Working Paper

A DESCRIPTIVE STUDY OF GAS
PIPELINE ROUTE SELECTION IN
WEST GEORGIA, USSR

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ABSTRACT

This paper describes the main issues involved in the selection of a gas pipeline route in West Georgia, USSR. The important factors taken into consideration during selection are depicted and attitudes of the decision making parties concerning the problem are shown. The MAMP descriptive model elaborated at IIASA is applied to the case given. Some prescriptive measures for improving the existing decision making system are proposed.

1. INTRODUCTION

During the last several years IIASA has been carrying out research on emergencies that occur with low probability but which have consequences that could be disastrous. Liquefied natural gas (LNG) terminals serve as a main practical source for these investigations. From 1980 to 1982 the research at IIASA was concentrated on developing four LNG case studies in the USA, the United Kingdom, West Germany and the Netherlands. Much attention was paid to organizational problems and interaction among different partners in the decision-making process. Special attention was paid to risk assessment.

In this paper we want to describe the task of selecting a very important gas pipeline route in the western part of Georgia in the USSR. A distinctive feature of gas output in the USSR is that the main gas output regions are located in northern, sparsely populated areas of the country, far from the main industrial centers and potential foreign consumers. This necessitates the construction of extra-long gas pipelines for domestic consumption and for export supplies.

Means for transporting liquefied natural gas involving the construction of liquefication plants and its subsequent transport by sea are now under preliminary development in the USSR.

Accomplishment of such projects is possible in the north of the European part of the USSR and in the Far East. In both regions, however, gas deposits are located far from possible construction sites for liquefied natural gas complexes, which include facilities for gas liquefication, storage, and shipping. For this reason a major component of the gas transportation complex is inevitably the main gas transportation system. Gas pipelines, which can be several thousand kilometers long, are the main factor in determining the cost of the whole transportation complex and its effectiveness. To a great extent this is because the pipelines have to be constructed through climatically severe, unpopulated regions. Analysis shows that capital investments required for such a venture may amount to 75-80% of the total cost of the complex.

The building of a gas pipeline is therefore a significant and often decisive element in a gas transportation complex designed to provide large-scale gas supplies. For the period 1981-1985, 49.5 thousand km of gas pipeline are scheduled for construction in the USSR. Fast development of pipeline transport, particularly for gases, is also characteristic of the world economy as a whole. Thus route selection problems will become increasingly important in the course of time.

2. THE TASK OF PIPELINE ROUTE SELECTION

2.1. The Route Variant

The pipeline under consideration is to be built in the western part of Georgia, a mountainous region with complicated relief and a high population density. The pipeline has to supply individual and industrial consumers in that area. In a preliminary stage of the study (research, field inspection, preliminary agreements) three alternative principal routes were selected: piedmont, meridian and maritime.

The piedmont version is the shortest route, passing through spurs of the Egriss ridge. The relief is heavily dissected with mountain river canyons. Differences in elevation range up to 700 meters. Small villages are located in the valleys along the route so that destruction of buildings would be inevitable. Otherwise it would be necessary to bypass them through difficult mountain terrain. The region is dangerously mud-laden and is made up of karst and landslide zones. Construction work would be impeded by the need to cut the special "terraces" into the slopes for moving construction equipment about and for laying the pipeline. The route is far removed from populated zones and the road system is poorly developed so that pipeline surveillance maintenance would only be possible with the help of helicopters.

The median version passes directly through populated zones. The relief is fairly flat with favorable geological conditions. Highway and railway systems are well developed. However, this version would require the most extensive destruction of buildings and the greatest loss of valuable crop lands. Moreover, it would be necessary to build numerous crossings over artificial obstacles.

The maritime version passes through the Kolkhida lowland, which has an even relief, considerable areas of older forest, and a well developed irrigation system. Some portions of the route might have to be laid through swamp areas, which would cause the route to be particularly hampered during rainy periods.

In addition to the main gas pipeline routes prospective branch routes leading directly to consumers were taken into account.

