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MULTICRITERIA MODELING AND RATIONAL USE OF WASTE

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ABSTRACT

A problem solving case is here presented to show the potentiality of an integrated approach in relation to a problem that developed in a wood company. Its very large quantity of waste wood has been sold for many years to plywood producers, but this income has been greatly reduced due to new market preferences. The waste wood has therefore become a stock and risk problem; it could however represent a potential clean and free energy source. The technical, financial and law constraints necessitated a multicriteria modeling of the problem, but the uncertainty elements that characterized the situation required integration between the multicriteria approach to the problem formulation and a different approach of problem structuring and strategy development which focuses attention on alternative ways of managing uncertainties. The combination of two different approaches of decision aiding improves the effectiveness of this technical intervention and is intended as a proposal for easier reading of the organizational decision context and for a better support for unstructured decision problems.

Key words: MultiCriteria Aid for Decision, multicriteria methods and modeling, Strategic Choice Approach**,** Knowledge management and Decision Support Systems

1. INTRODUCTION

Decision aiding consists in trying to provide answers to questions raised by actors involved in a decision process using a clearly specified model (Roy 1990; Bouyssou 1990). This model should include a multiplicity of points of view concerning the problem and a formal specification of each problem element; its structure should be simple, easy to understand and rigorous. The modeling process is of great importance in the decision aiding context, but effective and efficient modeling requires a great deal of expertise and is often not supported by well structured tools.

Ill-structured problems in particular require specific emphasis on the activities of conceptualization and problem specification, which lead to a good correspondence between the problem situation and its empirically supported model. An analyst's recognition of the problem situation is related to his/her initial perception of the complexity of the situation and to the adopted approach. The understanding of different contingent situations (in particular of their complexity in terms of organizational and process contexts) and the evolution of the problem formulation, information requirements and processing (in relation to the technical and operational complexity) (for more details see Marzano et al 1998) go hand and hand with the modeling and validation process, as proposed for the first time in (Landry et al. 1983).

A multicriteria (MC) model can be defined as a "good" model because it constitutes a richer language than one made up of a single criterion, a language common to all the actors of the decision process and operational in a variety of respects (implementation of simple reasoning and also sophisticated methods, data analysis and support for reflection, communication, negotiation, creativity and so on). The possibility of dealing with all kinds of data and then choosing a multicriteria method that is consistent with the nature of the data prevents a great deal of descriptive, interpretative and communication constraints from occurring, mainly in the first steps of the work, when the analysts need a simple vehicle for communication and a structured context to identify and validate the essential elements of the problem and the model. Stable and shared models can therefore introduce methods that reduce uncertainty on information and decisions.

This approach is particularly effective for at least partially structured problems. The situation becomes more difficult for ill-structured problems or in relation to innovative situations, when information does not exist and only the individual's views of the problem have to be included in the model. The MC models can be used in these situations in a learning phase to explore decision and action contexts, the solution space and the evaluation space. MC methods are used to evaluate possible decision actions and to support decision-making, but problems exist when the set of possible solutions must be constructed dynamically during the evolution of the process and the problem formulation. Multicriteria aid for decisions (MCDA) implies that the scientist, before attempting to apply a method, should help the decision-maker to define these elements, and this may be one of his most arduous tasks (Vincke 1992). Multicriteria modeling procedures, which can be used to support structuring and modeling in at least partially structured problems (Norese and Ostanello 1989; Ostanello 1990), should be integrated with, and supported by, flexible tools and an approach to cope with complexity, to face ill-structured or unstructured problems.

The focus on "knowledge", in the organizational studies, made these difficult situations evident. A visible representation of an individual's knowledge has to be made available for analysis and communication when the society and the organizations become composed of multiple communities with highly specialized technologies and knowledge domains. This formalized and flexible representation becomes a *boundary object* and provides a basis for *perspective taking*, i.e. for a communication that improves its ability to take the knowledge of other communities into account (Boland and Tenkasi 1995).

The creation of common boundary objects is central in the process of developing new ideas (Brown and Duguid 2001); these 'objects' are common representations of knowledge, that begin from different perspectives and interpose themselves as elements of communication between one community and another. The creation of these objects can constitute an exercise to create new perspectives of knowledge and to exchange these with each other actor's perspective. There are many possible forms of boundary object, including diagrams, cognitive maps and physical and analytical models (Boland and Tenkasi 1995).

