward and backward planning by using the AHP all included in his book Analytical planning translated to Russian.

Strategic, adaptive planning is a process of learning and growth. Above all it is an ongoing event kept in the foreground to be seen, studied, used as a guide, and revised as change is seen to happen in the environment. Strategic planning is the process of projecting the likely or logical future-the composite scenario-and of idealizing desired futures. It is the process of knowing how to attain these futures, using this knowledge to steer the logical future toward a more desired one, and then repeating the operation. The backward process of idealization inspires creative thinking. It affords people an opportunity to expand their awareness of what states of the system they would like to see take place, and with what priorities. Using the backward process, planners identify both opportunities and obstacles and eventually select effective policies to facilitate reaching the desired future.

David Cooperrider with his Appreciative Inquiry principles [4] contrasts the problem solving approach of organizational change that focuses on weaknesses by correcting things that do not work, with one that builds on strengths or things that work through envisioning a future in which the strengths become common norms rather than simply accidental. This approach requires the backward planning process with the vision clearly articulated by specifying its key elements and their priorities.

Forward-Backward Planning

Let us elaborate the idea of forward and backward planning process [5]. Planning is an ongoing decision process whose purposes are: (1) to specify the ideals, objectives, and goals an organization desires to obtain in the future; (2) to define the programs that must be undertaken to achieve these ends; and (3) to procure the resources, create the organization, and control the results of planning implementation.

An implicit assumption underlying an organization's long-range strategic planning process is that actions based only on what is best for present-day considerations (that is, tactical decisions) will not be sufficient for getting the organization to where it ought to be in the future. Were this assumption not so, the future could "take care of itself when we get there." However, the process by which an organization determines its strategic decisions is tremendously more complicated than it is for day-to-day tactical decisions. Among the complexities are the following:

1. Performance criteria: Long-range strategies strategic decisions must address a wider range and less quantifiable set of values in determining ends to be achieved than do short-range tactical decisions.
2. Feedback: Long-range strategic planning requires actions now, but the major impact is long term; hence the correctness of strategies and sustainability of the impact is difficult to evaluate because of the lack of feedback.
3. Controllability: In short-term tactical decisions, the factors that are under the organization's control can formally be separated from those that are not; over the long term there is less pure control over any single factor but more potential influence over many other factors.

Many planning processes move only in one direction. That is, they follow a time-sequenced order of events beginning at the present time $t = 0$ and terminating at some future point $t = T$. The first sequence, called the forward process, considers the factors and assumptions of the present state, which in turn generate some logical outcome. The second sequence, the backward process, begins with a desired outcome at time T and then works backward to identify and evaluate the factors and intermediate outcomes required to achieve that desired outcome. Both processes are theoretically sound and practical.

In the forward process, one considers the relevant present factors, influences, and objectives that lead to sensible conclusions or scenarios. The factors/influences/objectives may be economic, political, environmental, technological, cultural, and/or social in nature. The backward process begins with the desired scenarios then examines the policies and factors that might achieve those scenarios. Iteration of the two processes narrows or "converges" the gap between the desired and the logical scenarios. The forward planning process provides an assessment of the state of the likely outcome. The backward planning process provides a means for controlling and steering the forward process towards a desired state.

Scenarios

The key to these processes is the scenario. A scenario is a hypothesized outcome that is conceived and specified by making certain assumptions about current and future trends. The assumptions must be reasonable and should include constraints of nature, time, people, and technology. One must guard against uninhibited imagination.

There are two types of scenarios—exploratory and anticipatory. The former proceeds from the present to the future, whereas the latter takes an inverse path by starting with a future point and works backward toward the present to discover what influences and actions are required to fulfill the desired goal. Each of the scenarios can be reiterated as needed.

The exploratory scenario examines the logical sequence of events generated by the components of the system under study. It is used often as a technique to fire the imagination, stimulate discussion, and attract the attention of people involved in the planning process. Its significance does not lie in answering questions. Its importance may be to force attention on factors formerly unconsidered.

There are two kinds of anticipatory scenario: normative and contrast. The normative scenario determines at the start a given set of objectives to be achieved and then defines a path for their realization. In this case, objectives may be idealized to find if the path truly exists. The contrast scenario, on the other hand, is characterized by both a desired and feasible future. Its main asset is to sharply emphasize claims on which assumptions of feasibility rest.