2.2. The System of Criteria

Now let us charaterize the basic criteria usually taken into consideration in selecting a pipeline route (see Oseredko et al. 1981, Shterbina and Bokserman 1981, Belousou et al. 1978).

1. Presented costs is the most common and universal estimate criterion. It is determined by the exp·ession:

$$C = K \times P + A$$

where K = capital investments

P = normative coefficient of capital investment efficiency (for industrial objects it is taken as equal to 0.12)

A = annual maintenance costs

The basic criterion permits the selection of the route along which the gas supply will require minimum total capital costs and maintenance expenses. However, it does not guarantee us the selection of a really optimum route because environmental and social factors, etc., are either incompletely assessed or not taken into consideration at all.

The formula shows that presented costs are determined by capital investments and maintenance expenses. Capital investments consist mainly of equipment and labor costs.

2. Construction time may be a decisive factor when commissioning the main tasks. In general, the preferred alternatives are those where appropriate construction units and seasonal transport routes are available or those for which roads and other engineering maintenance facilities are already laid out. In addition conditions requiring a minimum change in existing construction technology, construction machines, and mechanisms are sought. The availability of a labor force ensuring construction is also taken into consideration.

3. Convenience of maintenance is the third criterion. Reliable operation requires access to all sections of the pipeline in order to carry out preventive inspection and repair work in cases of failure. Access is dependent on natural conditions along the pipeline route and on the development of the transport network.

4. Reliability of service depends mainly on natural climatic conditions along the route. To ensure faultless operation of the gas transportation system, the laying of two lines instead of one is standard practice for the most complicated and important sections (water barriers and swamps, almost inaccessible mountain regions), although this increases the capital expenditure and can require gas supply reservation by means of underground storage in natural formations, etc.

5. Environmental impact. Construction of main gas pipelines has a major impact on the environment. The allotment of land for construction inevitably results in agricultural production losses and local felling of trees. These losses are often evaluated without regard for the long term and the various consequences for the environment.

When laying a pipeline in the highlands, there is an acute danger of landslides, which threatens not only the environment but also the reliability of the pipeline. The danger of landslides may increase when cutting terraces into the slopes (for moving construction equipment and laying the pipeline) which often violates natural hydrological conditions.

6. Coordination with plans for regional development. The effects of gas pipeline construction on the population and on the economy of the construction region are also taken into consideration. The concentration of the labor force during the different construction periods and in different areas may change sharply. Social and economic impacts on the populated parts of the construction area may be quite important and must be taken into account during route selection. When demolition of homes is necessary, the problem of relocation arises.

A subject for serious study is the future infrastructure of the object that provides the normal living and operating conditions for the maintenance personnel and their families (social, cultural, medical facilities, etc.). The creation of such facilities is often connected with considerable costs. The influence of the gas pipeline route on regional development plans largely determines public opinion. The attitudes of administrative bodies and the population towards the impendent construction of the gas pipeline and their willingness to issue concordances, allot lands, and grant various permissions for the construction process can greatly accelerate the completion of design and survey work as well as the construction process itself, which can result in additional economic benefit.

7. Construction conditions are determined by geological, hydrological, topographical, and other conditions along the gas pipeline route as well as by the availability of a sufficiently well-developed infrastructure, construction basis, etc., in the region. This criterion is set forth as an independent factor because it is important for the construction firm, which is also involved in the process of route selection.

8. Population safety is mainly ensured by maintaining standard minimum distances from the main gas pipeline axis to the populated areas, i.e., buildings, farms, highways, etc., (guarding zone). However, this would not completely ensure population safety in the case of pipeline failure. There are two other ways of decreasing danger:

a. by increasing the reliability of technological systems and installations
b. by expanding the guarding zone and increasing the distances from the complex objects to the nearest populated areas.

It should be noted that Soviet standards for guarding zones and fire protection are more extensive than those of other countries (and this affects certain economic factors).

While there are no figures available for gauging pipeline safety, experts in this field can compare the different routes from the point of view of safety and make a decision as to what variant would be the best in this sense.

Thus when evaluating gas pipeline routes we have to take into consideration a number of criteria. Some of these can be expressed in quantitative form. Others, however, can only be expressed in qualitative form; the judgement of experts is the only possible way of getting information on these.