Some important approaches to problem structuring, which are proposed in literature and used in several application contexts, elaborate and use forms of boundary objects. Five well-known methodologies are presented in (Rosenhead 1989). One of these is a specific cognitive mapping approach (Eden 1989). Another, the Strategic Choice Approach (Friend 1989), supports the collaborative elaboration of logical diagrams, identifies and aims to control all the uncertainty elements of the decision problems, and implements a natural MC approach to the problem.

A real study and problem solving case is here presented to show the potentiality of an integrated approach (between multicriteria modeling procedures and the Strategic Choice Approach to planning under uncertainty) in relation to a problem that developed in a wood company. The problem of the rational use of waste wood is presented in the second section; the adopted decision-aid procedure and some steps of problem structuring and modeling are discussed in the last section as a proposal for integrating the different approaches. The first approach is oriented towards the use of formal methods while the other approach is more flexible and oriented to generating a common representation of knowledge. The integration can create a communication space to understand the problem and to iteratively structure a model, which becomes a real possibility of decision. It is a general suggestion for interventions in complex situations and for the design of intelligent Decision Support Systems.

2. THE PROBLEM OF THE RATIONAL USE OF WASTE

A medium sized wood company, with a specialized production (tool handles), has been producing a large quantity of waste (in this case shavings) since the beginning of the '80s. The waste wood, about 500-600 tons a year (requiring an enormous stocking space), has been sold for many years to plywood producers. The price in the '80s was about lire 60,000 a ton (equivalent to 40 euros), with no extra charge for transport. However, at the beginning of the '90s, the situation began to change, due to new market preferences. The prices became lower and lower, until they became equal to the transport charges.

The quantity of waste wood in 1990 was greater than that that was taken away. It was therefore necessary to transport exceedingly large quantities of waste wood to the public refuse dump, at a cost of about lire 40,000 per ton for transport and lire 60,000 per ton for stocking. The company passed from a situation of having a small profit of about lire 30 million a year in the '80s, to an expected loss of 50 million in the '90s.

The owner of the wood company tried to solve the problem by selling the waste wood to some companies in the surrounding areas, whose work processes require heat. As a last attempt, he asked an expert for a preliminary problem solving project, but its estimated cost of about lire 200 million was considered more than he could afford.

When the owner of the wood company was interviewed, it was clear that only a complete and structured analysis could help him to acquire a system view of his problem and to identify (or elaborate) valid solutions and select the best one.
It was easy to understand that in order to heat the company's large work shop, about 80,000 kW/h would probably be needed and the electric power would be about 100-120,000 kW/h. Therefore, the first idea was to burn all the dry wood to heat the work shop and then, if possible, to produce electricity.

Experienced and professional companies that have operated for many years in problematics concerning the rational use of waste and clean energy sources were interviewed and their opinions were filed in order, first of all, to understand the real theoretical and practical complexity of the problem more clearly and then to build an almost complete list of solutions and opportunities that would suite this specific case. Essential suggestions and documentation (literature and internal reports) were proposed by the Department of Energetics at the Politecnico di Torino, the regional Institute for Plants and Environment (IPLA), which was once the research laboratory of an important Italian paper manufacturer, and the National Company for New Technologies (ENEA), previously known as the Italian National Company for alternative energy. Experimental installations to heat small houses using new, rational and unconventional ways were also examined.

It was thus possible to understand that there are some classical ways of producing energy from biological masses (direct combustion, gasification and pyrolisis, the latter inducing carbonization or liquefaction) and only two of them (direct combustion and gasification) are suitable to resolve the problem and can be undertaken both by a single user and by an association of several companies (a consortium, in this case between the producer and the user). This organizational structure is related to a specific legal aspect of the problem; until 1990, no Italian company was allowed to produce and distribute electric energy, as ENEL (Ente Nazionale Energia Elettrica - National Company for Electric Energy) had the monopoly in this field; as a way of overcoming this problem, some companies decided to combine their different energy productions. A consortium is only suitable if heat and electricity are both generated at the same time; co-generation is however also possible with a single-user installation. If co-generation is adopted at a later date, it is possible to save money and time by adding a turbine to the burner-boiler plant; of course, if such a possibility is considered from the beginning, but not adopted because of the expense, it is better to buy a slightly larger boiler than required, so that it will be possible to convert an original heating installation into a co-generation one.