The combination of normative and contrast scenarios forms a composite scenario, which in turn retains the properties of the specific scenario. This scenario allows for a synthesis of a wider range of considerations.

Rationale for the Forward-Backward Planning Process

One may question whether either the forward or the backward process is the most effective method of planning. Depending on the circumstances, one might be totally acceptable while the other is impractical. More importantly, each one alone may be inadequate to generate a good plan. Combining the two into a single forward-backward process can effectively overcome the problem. In this manner we conscientiously attempt to unite desired goals with logical goals, thereby providing a framework for the convergence of the two outcomes.

Perhaps the best reason for using the forward-backward planning process is classical planning theory itself. The theory states that there are essentially two planning goals. One is a logical or reachable goal that assumes the assumptions and factors affecting the outcome will remain substantially unchanged from the present state of affairs. Marginal changes in strategy and inputs will affect output only slightly or not at all. The other planning goal is a desired one whose attainment requires a great deal of change in inputs—both internal and external. These changes must not only be implemented, but they must survive against the entrenched policies of the system. Inertia is a powerful force. Good intuitions for making a change in course must be backed up with persistence.

Combining the Forward and Backward Processes

To integrate "forward" and "backward" hierarchical planning one projects the likely future from present actions, adopts a desired future, designs new policies, adjoins them to the set of existing policies, projects a new future, and compares the two futures—the projected and the desired—for their main attributes. The desired future is modified to see what policy modification is again needed to make it become the projected future, and the process is continued. The basic process is shown in Figure 8.2.

Formulation of a planning process for an organization as boundary problem enables us to explicitly structure the decision framework. Using decision theory notions, we identify three basic variables: (1) planning policies available to the organization, (2) outcomes the organization may realize in the future, and (3) efficiencies that show the probabilistic relationship between planning policies and outcomes.

These three variables are common to all decision processes, but the relationship among them is different for all projected planning processes and the desired planning processes. For the projected process the policies are defined, the efficiencies are estimated, and the probable outcomes are deduced.

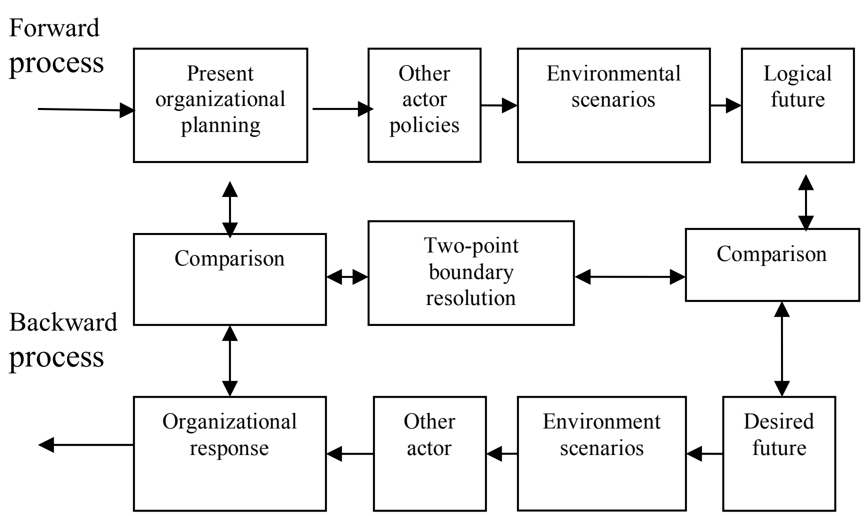
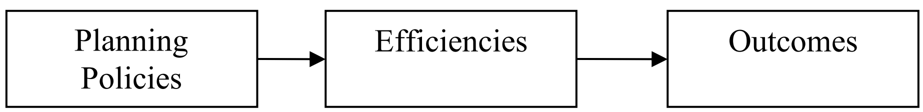


Figure 8.2 A Schematic Representation of the Basic Planning Orientation

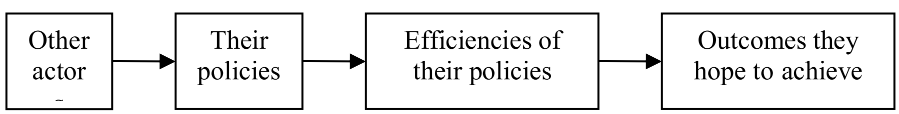
For the desired process the outcomes are valued, the efficiencies are influenced, and the policies are developed. This difference is due fundamentally to the way the problem is organized in each case. The organizing principle in both processes is hierarchical, but the dominance relationships are reversed. Our purpose is to show that the use of hierarchies as an organizing principle for the two-point boundary planning problem enables rich solutions to be developed because directions of dominance are made explicit.

