The potential of OTSM[1] and Classical TRIZ as a framework method for modern regional, integrated energy planning and modelling

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Abstract

The reorganization of national energy markets in many countries, the increasing energy and environmental restrictions, the further energy market uncertainties and the diverse, regional conditions makes regional energy and environmental planning tasks very complex and region-specific. Numerous methods and tools have been used and are still useful for energy planning and modeling. However, there is a need for a systematic and well structured method to deal with these challenges.

This paper presents OTSM-TRIZ as a potential method, which is intended to deal with modern challenges creating innovative solutions and supporting the whole modeling and planning processes.

The initial use of OTSM-TRIZ in a case study provides useful guidelines for the planning and modeling processes, creating not only typical solutions but also combinations of typical solutions with various innovative solutions which fit the specific regional conditions.

1. Introduction

After deregulation of energy markets in many countries, the further uncertainties of energy prices and availability of energy recourses and specific regional conditions have made the regional energy planning very complex and specific. This is one of many real tendencies, which is described by The Law of uneven development of a system parts. [1]. Today various computerized tools and methods are in use for regional energy planning. OTSM-TRIZ have been implemented here as a framework method for Regional, Integrated, Energy Planning (RIEP). This improves the level of systemic analysis, integrates other various tools in a complementary way, organizes and supports the learning process during the planning process.

In the last decades the long term strategic planning was concentrated on analytical exercises, and did not provide satisfactory results for current challenges. Therefore it had become necessary and popular to use qualitative methods like expert judgments, the logical framework approach, a learning curve, SWOT analysis, etc. and to involve various participants in the planning process in the modern situation.

Different instruments of OTSM and Classical -TRIZ have been implemented in this study to support the planning process. For instance, OTSM "Network of problems" and "Tongs"-model have been used very successfully.

The notion of Ideality in Classical TRIZ and OTSM directly links with a concept of Sustainable Development. Classical TRIZ and OTSM, however, provide a system of particular tools to improve functionality by minimum consumption of recourses and dynamic work with different levels of systems involved into planning process, in order to harmonize in time and in space all of that components as much as it is possible into the whole system. This approach corresponds to the domain of Sustainable Development: E.g. development which takes into account future needs of coming generation. OTSM-TRIZ tools can be used to "zoom in" the process in details and "zoom out" and observe a particular/solution in the context of the particular situation and arrange planning according to David R. Brower's rule: "Think globally, Act locally".

2. Regional Integrated, Interactive energy planning (RIEP[2])

RIEP is an approach to find environmentally friendly, technical reliable, institutionally sound, socially acceptable and cost–effective solutions to the best mix of energy supply and demand options for a defined region in order to support long–

[1] OTSM is Russian acronym for General Theory of Powerful Thinking. This term was proposed between 1970s and 1980s by the author of Classical TRIZ – Genrich Altshuller for the further extension of Classical TRIZ to make it more universal and efficient.

[2] RIEP – Region Integrated Energy Planning is a planning methodology developed by Atom Mirakyan since 2007 [2]

term regional sustainable development. It is an opportunity for energy planners to present complex, uncertain issues in a structured, holistic and transparent way, for interested parties to assess, understand and contribute to planning decisions [2]. RIEP is an open process with many decision makers with different interests and preferences. The steps of planning are not necessarily sequential, and often require iteration the same as in OTSM-TRIZ problem solving process (Fig. 1).

The selection and sequence of steps can vary from a situation to a situation, from the problem-goal relation, availability of recourses etc. It is the evolutionary process.

Fig. 1 shows the whole dynamics of RIEP and usage of methods and tools for a problem and goal definition, for quantitative and qualitative analysis of different options and their impacts, for multi-criteria analysis, for dealing with uncertainties and for generating strategies for sustainable development.