2.3. Assessing the Alternatives Using the System of Criteria

The criteria for the three variants under consideration were estimated as shown in Table 1. Let us comment on these data

1. Two stages are envisaged for the pipeline construction process. The first stage involves construction of the main pipeline route; the second stage, the laying of the branches of the gas pipeline from the main route to the consumers. These stages were approached differently in terms of both time and source of finances: the construction of the pipeline branches is to be paid for from the regional

Table 1. The criteria used in making the decision

Item	Criteria	Designation	Preferable order of versions on criteria		
			Maritime	Median	Piedmont
1.	Presented costs (million rubles)	C	8.9	9.5	10.8
2.	Cost of laying the main route (million rubles)	C1	30	40	46
3.	Cost of prospective gas pipeline's branches laying up to consumers (million rubles)	C2	9.5	5	5
4.	Construction time	T	best	best	worst
5.	Convenience of maintenance	M	good	best	worst
6.	Reliability of service	R	worst	best	worst
7.	Environmental impact	IN	best	good	worst
8.	Coordination with plans for region development	RP	worst	best	worst
9.	Conditions of construction	B	worst	best	worst
10.	Safety of population	S	best	worst	worst

organization's budget. In view of this it is expedient to consider separately two price criteria: capital costs for the main route and capital costs for the branches.

2. When assessed according to the existing standards for the pipeline construction, the minimum time required for constructing the different versions did not vary greatly. However, experience suggests that the piedmont version would take much more time due to route laying difficulties. In the maritime version, delays would be likely during the construction in swampy areas and while crossing three big rivers.

3. The most difficult version in terms of convenience of maintenance was recognized to be the piedmont version (access to the main route only with the aid of helicopters). Most convenient for maintenance purposes would be the median version (good access to all sections of the pipeline). The maritime version was judged inferior to the median version in this respect because of the swamps.

4. Reliability of service is another important factor. Regardless of the quality of the pipeline's construction, the possibility of small failures cannot be totally ruled out. Experience with gas pipeline maintenance under various terrain conditions indicates that the maritime version is the least suitable one, because the main part of the route runs through as active corrosion medium (swamps). Here, with time, failure is almost inevitable.

A similar assessment can be made regarding the piedmont version: practical experience with gas pipeline maintenance in mountainous regions reveals a probability of failure due to landslides. Eliminating this danger is very difficult.

Most reliable is the median version where laying conditions are most favorable. The best maintenance conditions are available with this version; this in turn increases its reliability.

It is necessary to point out that there are no reliable data about pipeline maintenance because of the unique character of every pipeline construction project. The pipeline designers can compare the different routes in qualitative terms only.

5. Most preferable in terms of environmental impact was the maritime version, where the route passes through the Kolkhida lowland with its numerous swamps. With the median version the route rounded unique ancient forests. The median version passes through agricultural lands and would adversely affect tea and citrus plantations to a greater degree than would the two other versions. Though the loss of lands would be temporary (for the period of construction) it would be undesirable.

The most undesirable route according to this criterion was the piedmont one. The cutting of terraces into the mountain slopes would adversely affect the environment; previous experience with laying gas pipelines suggests that landslides could occur in consequence. Besides, the construction of terraces requires greater amounts of land than when laying pipeline in flat areas.

6. Coordination with plans for regional development. For the median and maritime versions, a similar number of buildings would have to be demolished (69 and 61 respectively); in this respect the piedmont version would be considerably worse (136). From the point of view of agricultural crop damage the piedmont version is again the worst (129 hectares), followed by the median version (102 hectares), and the maritime version (57 hectares). However, from the point of view of regional plans for supplying gas to potential consumers the median version is much better. Because of this fact and some others (existing infrastructure, future economic plans, etc.), this is the version favored by local authorities.

7. Construction. According to this criterion, which is greatly dependent upon the relief and local pecularities, the median version was assessed as best. The maritime

version received a worse assessment and the piedmont version, a much worse one.