The Forward Process

The hierarchy of the forward or projected process may be characterized in the following sequence:



This process can be divided further by segmenting the efficiencies level into its two basic components: events caused by the purposeful behavior of other actors, and events caused by non-purposeful behavior (for example, by the weather). Purposeful behavior is itself a hierarchy, diagrammatically composed of the following elements:



Some people have used the term transactional environment to describe other actors whose behavior directly affects organizational efficiencies. Such actors include suppliers, investors, customers, and the like. This analysis can, in turn, be expanded by adding another level to analyze the elements that contribute in the efficiency of the behavior of members of the transaction environment. Purposeful behavior of such actors has an indirect effect on the original organization; some use the term contextual environment to describe such effects

There are times when the elements (state variables) of the different outcomes are compatible and can thus be combined into a single composite outcome. From the pure outcomes of generating energy from nuclear power, fossil fuels, and solar energy one may use a strategy to combine all three outcomes. However, the outcomes may have incompatibilities that cannot be combined. For example, different plant site location outcomes cannot be combined to locate the plant in parts in each of them. Only one of the sites must be chosen.

The Backward Process

The hierarchy of the backward or desired process may be characterized in the following sequence:

The desired process begins where the projected process ends. The organization first examines the range of projected outcomes and determines the set of outcomes for which it desires to increase the likelihood of achievement and also the set of outcomes for which it is desired to minimize the likelihood of achievement. Then it works back to the efficiencies to identify the changes that are critical to the achievement of this goal. These changes must occur through planning policies adopted by the organization to influence the action of key actors in the transactional environment. Such policies, called counter-policies, are developed to make other policies more effective. These counter-policies can achieve their purposes by (1) instructing the actors to change their choice directly, (2) motivating them to change the values of the outcomes, or (3) inducing them to change their behavior by affecting the efficiencies of their choices. Inducement can, of course, take place by direct action of the organization if it has the power to affect efficiencies, or by instructing or motivating members of the contextual environment, who are part of the actors' transactional environment.

Note that the forward and backward hierarchic processes produce opposite effects. The projected process starts with a small number of planning policies and produces a large number of possible outcomes. The desired process starts with a small number of outcomes and produces a large number of policy options. Hence an interesting and highly relevant two-point boundary problem is raised: how do we reconcile into one integrated solution the large number of options that are created when each problem is defined separately? As we shall see in the examples that follow: the vehicle to accomplish this is the prioritization principle of the Analytic Hierarchy Process used by iteration of the forward and backward planning processes.

Summary of Forward-Backward Analysis

The mechanics of carrying out the forward-backward process of planning can be summarized as follows. Establish the forward process hierarchy by identifying the overall purpose of the planning exercise. It is the single element or focus of the hierarchy which occupies the top level. The second level should include the various forces, economic, political, social, which affect the outcome. The third level consists of the actors who manipulate these forces (sometimes it is possible to put the actors in the second level without any mention of the forces). In the fourth level one includes the objectives of each actor. The fifth level of the hierarchy is often optional and should include the policies that each actor pursues to fulfill his objectives. The sixth level is important. It involves the possible scenarios or outcomes that each actor is struggling to bring about as a result of pursuing his objectives (and applying his policies). The final level of the hierarchy is the composite outcome that is a result of all these different scenarios. After all, there is only one possible state of the world and it is a mixture of different people's attempts to shape it in a way which serves their interests. The composite scenario is also known as the logical outcome.