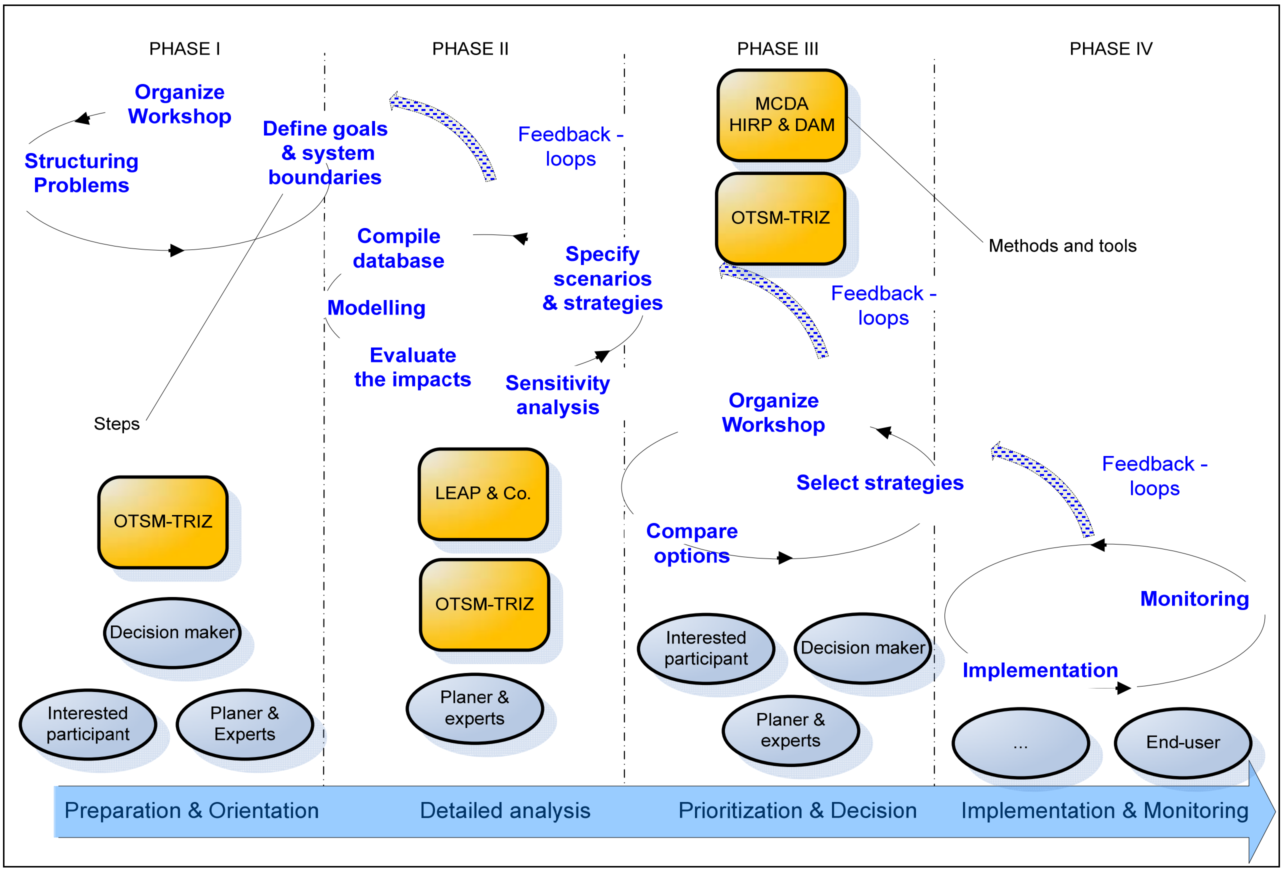

Fig 1. General overview of RIEP procedures based partially on [2]

The planning can be divided into four phases. For each stage different tools are implemented. During the first phase OTSM Network of Problems [3], [4] has been implemented for preparation and orientation. During the second phase a set of OTSM-TRIZ tools supports the model building process in LEAP (Long rang Energy Alternative Planning) tool.

During the third phase MDR (Most Desirable Result) is presented as a value tree in HIerarchical PREference analysis (HIRPE) (http://www.hipre.hut.fi/) or in Decision Analysis Modules (DAM). They are methods of Multi Criteria Decision Analysis (MCDA). The MDR is defined by OTSM-TRIZ tools as a set of evaluation/target parameters.