8. Population safety. Existing standards for laying gas pipelines define necessary minimum distances from the gas pipeline to residential areas. In the case of a gas pipeline failure (gas leak), there would be a risk of fire. However, with the adopted working pressures and types of steel used, this possibility is hardly probable. Previous experience led experts to conclude that the maritime version, along the route of which there are few settlements, agricultural lands, and highways, would least endanger the population. The other two versions are approximately equal in this respect.

3. THE PARTIES INVOLVED IN THE DECISION MAKING PROCESS

We can single out four major participants in the pipeline route selection process. The first of these is the customer organization (CO), which is responsible for the energy supply for the region, for maintenance of energy systems and for pipeline maintenance in particular. This regional organization estimates current regional energy demand, elaborates prospective plans, and after having agreed with central planning bodies, designs the task for the project organization.

The project organization (PO), which designs the gas pipeline, plays a central role in the decision making process. It has main responsibility for the entire project and must be able to prove to any other organization (for instance, the special test commission of the gas ministry) that the variant chosen is really the best one.

In its work the project organization has to meet the demands of the customer organization. These demands are the basic point of the organization's activities. Besides this, the project organization also has to agree on the project with the regional authorities (RA), who represent the interests of the population living in this area. The regional authorities present some information about regional peculiarities to the project organization, including information about regional development plans. The regional authorities have their own system of preferences in which criteria RP, C2, IN, R, S play the main roles. They want the project to satisfy in the best way present and future needs of the region.

The last partner in the decision making process is the construction contractor (CC), who is responsible for the construction of the gas pipeline. The construction contractor's main selection criteria are B and T.

In Table 2 the principal party-by-criterion matrix for the task is given.

As was mentioned above, the project organization is mainly responsible for making decisions about the task under consideration. Looking at the relationships between the organizations concerned, we note that the ties between the project organization and its partners are much more active than those among the other partners, as can be seen in Figure 1.

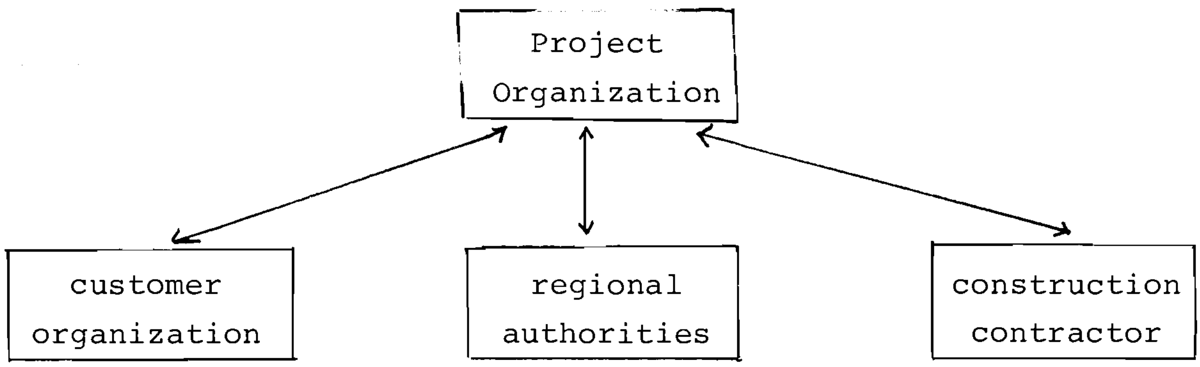

Figure 1. The parties involved in the decision making process and their relationships to one another.

Table 2. Party by criterion matrix.

	CO	PO	RA	CC
1. Presented costs		X		
2. Cost of the main route		X		
3. Cost of prospective branches			X	
4. Time of construction		X		X
5. Convenience of maintenance		X		
6. Reliability of maintenance	X	X	X	
7. Influence upon the environment		X	X	
8. Connection with regional plans of development		X	X	
9. Conditions of construction	X			X
10. Safety of population		X	X	

CO = customer organization

PO = project organization

RA = regional authorities

CC = construction contractor

4. THE DECISION MAKING PROCESS

As we have mentioned above, the customer organization took the first step in the decision making process by designing the task for the project organization. The project organization analyzed the possible pipeline routes and submitted the information about the three versions to the other three parties for their consideration. The project organization also informed its partners that it preferred the maritime route as it had the best evaluations on criteria C, C1, IN, S and because the difference between the maritime and meridian versions on criterion R was not very large.