Because of the many and often conflicting interests that coalesce in this scenario, the result may be a dilution or weakening of what any of the actors' wishes to see as an outcome. As a result one or several of the actors may work to change some of their policies to bring about a new outcome that is closer to what they want to get. This calls for the backward process. In this process each actor identifies for his second level one or several desired scenarios he wishes to see take place and sets priorities for them as to how well he wishes to see them affect his overall desired future. The third level consists of problems and opportunities that prevent the attainment of the scenarios. The fourth level includes actors (whether mentioned in the forward process or not) who can influence solution of the problems. The fifth level includes these actor's objectives. The sixth level may or may not include their policies. The seventh level includes one particular actor's policies (or change in objectives) which if pursued can affect the attainment of the desired futures.

After prioritization of these policies (or objectives) in the backward process, only the most important ones are used in a second forward process. They are included with the previous forward policies of just those actors desiring change. Prioritization of the second forward process is revised only from the level of objectives or if there is a level of policies then from that level downward. Then one compares the priorities of the composite likely outcome of the second forward process with the priorities of the desired futures of the first backward process to see if the logical future is driven closer to the desired future. If not, a second iteration of the backward process is carried out by changing the priorities of the desired futures and/or examining new policies. Again the important ones are substituted in a third forward process and scenario priorities are calculated and compared with those of the second backward process. The procedure is repeated until one has fairly exhausted the possibilities in search of ways to improve the logical or likely outcome.

State Variables

There is an alternative way to use the weights assigned to the outcomes. A scenario describes a state of a system. In that state the system has a particular structure and flows. To characterize these meaningfully one uses a set of variables called state variables which specify the structure and flows of the system in that state. Thus a set of state variables may be defined and used to describe an outcome of a planning process. These variables may range over the different aspects of an outcome: political, economic, social, legal. Each of the basic scenarios may be described in terms of the change in each of these variables from the status quo. The intensity of variations above or below the status quo is indicated by a difference scale which ranges from - 9 to 9 (nine times below or nine times above).

An Example

Several years ago or we may say long ago since the 1973 fuel crisis, the federal government displayed an interest in cooperating with the private sector in the development of synthetic fuels [6]. The government, however, has not followed up very convincingly on its early initiatives and has yet to develop an explicit synthetic fuels (synfuels) policy. That was the thinking many years ago before ethanol came on the market in recent years. Ethanol requires a vast amount of land to grow corn (500 gallons of ethanol per acre with each acre yielding 200 bushels of corn or 2 and ½ gallons of ethanol per bushel), more than there is to cultivate enough corn and other cellulosic materials like wheat and rice straw and corn cobs, cardboard, wood and other fibrous plant materials (sugar cane in Brazil) to partly replace the 21 million barrels of oil the US consumes every day (6.6 billion barrels a year)-nearly a fourth of the entire world's consumption of oil. It is known that according to one estimate, a gallon of ethanol has 56% more energy than it takes to produce it.

Much of the US vast coal and shale reserves are located in the relatively sparsely settled West. In fact, some of the richest reserves are located in national parks and other protected areas, thereby setting the stage for a national debate on the trade-offs between ecological protection and energy independence. Thus, even on the tenuous assumption that the mass production of synthetic fuel is economically feasible, there is a thicket of regulations and environmental concerns that may impede progress in the synfuels industry.

Finally, the policies of the Oil and Petroleum Exporting Countries (OPEC) have an impact on the future of the synfuels industry. OPEC is interested in ensuring that the western industrialized nations (particularly the U. S. and Western Europe) remain dependent on Middle Eastern oil. A viable synfuels industry would enhance competition thus forcing OPEC to lower its prices in order to survive in the marketplace. OPEC may use its pricing policies to discourage investment in synfuels research and development. For example, it might temporarily stabilize oil prices in order to defuse the occasional clamoring for viable energy alternatives OPEC might then gradually increase its prices in order to continue to reap enormous profits. In this manner, the synfuels industry would become little more than a puppet with OPEC pulling the strings.

It is evident from the discussion above that the future of the synfuels industry in the United States with respect to transportation fuels is uncertain due to (1) the conflicting signals which the industry is receiving from the federal government; (2) the high cost of developing the synfuels industry, (3) the environmental concerns associated with the development of synthetic fuels, and, (4) the pricing policies of OPEC.