The fifth course of action, mangling and compressing wood waste, is suitable for producing small wooden bricks; these could be sold, but in this case finding a ready market could be a problem. The last course of action is rather different from the others; the first five are oriented to heating the energy producer, the last (district heating) implies heating large buildings at a distance (for example, schools) and therefore orients towards external actors, who are not the energy producers. Each form of company association or consortium obviously means that different organizational and administrative problems would arise; district heating adds an additional complexity, due to contractual obligations with the external users, to the other organizational problems. For this reason, district heating should be excluded from the acceptable solutions.

Valuable data were obtained from a test that was conducted by ENEA and the Thermotechnic Laboratory of the Politecnico di Torino to evaluate the technical characteristics of several boilers. Autonomy, feed, power and especially the input/output ratio (η, a coefficient between 0 and 1) were considered and tested; a semi-gazogene and a gazogene boiler obtained the best values of η (0.78 and 0.77 respectively), while a conventional steel boiler obtained only 0.59.

While different technological solutions were identified on the market and screened, the possibility of obtaining financial support was analyzed with the help of the same information sources (ENEA and the Energetics Department of the Politecnico di Torino). The basic law on the rational use of waste is Law n° 308/1982, which sets aside funds for such works. However, in 1990 these funds were exhausted, and experts from the Piedmontese Regional

Government explained that in a few months a new law would be drawn up. In 1991 Law n° 10/1991 set aside new funds, which were shared among all the applicants. In 1992 however, when the wood company was able to ask for funds, new economic requirements blocked these funds, which were frozen in 1993 and 1994.

At the same time another solution was suggested by IPLA: the use of this waste wood to facilitate the production of mixed organic manure (compost). This is a completely different process, which does not produce heating or electricity, but simply solves the problem of stocking waste wood.

Law constraints and delays in obtaining clear indications about the financial support led to a hold up in the process which allowed a critical analysis to be made of the first modeling phase results (which are synthesized in this section) and a new modeling phase that is proposed in the next section as an integration between the multicriteria approach and another which is more oriented to 'planning under uncertainty' (Friend 1989).

The main activities of the first modeling phase were activated to identify and explore the operative context, to search for alternatives, to formalize and evaluate them, to identify and/or refine needs and potentialities and then to define a new set of actions, and so on, until a final "stable" set of developed alternatives was reached. All these activities can be seen as a sequence of Search and Screen routines, as defined in (Mintzberg et al. 1976).[1]

The identification of a correct investigation context and then of reliable information sources characterizes the first step of searching (see Fig.1). Some classical ways of producing energy from biological masses are proposed in literature; three of these were excluded from the analysis and then the direct search for alternatives focused on two technological processes (direct combustion and gasification). Different solutions (in terms of boilers) are present on the market; to reduce this large number of ready-made alternatives to a few feasible ones, screening was activated to reject unfeasible solutions and to store (and later handle) the others. Three points of view were used both to identify and then to select these ready-made solutions. They were *efficiency* (mainly in terms of input/output ratio), *maintenance* (in terms of technology presence on the Italian market, reliability and low installation difficulty) and *bureaucracy* or *administrative complexity* (license or concession requirements).

One specific use of the produced energy (district heating) was excluded. The association of several companies to produce and use energy (a consortium) was considered as a possible course of action. Other processes to rationally use waste wood were proposed during the inquiry (passive search), accepted and then included in the set of alternatives.

At the end of this quite tumultuous phase, the first multicriteria model was developed and temporarily settled to represent the global knowledge of the situation and the possible actions in a more structured way. The model was discussed and its drawbacks were made evident, as an immediate decision was considered impossible or at least not realistic. In this situation of uncertainty concerning the possibility of obtaining financial support, the model was mainly used as a communication tool to better analyze all the possible solutions.

A synthesis of the model is presented in Fig.2. The alternative actions are evaluated on two aspects (*technological* and *financial*) according to five criteria elaborated in relation to these categories. All the action evaluations propose a qualitative assessment, i.e. a synthesis of multiple indications, which have been acquired and considered to be significant for the evaluation model. The action of making waste wood into compost was included as a new and different solution that was interesting, mainly in relation to new cultural and economic scenarios, but technologically different from the other solutions and not sufficiently documented. It was proposed in the model as an action for which the identified criteria were not pertinent and a comparison with the other actions was impossible, at least according to these criteria.