Opinions differed little among the participants with respect to their assessments of all three versions on the system of criteria, except for the RP criterion. The regional authorities and the project organization agreed that the meridian version was better than the maritime one from the point of view of future regional development, but they differed in their estimation of the gap between them. The project organization considered the median route to be a little bit better than the maritime one; the regional authorities insisted that the difference was much greater.

All the participants agreed that the piedmont version was the least desirable and so they eliminated it from further consideration. Three of the participants, the regional authorities, the customer organization, and the construction contractor, preferred the median version: the customer organization because it was better on criterion M and R, and the construction contractor because it was better on criterion B, its score on criterion T being about the same as the others. The RA's attitude toward the comparison of the two versions was more complicated. The median version had better scores on criteria RP and C2, but lower ones on criteria IN and S. After a comparison of the better scores of the median version on criteria C2 and RP with the better scores of the maritime version on criteria IN and S, they inclined toward the median version. They explained their position by saying that the median version had better scores on criteria RP, C2, B, M, and R and the maritime version had better ones only on criteria IN, C, C1, and S. At the same time they asked the project organization to consider the possibility of finding new technical solutions that could improve the scores of the median version on criteria IN and S, as they were very much interested in those criteria and wanted to bring them closer to the maritime version scores.

The project organization did not oppose the median version as a whole, but was concerned about its potential negative impact on the environment of the region and wanted to make sure that the final decision would have the best score on criterion C.

It was quite clear that the regional authorities were very interested in coordination of the project with plans for regional development. They wanted to minimize the costs of the prospective pipeline branches and were prepared to take various actions in defense of their position.

For this reason the PO began looking for a solution that could improve the median version on criteria C, IN, and S and that did not greatly worsen it on the other criteria.

The technical department of the project organization suggested the possibility of reducing the guarding zone if there could be a compensatory increase in reliability through an increase in the thickness of the pipeline walls. It also suggested the possibility of slightly decreasing the gas pressure inside the pipeline. With these technical solutions the number of farmsteads to be demolished could be considerably diminished and, despite a certain increase in metal capacity and in the cost of the pipeline, the presented costs for the median version would drop below those of the maritime one (see Table 3).

At the same time these solutions would allow the project organization to increase the safety of the population and to decrease the impact on the environment. In view of this new technical solution all participants in the selection process agreed on the median version and so this version was chosen.

Table 3. Scores awarded criteria by decision makers.

Item	Criteria	Designation	Cost/Order of preferable order according to crieteria: Maritime	Median
1.	Presented costs (million rubles)	C	8.9	8.5
2.	Cost of the main route laying (million rubles)	C1	31	34
3.	Cost of prospective gas pipeline's branches laying up to consumers (million rubles)	C2	9.5	5
4.	Time of construction	T	best	best
5.	Convenience of maintenance	M	good	best
6.	Reliability of service	R	poorest	best
7.	Environmental impact	IN	best	good
8.	Coordination with regional plans of development	RP	poorest	best
9.	Construction conditions	B	poorest	best
10.	Population safety	S	best	good

5. PECULARITIES OF THE DECISION MAKING PROCESS

Let us try to outline the main points of the decision making process we have described.

1. During the discussion of the problem there were no great differences among the decision making participants as to the scores of the criteria in the three versions, probably because while assessing the project using the system of criteria, the project organization had agreed upon the scores with the other organizations.

2. The project organization, the main participant in the decision making process, as well as the other participants wanted to make a decision that would be easy to justify. For this reason the project organization wanted the final decision to have scores that were not much below those of the other possible variant, even on criterion 1. So it wanted the decision to have at least satisfactory scores on every criterion.

3. As a rule, decision makers, experts, and designers tend to use wordy estimations that reflect their understanding of the situations under consideration. They avoid the use of quantitative estimations, especially when assessing probabilities, as they are not in the habit of using probabilistic estimations and they do not know how to operate with them.