Where does the industry appear to be going and where should it go if the environment becomes more favorable? This problem was once approached from the standpoint of an energy company who, in the first forward process, attempts to envision what type of environment the synfuels industry will have to adapt to in the next 10 years. By "environment" we are referring to the general political, economic, technological and social milieu, within which the synfuels industry would develop or perhaps, stagnate and die.

The First Forward Process

Figure 8.3 illustrates the hierarchy for the first forward process. The focus or objective is to portray the likely environment facing the synfuels industry in the U.S. in the next 10 years from when the study was done. Note that for purposes of this example for the synfuels industry pertains to transportation fuels, not fuels for industrial use, home heating, and the like.

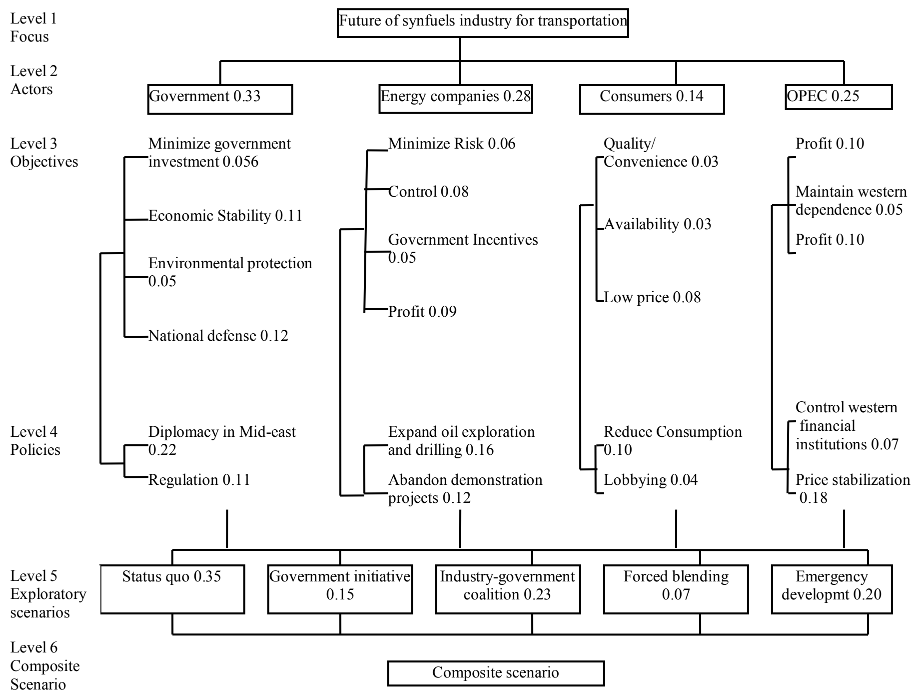


Figure 8.3 First Forward Planning Hierarchy

The main actors affecting the future of the synfuels industry are: (1) government; (2) energy companies; (3) consumers, and (4) OPEC. Each actor has certain objectives and is pursuing certain policies in order to fulfill those objectives. Finally, the hierarchy contains five exploratory scenarios which will comprise the composite scenario. The exploratory scenarios are briefly described below.

Status Quo: This scenario is characterized by continued government disinvestment in synfuels accompanied by reluctance on the part of the private sector to take the necessary risks to enhance the economic viability of the synfuels industry. The scenario assumes that OPEC oil prices will remain relatively stable thereby diminishing the attractiveness of alternative energy sources. Also there will be little or no change in the regulatory and environmental concerns which currently pose barriers to synfuel development.

Government Initiative: This scenario assumes that the federal government will act preemptively to minimize the capability of OPEC to once again bring the Western nations to their knees with an oil embargo. The

scenario forecasts increased government involvement in and subsidization of synfuels research and development. Relatedly, the government will breathe new life into the synthetic Fuels Corporation, giving it the political mandate and financial resources necessary to design the research agenda and to develop a coherent national policy on synthetic fuels. The synfuels industry would be closely monitored and regulated in the same way that utility companies are controlled by government today. Finally, the scenario assumes that environmental concerns will be diminished by a combination of new technologies that will minimize adverse environmental effects and by the diminishing power of environmental interest groups.
Industry-Government Coalition: This scenario is similar to "Government Initiative" in that the federal government will take a renewed interest in synfuels research and will provide financial and technical support for those research efforts. The major difference is that the energy companies will control the research agenda and will maintain private ownership of demonstration plants, patents, and the like. Moreover, the industry will not be strictly monitored or controlled by government; rather, the free market system will prevail; therefore supply and demand patterns, not government regulations, will determine both the quantities of synfuels produced and the market price for those fuels.