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[1] A *Search and Screen Routine* is proposed to develop problem solutions that may be found *ready-made* during the process. Search is a hierarchical, stepwise process. Four types of search behaviors can be isolated: the scanning of the organization's existing memory (memory search), the waiting for unsolicited alternatives to appear (passive s.), the activation of "search generators" to produce alternatives (trap s.) and the direct seeking of alternatives, either through scanning a wide area or focusing on a narrow one. The Screen routine is applied when a search is expected to generate more ready-made alternatives than can be intensively evaluated. It is a superficial routine, more concerned with eliminating what is unfeasible than with determining what is appropriate, in order to reduce the alternatives to a number that can be stored and later handled by time-constrained decision makers. Screening is an implicit part of search: as ready-made alternatives appear, they are quickly screened and either rejected immediately or stored. Initial failure in a search leads to the use of more active search procedures and to search in more remote and less familiar areas.

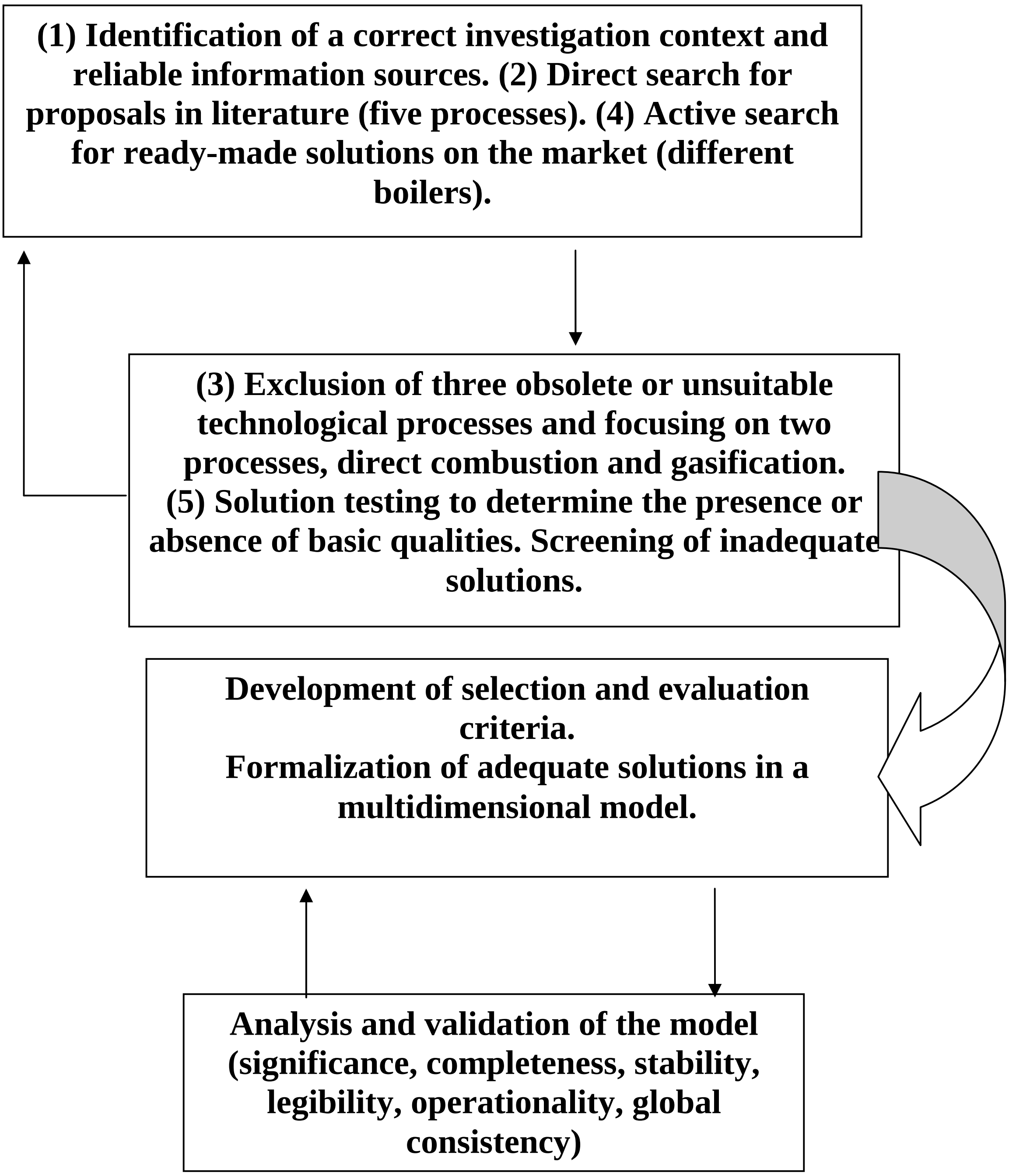

Figure 1 – An MC model as result of iterative search and screen routines

Criteria / Actions	Technological aspect		Financial aspect		
	Technol. efficiency	**Maintenance**	**Economic efficiency**	**Global cost**	**Fund allocation**
Direct combustion	**H**	**H**	**H**	**L**	**M**
Consortium and direct combustion	**H**	**H**	**M**	**L**	**M**
Gasification	**H**	**H**	**H**	**L**	**M**
Consortium and gasification	**M**	**M**	**M**	**M**	**M**
Mangling and compressing in bricks	**M**	**H**	**M**	**L**	**L**
Making waste wood into compost	**-**	**-**	**-**	**-**	**-**

Fig.2 - Multicriteria model (Low, Medium and High as qualitative assessments)

The part of the acquired knowledge, which is included in the model, does not define a consistent family of criteria for the set of six actions and this is the condition that has to be respected to apply a multicriteria method**.**

Two actions (Direct combustion and Gasification) result to be the best, as they dominate all the others, but the criteria and their evaluation states are not able to distinguish between the two alternatives, to identify the best one. The 'Consortium and direct combustion' solution is interesting, as it dominates two other solutions, but its economic efficiency is only Medium. The 'Compost' solution cannot be evaluated in the model because it was the last action to be proposed; it was new and not sufficiently documented, but above all it was too different from the others. Its 'diversity' is not 'accepted' by this model. This difficulty suggests that another action, the solution of 'Mangling and compressing in bricks', could be wrongly evaluated because this action is also different from the other four and a new, different and better model could prefer this action to the others.