The last phase is very heterogenic in the planning process. The diverse tools and methods are used for implementation. It is not the focus of this research.

3. Classical TRIZ, OTSM and OTSM-TRIZ tools

3.1 The Classical TRIZ

Classical TRIZ [1], [5] is a Russian acronym for Theory on Solving Inventive Problems". It is an applied theory about developing instruments for solving non typical, so called - creative problems. "Non Typical" means a problem that top level professionals are not able solve the problem by traditional (typical) professional methods. In these cases usually people say that they need an unusual, creative solution. For many years "Trials & Errors" was and still is the main tool for solving non typical problems.

In 1946 Genrich Altshuller took the challenge and started his work on the better tool for solving non typical, creative problems. Initially the tool appeared as a relatively simple technique. Eventually this technique evolved into Algorithms named ARIZ (Russian Acronym for Algorithm of solving inventive i.e. non typical problems). ARIZ was much more powerful tool than the simple technique. However the problem solving power was increased by the author every time, new and even more complicated problems appeared. This initiated new cycle of ARIZ evolution and made possible to work with more difficult problems. In 1980s Altshuller arrived at the conclusion that TRIZ had to start a new S-curve of its evolution in order to be able to work on more complex and interdisciplinary problematic situations. He proposed a new name of this branch of Classical TRIZ – OTSM, which is a Russian acronym for General Theory of Powerful Thinking.

A lot of conclusions were done during Altshuller's research for ARIZ improvement and development of new versions of the algorithm. After generalization of those conclusions and systematization of the results and theoretical ideas G.S. Altshuller created the Theory of Solving Inventive Problems – TRIZ is a Russian acronym and appeared in the end of 70 [1]. As soon as harmonized theoretical background on solving non typical problems arose the ideology of ARIZ has been dramatically changed to develop a solution but not looking for a solution as it was before. This is the important turning point for understanding evolution of Classical TRIZ and its tools. TRIZ helps problem solver avoid a random search of a satisfactory solution, but assist to develop the appropriate solution step by step in a systemic way.

In the 80-90s years of the XX century Classical TRIZ appeared in the following structure. [5] The Key Problem to be solved by the theory was formulated by Genrich Altshuller like this: "How can someone solve non typical problem with minimum, - or even without, - useless trials and errors without degradation quality of a solution.

In order to answer the Key Problem question three assumptions were formulated as postulates of the Classical TRIZ: (1) Postulate on Existing objective laws of Engineering System evolution, it means that when we solve a particular problem and improve our system we move it to the next stage of the evolution, in turn it means that we can improve the system better if we know laws of the system evolution; (2) Postulate of Contradiction that says that the systems evolve when they faced with contradictions and resolve the conflict presented in the shape of TRIZ contradictions; (3) Postulate of a specific situation that says that problem situation should be solved on the basis of context of the each particular problematic situation. The same problem in various contexts will have different solutions than the same problem situation in the other context. This three postulates help to obtain navigation during solving process. They also give directions for the theory development: to discover objective laws of systems evolution; to develop tools to identify and resolve contradictions; to provide a user with instruments to clarify the initial problematic situation and pose a problem correctly.

On the basis of the Key Problems and postulates two main models were proposed by G.S. Altshuller [3] in order to develop tools for practical needs. The first one is a Schema of Powerful Thinking that is used for a description of problematic situation and its context. This schema is used in many other ways during problem solving process. The second model is a Model of Problem Solving Process that should underline each problem solving case and should be used in order to create and improve problem solving tools of Classical TRIZ. Both of those models are integrated to each other and are evolving in time. One of initial models of problem solving process well known as 4 boxes ("Specific Problem description"; "General description of the problem"; "General solution";; Specific solution".) is an oversimplified model that has underlined ARIZ-77 (year 1977 [6]). ARIZ 85-C (year 1985) is underlined by the advanced model of problem solving process.