Forced Blending: Some countries, such as Brazil, have implemented a policy of forced blending. In this scenario refineries are required to blend conventional fuels with prescribed percentages of synthetic fuels; the prescribed percentage increases over time. The policy would be analogous to the government forcing industry to conform to air quality standards by a particular date. The burden of developing the appropriate technology falls, of course, on the energy and transportation companies alone with the government providing little or no assistance.

Emergency Development: This scenario portrays a repetition of the 1973-74 oil embargo. Increased military and political tensions in the Middle East combined with continuous U.S. support of Israel will prompt retaliatory action by OPEC. The U.S. will react with an emergency research and development program. A "crisis atmosphere" will prevail and, therefore, the research and development agenda will not be systematically planned or coordinated. Most social and environmental concerns will be ignored as the country makes a concerted effort to establish energy independence. Also, energy companies will be encouraged (or coerced), through government appeals to their patriotism, to temporarily abandon the profit motive as the driving force behind their research and development activities.

Table 8.1 illustrates the prioritization of the state variables. Note that the state variables and their associated priorities reflect the interests of the energy company since the planning exercise is being conducted from its perspective. Table 8.2 illustrates the calibration of the state variables with respect to the exploratory scenarios. The first forward process produced a composite measurement of (-.31).

Table 8.1 Priorities of State Variables

State variables	Priority
Control	.32
Government incentives	.16
Free Market	.28
Research funds	.15
Citizen support	.09

The First Backward Process

The first backward process hierarchy is illustrated in Figure 8.4. Note that, while "Status Quo" is projected to be the most likely scenario, "Industry-Government Coalition" is the desired scenario from the point of view of the energy companies. The fifth level of this hierarchy contains policies that are being considered by the energy companies. A brief explanation of those policies follows.

Industrial Consortium: The consortium would serve as an industry-wise advisory body which would present a unified voice to the federal government on matters pertaining to synfuels research and development. The consortium would be a strictly voluntary organization with no formal policy making authority; it would, therefore, not violate laws pertaining to restraint of trade. It would serve as an informal forum for industry-government planning. It is believed that such a forum would streamline patterns of communication between government and industry.

Laboratory Research and Development: Even small scale field demonstration, e.g., coal gasification plants, have proved to be extremely costly and thus far have offered little promise of short term or long term pay-offs. Some industry representatives believe that synfuels researchers should "go back to the drawing board" so to speak through intensified laboratory research which is relatively inexpensive compared with field demonstration projects. Only when such research produces highly promising results would the industry approach the federal government for direct financial assistance or indirect incentives to proceed with the construction of demonstration plants.

Table 8.2 State Variable Calibration

	Status quo (.35)	Government initiative (.15)	Coalition (.23)	Forced Blend (.70)	Emergency Development (.20)	First forward process
Control	0	-5	+4	-7	-7	-1.72
Government incentives	-3	+2	+5	+2	+5	1.54
Free market	0	-7	+3	-2	-4	-1.30
Research funds	-3	+5	+4	0	+6	1.82
Citizen support	0	+2	-2	+1	+5	91
Composite						-.31