The evident limitations of the model would suggest the presence of other critical elements concerning the evolving set of solutions which may not be complete yet, and would also suggest the possibility that some previously excluded actions might not be dominated by the ones that are best at present (Direct combustion and Gasification) if the evolving normative framework could guarantee a high fund allocation to them (H assessment in the last financial criterion).

Adopting a new modeling approach could solve the problem of the presence of several uncertainties in the decision context and of these doubts and limitations in the first model.

3. MC MODELING AND STRATEGIC CHOICE APPROACH

The obligatory pause in the decision process led to a revision of both the model and the modeling approach and the integration between the multicriteria approach to the problem and the main concepts that are proposed in the Strategic Choice Approach (Friend 1989) to planning under uncertainty. The activities that were developed during the first phase of this intervention were re-analyzed and it became clear that the three points of view, efficiency, maintenance and bureaucracy or administrative complexity, had been used to identify and select the solutions in relation to an *uncertainty* in the operation environment, which seemed prominent in this problem situation.

Friend identifies various sources of uncertainty – technical, political, structural – which make the decision problems difficult to resolve. Uncertainties pertaining to the working Environment (UE) can be dealt with by responses of a relatively technical nature (such as surveys, investigations or cost estimations). Those pertaining to guiding Values (UV) call for a more political response (i.e. an exercise to clarify the objectives or a program of consultations among those who are involved) while the kind of uncertainty that pertains to Related decision fields (UR) calls for a response "in the form of exploration of the structural relationships between the decision currently in view and others which appear to be interconnected". When a specific uncertainty is seen as an element that has to be analyzed before proceeding to the Decision aiding, it may be defined as a *problem dimension*, that is, a term of reference in the desegregation of the problem situation in a multi-dimensional and multilevel structure (as defined in Norese 1995 and Buffa et al. 1996). In the first phase of modeling, the investigation context and information sources were related to one single specific reading of the problem, the technological dimension of the problem, and an iterative development procedure was activated to limit the uncertainty concerning the technological environment and allow a progressively deeper investigation of the alternative technological solutions to be made.