4. There is no systematic estimation of the risks involved in gas pipeline construction and exploitation. Analysis of actual decision making procedures shows that experts usually prepare such estimations in a wordy qualitative form. Naturally these estimations are based on past experience and on the knowledge of previous breaches of pipeline operation as well as on knowledge about conditions under which breaches have occurred. Various cases, especially recent ones, influence these estimations (2,4,10) (see Shterbina and Bokserman 1981, Belousov et al. 1978, Tversky 1969).

When selecting the route the decision makers try to avoid such conditions and to take additional measures to increase reliability so that an initial, undesirable estimation can be made acceptable.

6. THE APPLICATION OF THE MAMP MODEL

Kunreuther (1980) proposed that the MAMP model be used as an instrument for comparative descriptive studies. The main idea behind the MAMP model is to separate the whole decision making process into separate rounds. Each round is bounded by a set of issues--problem definition, initiating events, alternatives--that describe the main problem of the round. It includes the so-called interaction phase, which illustrates the interaction among the parties. Every round finishes with key decisions and conclusions.

Like every model, the MAMP model simplifies the real decision process. However, it allows a systemization of descriptive studies and in this way it promotes the carrying out of a comparative analysis.

We see the case under consideration as consisting of two rounds. The first round includes the first elaboration of the project and the first joint consideration of the possible variants by all parties concerned. During this round, differences of views among parties were revealed. It concludes with a search for new technical solutions for improving the desired version on some criteria (Table 4).

The second round consists of joint consideration of the new version of the median route, which has better estimations on some criteria than the old one. As there were no changes in the participants' attitudes toward the system of criteria, the new median version was adopted (Table 5).

Table 4. Round 1 of the decision making process.

Problem definition:	Determination of pipeline route
Initiating event:	Co-design of the task for the project organization
Alternatives:	Maritime, median, piedmont route
Interaction:	
Involved parties	Criteria
Project organization	C, C1, IN, S
Regional authorities	C2, RP, M, R, B
Customer organization	M, R
Construction contractor	B

Key decisions and conclusions:

1. To exclude the piedmont route from further consideration
2. To ask the project organization to find new technical solutions that can improve the scores of the median version on the system of criteria

Table 5. Round 2 of the decision making process.

Problem definition:	Improvement of the median route and comparison of it with the maritime route
Initiating event:	Project organization elaborated a new version of the median route
Alternatives:	Maritime and median routes
Interaction:	
Involved parties	Criteria
Project organization	C, C1, IN, S
Regional authorities	C2, RP, M, R, B
Customer organization	M, R
Construction contractor	B

Key decisions and conclusion:

1. To adopt the median route as the best one.

7. ANALYSIS OF POSSIBLE PRESCRIPTIVE MEASURES

The main purpose of the descriptive studies being carried out at IIASA is to analyze existing systems of decision making and to propose some prescriptive measures that could improve them. In order to do this, let us first define more exactly the task under consideration. From the point of view of a decision theory, the task considered above involves a decision making problem in which several decision makers evaluate several alternatives according to a number of criteria. There are usually several alternatives and about 10 criteria.

It is necessary to point out that every large technological project--gas pipeline, LNG terminal, or any other project--is a unique object, even if it is not a novel one. Every project involves different criteria and different decision makers, with peculiarities in their interactions. In making comparative studies we also have to account for national features of the decision making process, etc. That is why it is difficult to hope that it will be possible to make exhaustive universal conclusions as to what methods to use and how to use them. A decision on a concrete problem has to take into account all details of the task under consideration.

One of the main problems in evaluating a project is that of assessing the project on a set of criteria. We can distinguish (1) quantitative criteria for which we can obtain fairly exact, objective estimations (cost, time of construction), (2) quantitative criteria for which it is possible to obtain only the subjective judgments of experts (reliability of maintenance, population safety), and (3) qualitative criteria, where it is also only possible to obtain subjective estimations in verbal form.