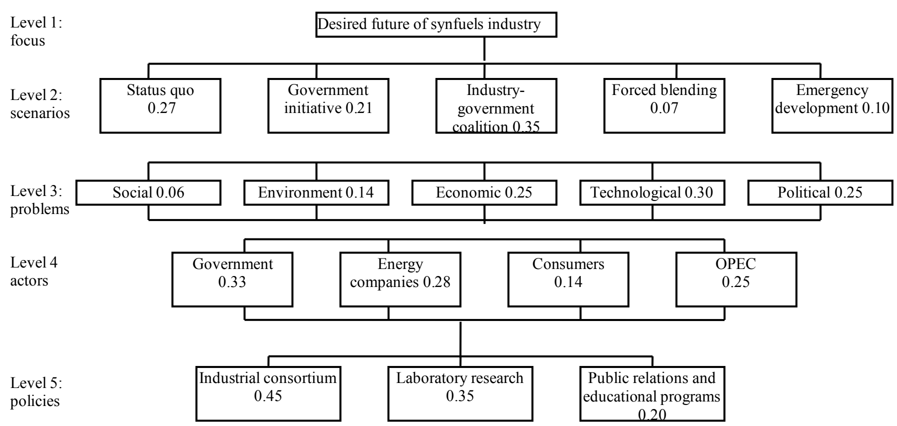


Figure 8.4 First Backward Planning Hierarchy

Public Relations and Educational Campaigns: It is suspected that the relatively stable oil prices combined with the disappointing performance of demonstration projects has produced widespread complacency and apathy toward synfuels research. A national media campaign would stress America's growing reliance on foreign oil, highlighting the politically volatile situation in the Mid-East and calling for long range planning to avoid a repetition of the 1973-74 embargo. In general, such a campaign would attempt to sway public opinion toward synfuels research.

Remark: At this point it should be noted that pair-wise comparison of the scenarios, with respect to the desired future (as was done in Table 8.3), is based on implicit assumptions of the scenarios without looking at the state variable values. Imprecision in judgment can be a result of lack of a more detailed understanding of the state variables whose values define each scenario. If we use the state variable priorities given in Table 8.1 and the state variable calibrations given in Table 8.2, a composite for each scenario in Table 8.2 can be obtained by multiplying the values of the state variables by their priorities. For example for the "status quo" we obtain

(0) (0.32) +(-3) (0.16) +(0) (0.28) +(-3) (0.15) +(0) (0.09)= -0.93

Doing this for the remaining four scenarios yields values of -2.31, 3.34, -2.39, and - 1.21, respectively.

Here "coalition" with the only positive value (3.34) is the most favored future outcome, and "forced blend" is the least favorable one. The desired priorities of the exploratory scenarios for the backward planning hierarchy in Table 8.3 can then be adjusted relying in part on the magnitudes of these individual composites.

The Second Forward Process

The two high priority policies, Industrial Consortium and Laboratory Research, were introduced into the second forward process hierarchy as policies of the energy companies. The prioritization proceeded from the level of policies downward. The relative likelihood of "Industry-Government Coalition" (the desired scenario) occurring, improved somewhat from .23 to .29 as illustrated in Table 8.3. The "true" convergence, as determined by the composite measurement improved by nearly 100 from - .31 to - .003. Remember that a move toward zero in this case is a positive move. Table 8.4 illustrates the state variable calibrations and the composite measurement for the first and second forward processes.

Table 8.3 Second Forward Process—Relative Likelihood of Exploratory Scenarios

Scenarios	Relative likelihood
Status quo	.32
Government initiative	.13
Coalition	.29
Forced blending	.05
Emergency development	.21

Table 8.4 State Variable Calibrations for First and Second Forward Processes

State variables	First forward	Second forward
Control	-1.72	-1.31
Government incentives	1.54	1.90
Free Market	-1.30	-.98
Research funds	1.82	2.11
Citizen support	.91	.78

The Second Backward Process

Even though significant convergence was achieved, the future prospects for the synfuels industry do not appear very bright. It was determined, therefore, that another iteration of the forward-backward process was required. In the second backward process the planners decided to add a policy that would have a short term impact on shaping the future of the synfuels industry. "Industrial Consortium" and "Laboratory Research" would require time to produce meaningful results; the planners believed that the efficacy of these two policies might be enhanced if they were complemented with some policies that had positive impacts in the short term as well as long term. A second backward process hierarchy was constructed which was identical to that illustrated in Figure 8.2 (the first backward process) with one exception—a new policy ("Gasohol") was added and the weights of the three previous policies were adjusted to reflect the new alternative. A brief explanation of the new policy follows:

Gasohol: Alcohol may be produced from excess foodstuffs through fermentation and blended with gasoline to produce a fuel ("gasohol") suitable for use in conventional engines. At present, conventional engines can operate efficiently on fuel with up to a nine to one gas to alcohol ratio, above which there is a need to modify conventional engines. Also, large quantities of grain are required to produce relatively small quantities of alcohol. Despite these drawbacks the technology for producing gasohol is currently being used, with high consumer satisfaction, especially in the Mid-West States. Also, there are relatively few technological, social or environmental patterns associated with increasing its usage. While the long term prospects for gasohol may not be as promising as those for synfuels derived from shale, coal and other natural resources, it offers significant short-term potential. Specifically, if the energy companies can increase the short-term demand for gasohol, through price reductions, advertising campaigns, and the like, they may be more successful in gaining government and public support for long-term research and development efforts related to other synfuel technologies.