A second problem dimension only became operative when the technological reading of the problem was sufficiently structured and a good relationship with the information sources was established (i.e. the uncertainty was reduced and under control). The possibility of obtaining financial support was then analyzed in the context of the "financial dimension of the problem", which is the expression of another decision uncertainty, this time a mixture of UE and UR because the evolution of the normative framework is not under control and has to be monitored.

This second dimension played a minor role in the modeling process, but it generated delays and interruptions that characterized this decision process. In the first modeling, this latent "financial dimension of the problem" became a *selection criterion* that eliminated any alternatives that would surely not be financially supported, and then oriented the attention toward the normative context, which needs continuous close observation, and finally toward the various risks which can be connected to the different courses of action.

Another problem dimension could be identified in the first modeling phase, the "organizational dimension", but it was not completely explored and it was only used as an implicit selection criterion to eliminate alternatives that require collective management (and then potential conflicts) and which are no more interesting than the others, in terms of technological and economic performances. The relational nature of this uncertainty is evident and the result of its presence in the modeling process could be a too radical selective action.

A new model was developed at the end of this critical analysis of the previous approach to the problem.[2] In fig.3, the Focus and the Overview windows of STRAD (the software which supports the Strategic Choice Approach implementation) synthesize *all the new acquired indications:* the Uncertainty areas that are now made explicit, the Decision areas which are in focus and allow the new alternatives to be designed as a combination of compatible options, and the Comparison areas, which are used to compare the alternatives (options or strategies) in a less formal way than in a multicriteria model, using both value judgments and clear scales of measurement and verifying the significance of each area.

The new strategies are developed by defining all the alternative options for each decision area (TECHNOLOGY, i.e. the choice of a technical process, ORGANIZATION, i.e. how the technology has to be implemented from the organizational point of view, and process FINALITY, i.e. the choice of a specific product of the technological process) and by verifying the compatibility of these options (see fig.4). The 18 strategies that resulted are synthesized as feasible decision schemes in fig.5.

The strategies can be compared from different points of view, which are related to the main uncertainties/problem dimensions and are here introduced as the Comparison areas:

- financial dimension, to evaluate the costs and income of the solutions,
- environmental dimension, to assess the global environmental impact,
- risk dimension, to estimate the complexity related to the procedural constraints, the normative framework evolution, the conflictuality risk and so on.

This new model globally proposes all the significant elements that have been acquired; it seems to be sufficiently rich and quantitative and/or qualitative evaluations can be easily elaborated in a dynamic way in relation to this specific decision context. It is a good basis for discussion to facilitate communication between the analyst and client/decision-maker, the analyst and experts and the decision maker and experts. The essential elements of an MC model can all be identified and validated, if they are not ‘well defined’, but present in the decision context, or they can evolve towards the "construction" of different, more consistent model elements, a construction which can be seen as an application point of the DA activity.

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[2] In this case the Design routine by Mintzberg et al. (1976) can be considered as a reference for this iterative procedure, which was oriented toward building a *custom made* solution brick by brick.