Analysis of actual decision making procedures shows that even in the case of quantitative criteria with subjective estimations, the estimations are usually given by the experts in verbal form. This can be explained firstly by the unique character of each route, i.e., the absence of statistics. Secondly, human cognitive limits prevent decision makers from operating with exact estimates for every criterion. Therefore the task under consideration combines both quantitative and qualitative elements and is a typical ill-structured problem according to Simon's well-known definition. The main issue here is what can we gain from utilizing the decision making methods for the solution of a given task and which methods can take into account the above-mentioned task peculiarities.

This question may be considered at two levels:

1) at the level of the individual decision maker (the problem of individual decisive rule) and
2) at the level of the decision making group (decision-concordance procedures).

The original method for making individual decisions on ill-structured problems was developed at the All-Union Research Institute for Systems Studies (see Oseredko et al. 1981, Multi-criteria choice 1978). Its main characteristic features are: (1) to get reliable information from the decision maker, (2) to incorporate the decision maker's preference into the final decision with the least falsification.

The first requirement can be satisfied by using the usual terminology of experts and decision makers for describing the problem while obtaining the necessary information. This demands that discreet levels of criteria be used. These must be formulated in quantitative or qualitative form, depending on the nature of the criteria. The peculiarity of our task is that the majority of the criteria used have qualitative levels (as can be seen from Tables 1 and 3).

There is no universal method for ensuring that the final decision reflects the decision maker's preference. In every concrete case the decision making methods that least falsify the decision makers preference system should be used. In our case, in view of the small number of alternatives, trade-off analysis proved most expedient. Trade-off analyses permit alternatives to be assessed qualitatively, especially where estimations are of a comparative nature.

Selection of the best version is carried out by means of a binary comparison of the decision alternatives, according to which the estimates of separate criteria are compared.

Descriptive studies of such procedures have revealed the possibility of the appearance of nontransitiveness (see Tversky 1969). These studies have shown that when making a binary comparison of alternatives involving estimates of numerous criteria, people employ simplified heuristics, of which the following should be mentioned: (a) consideration of criteria in turn, (b) disregard of some part of the criteria, and (c) simple calculation of the number criteria for which one version is found to be superior to another. Despite the usefulness of such heuristics, in some cases they can lead to nontransitiveness.

However, when the number of versions is small, this possibility is not great, so that in cases where nontransitiveness appears, it can be detected and eliminated rather easily. Data from descriptive studies show which requirements have to be met by trade-off analyses in order to avoid distortions induced by the limits of cognitive abilities in multidimensional information processing.

In order to avoid undesirable heuristics, it is necessary for decision makers to consider information in sections, for instance, by comparing conflicting estimates on two criteria only (11). Also, if the comparison system is biased, then it is desirable for decision makers to consider using a new one.

In addition, it is desirable to expedite the comparison process by agreeing quickly on the necessity for a compromise between competing aims. Comparison procedures should include methods for checking information even where there appears to be no discrepancy.

Possible methods for improving the procedures for preference correlation should be investigated. The primary efforts in the elaboration of route alternatives are made by the designers, who are also the first to carry out comparisons. From the point of view of the rationality of the whole process of decision making, it is desirable for the organization designer to take into consideration the whole set of estimation criteria for the various alternatives, together with any ideas put forward by other participants. In the final analysis, the decision maker (or designer) introduces his own preferences into the comparisons even when taking into account all the criteria. However, preliminary assessment of the viewpoints of the other decision makers will help the designer to better control the development of a proposed version. Anticipating objections, a decision maker can show in advance all the negative consequences of the selection of other versions, and this improves the selection process.

CONCLUSION

In the world around us we often encounter the problem of making decisions involving uncertainty and the risk that major failure will occur. This is particularly true of problems related to the output, transport, liquefaction, and storage of natural gas. Any possibility for a real improvement in the decision making process under such circumstances should be exploited. In the attempt to determine such a possibility, certain methods can be applied to enhance decision making tools. A rational basis for such methods is a comparison between descriptive and normative approaches. Inherent in normative decision making methods should be a sound knowledge of the information available and an awareness of human limitations.

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