The Third Forward Process

In the third forward process hierarchy all four policies from the second backward process were included as policies of the energy companies. With the addition of short term as well as long-term policies, the perceived likelihood of "Industry-Government Coalition" (the desired scenario) increased again from .29 in the second forward process to .34 in the third forward process as illustrated in Table 8.5.

Table 8.5 Third Forward Process

Scenarios	Relative likelihood
Status quo	.31
Government initiative	.13
Coalition	.34
Forced blending	.01
Emergency development	.21

Table 8.6 illustrates the composite measurements for the first, second, and third forward hierarchies. Note that the convergence between the likely and desired futures improved rather significantly (186) between the first and third iterations. On the basis of this convergence, the planners recommended that the company pursue all four policies with emphasis corresponding to the priorities. A description of the scenario that will result from the implementation of these four policies follows:

Table 8.6 State Variable Calibrations for First, Second, and Third Forward Processes

State variables	First forward	Second forward	Third forward
Control	-1.72	-1.31	-.83
Government incentives	1.54	1.90	2.10
Free Market	-1.30	-.98	-.75
Research funds	1.82	2.11	2.34
Citizen support	.91	.78	.64
Composite	-.34	-.003	.269

It appears inevitable that the energy companies will lose a small amount of control over the synfuels industry by attempting to foster an industry-government coalition. Relatively, the free market forces of supply and demand will not be allowed to seek their true equilibrium point due to anticipated government intervention in the synfuels industry. On the positive side, however, government incentives to engage in synfuels research will be enhanced. Available research funds will increase slightly and public support for synfuels research will also increase slightly.

Conclusion

We have seen how to actualize our intuitive understanding of planning by successive iterations of the forward-backward process. The purpose is to decide on what is likely to happen, what we want, what we must control or bring about, and how effective this control is likely to be in directing the likely future towards the desired future. This approach not only unfolds our understanding but provides logical dynamics to test for promising alternatives. This kind of understanding must precede action. Before we proceed to alter the world we live in, with the hope that we can change it for the better, we need a means to test the soundness of our approach.

The complexity of the environment is increasing so rapidly that the impetus to plan and replan to keep up with change must always be present. As any plan is used to make a change, it must soon after be revised to incorporate the full impact of the change it has brought about. There are several reasons why no plan can be so fully dynamic that all aspects of change can be anticipated in it.

One is that we always plan for a part of our world, and occurrences elsewhere tend to overtake the system being planned for; hence the plan must be periodically revised. Another is that not all impacts can be anticipated, particularly those of a synergistic nature, which give rise to completely new entities that cannot be fully characterized in advance. This is true both of concrete physical constructions and of relations among people or among ideas. The close association of a few ideas could lead to the emergence of a new idea that is radically different from its constituent parts. The plan must now be rethought to take into consideration the new developments and their impacts.

Revising a plan may involve the addition or deletion of factors or preferably it can be restructured ab initio to incorporate subtleties that have come to light which cannot be easily accommodated in the older framework. We propose that in the process of implementing the composite scenario the plan should be revised periodically in periods ranging from 3 to 5 years: 3 years to allow the effects of actions to have sufficient time to become noticeable; 5 years to prevent the system from becoming too resistant to change. The ideas in the plan should be constantly reviewed and changed or interpreted on a daily basis as a means of tactical revision. But the structure and recommendations of the strategic plan, once adopted, should not be questioned every day.

The systems approach requires that a plan be approached as an organic whole, not in pieces. Thus major revisions must encompass the entire plan and not simply relate to some parts, leaving out others. This necessitates that not only the components of the plan but their interactions be studied and synthesized, that applications in one part be thought of in terms of their effect on the organization with regard to its structure and its function. Planning is more effective when practiced as an integrated whole.

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