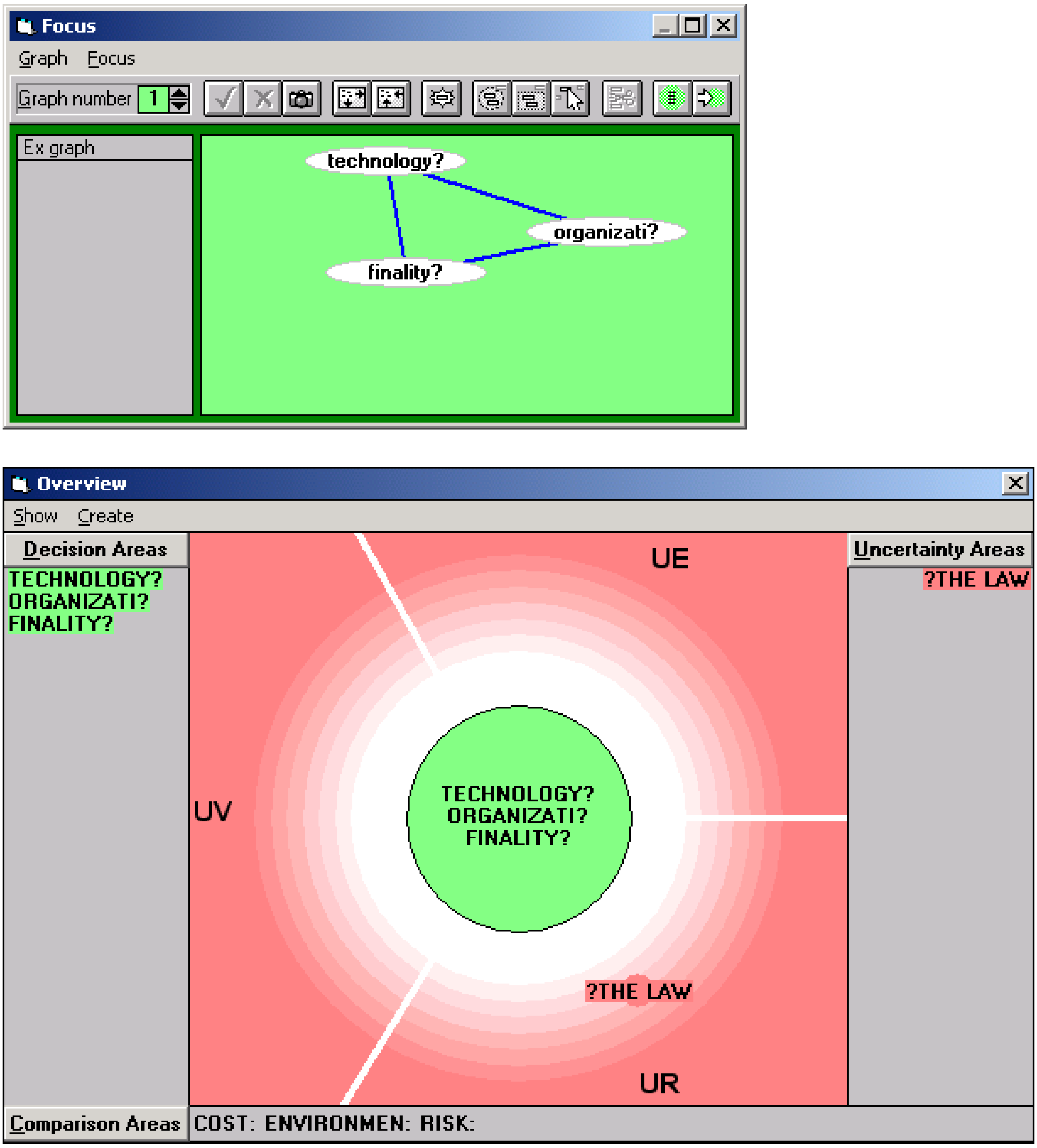

Figure 3 – Focus and Overview windows, a synthesis of the new problem reading

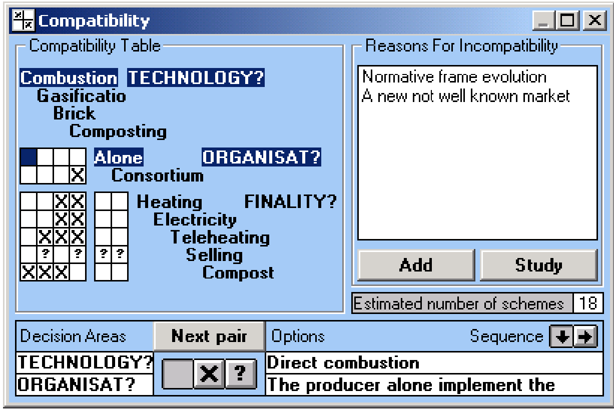

Figure 4 – Compatibility table

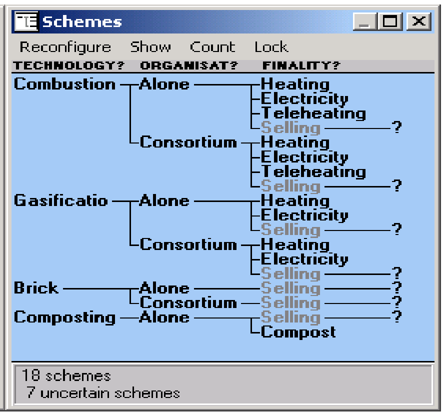

Figure 5 – Schemes of the strategies

4. CONCLUDING REMARKS

The interaction between an analyst, the context and its key actors is essential to elaborate a model. This interaction generally causes delays and a difficult technical action, above all in terms of recurring cycles of problem formulation, common language definition and modeling.
Multicriteria models developed in an MCDA process are useful to specify a problem and their modifications make the individual and collective learning processes easier and more evident. An MC language and its way of reading the problem usefully integrate with an approach to coping with complexity and helping the users to make “incremental progress towards decision by focusing their attention on alternative ways of managing uncertainties” (Friend, 1989). The results are particularly interesting in terms of conceptual and operational validity of the model and of intelligent acquisition and use of tacit organizational knowledge.

A rational use of the waste wood was easily identified mainly because this integrated approach to the problem led to a good relationship between the wood company and the actors of the process. Other effective applications of this integrated approach to problems, in different decision contexts, suggested some teaching procedures oriented to the dynamic development of problem formulation and model building and validation. The Strategic Choice Approach and the STRAD software are powerful tools to design a model of a complex problem, to structure the related MC model and to identify the strengths and limitations of both models, and to improve the problem definition and modeling until a satisfactory result is obtained.

5. REFERENCES

Boland, R.J, and Tenkasi, R.V. (1995) Perspective making and perspective taking in communities of knowing, Organization Science, 6, 4, 350-372.

Bouyssou, D. (1990) Building criteria: a prerequisite for MCDA, in C.A. Bana e Costa (Ed.), Readings in Multiple Criteria Decision Aid (pp. 58-80), Springer-Verlag, Heidelberg.

Brown J. S., Duguid P. (2001) Knowledge and Organization: a Social Practices Perspective, Organization Science, 12, 2, 205- 213.

Buffa, F., Marzano, G. and Norese, M.F. (1996) MACRAME: a modelling methodology in multiactor contexts, Decision Support System, 17, 331-344.

Eden, C. (1989) Using cognitive mapping for strategic options development and analysis (SODA), in J. Rosenhead (Ed.), Rational analysis for a problematic world: problem structuring methods for complexity, uncertainty and conflict (pp.21-42), Wiley, Chichester.

Friend, J. (1989) The strategic choice approach, in J. Rosenhead (Ed.), Rational analysis for a problematic world: problem structuring methods for complexity, uncertainty and conflict (pp.121-158), Wiley, Chichester.

Landry, M., Malouin, J.L. and Oral, M. (1983) Model validation in Operations Research, European Journal of Operational Research, 17, 207-220.

Mintzberg, H., Raisinghani, D. and Theoret, A. (1976) The structure of the unstructured decision process, Administrative Science Quarterly, 21, 246-276.

Marzano, G., Norese, M.F. and Silli, E.(1998) Information management and multicriteria methods in a context-sensitive decision aid, in P. Brézillon and V.Rajkovic (Eds.) Context-Sensitive Decision Support Systems: Supplement papers (pp.45-55), LIP6 1998/019, Paris.

Norese, M.F. (1995) MACRAME: a problem formulation and model-structuring assistant in multiactorial contexts, European Journal of Operational Research, 84, 25-34.

Norese, M.F. (1991) A multiple criteria approach to complex situations, in M.C. Jackson et al., (Eds.), Systems thinking in Europe (pp.361-369), Plenum Press, New York.

Norese, M.F. and Ostanello, A. (1989) Identification and Development of Alternatives: Introduction to the recognition of process typologies', in A.G. Lockett and G. Islei (Eds.), Improving Decision Making in Organisations (pp.112-123), Springer-Verlag, Heidelberg.

Ostanello, A. (1990) Action evaluation and action structuring: different decision aid situations reviewed through two actual cases, in C.A. Bana e Costa (Ed.), Readings in Multiple Criteria Decision Aid (pp.36-57), Springer-Verlag, Heidelberg.

Rosenhead, J.(1989) Rational analysis for a problematic world: problem structuring methods for complexity, uncertainty and conflict, Wiley, Chichester,

Roy, B. (1996) Multicriteria methodology for Decision Aiding, Kluwer, Dordrecht.

Roy, B. (1990) Decision-aid and decision-making, in C.A. Bana e Costa (Ed.), Readings in Multiple Criteria Decision Aid (pp. 17-35), Springer-Verlag, Heidelberg.

Vincke, P. (1992) Multicriteria Decision-Aid, Wiley, Chichester.

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