Based on the theoretical background two types of problems and solving tools were created. The first group of the tools is devoted to solve problems that just seem as non typical and could be reframed as a typical after appropriate analysis (use "4 Boxes" model). The most advanced tools of this kind are a System of TRIZ standard inventive solution as G. Altshuller named it. For problems that could not be reframed as typical we should use the second group of tools, namely ARIZ-85-C that integrates all other tools of Classical TRIZ on the basis of advanced parallel model of problem solving process. This parallel model initiates OTSM.

3.2 OTSM as advancements of Classical TRIZ for solving complex interdisciplinary problems.

Tools based on Classical TRIZ were tested by many people and even used for solving non engineering problems. That is why in the middle of 70s G.Altshuller posed a new goal for Classical TRIZ evolution [7] – General Theory of a powerful Thinking as Altshuller named this new theory - OTSM [8, 9].

The Initial aim posed by G.S. Altshuller for the new theory was to enhance a domain of Classical TRIZ application. However in the 90s it was discovered that theoretical background of OTSM allowed not only use it for solving non technical problems but can help with managing complex interdisciplinary problem situation either.

Classical TRIZ solves perfectly a problematic situation that consists of dozen of sub problems or contradictions. But the application of tools of Classical TRIZ becomes difficult when the problematic situation consists of hundreds of sub problems. Theoretical background of OTSM allowed to create a tool to manage a large network of interdisciplinary sub-problems that link and influent each other. The tool named Problem Flow Networks (PFN) approach has a structure similar to ARIZ. While ARIZ works with different kind of contradictions that represent problematic situation, PFN approach operates with networks of appropriate contradictions and helps problem solvers think on problem globally, but act locally on the most important sub-problems and keep in mind all other sub-problems and entire context of the problematic situation. This feature makes it attractive as a framework for many other tools developed in various domains.

Many other advancements for tools based on Classical TRIZ are provided by the reframing Classical TRIZ into OTSM. For Instance we use OTSM ENV model for a description of problematic situation. OTSM ENV (Element Name Value) model helps a lot to integrate and increase a level of formalization for using tools of Classical TRIZ and ARIZ in particular. OTSM ENV model allows us to make domain free tools for various Knowledge processing. Above all ENV model makes possible for intellectual workers the easy integration of OTSM tools into many other instruments so as qualitative as quantitative like LEAP etc. OTSM framework provides a platform for creating unified systems of instruments in order to harmonize them for achieving appropriate goals. In our case we integrate the tools into the whole unified system instruments for energy planning in the context of new European relationships namely: de-monopolisation of market and de-centralization of power supply.

Problem Flow Networks approach is devoted to represent a problem as a system of semantic networks. The System of rules for the presented knowledge processing was borrowed from classical TRIZ and developed further. The tools based on Classical TRIZ and OTSM are deeply integrated to each other. That is why we use the name OTSM-TRIZ for tools to solve a complex interdisciplinary problematic situation. However the same as ARIZ OTSM-TRIZ tools and PFN approach in particular can be used for simple problems as well, once a user has learned it correctly. The same as ARIZ, PFN approach is a tool to develop a particular way of thinking according to Altshuller's schema of powerful thinking.

3.3 OTSM-TRIZ tools were used in the study

3.3.1 The mission for OTSM-TRIZ for RIEP

For successful energy planning two key tasks should be done by using OTSM-TRIZ:

1. Clearly identify and study the object of planning and manage solutions development with other planning tools.
2. Provide planning process efficiently in order to obtain a convention for various planning participants and support the learning process.

Above all two instruments of OTSM-TRIZ have been implemented in the study intensively: "Network of problems" and "Tongs" – model.

3.3.2 OTSM "Network of problems"

An object of planning is a fragment of our reality that we take out for energy planning purpose. This is extremely difficult because of all things are closely connected to each other in the world. OTSM "Network Problems" approach has allowed us to develop, observe and study a "Big Picture" of the problematic situation in a systematic way and develop a clear and precise system of goals for planning. As a result we can establish priorities according to the chosen system of goals and a peculiarity of the given situation. This tool is also helpful to identify how deep our study and planning process should be done. It depends mainly on the peculiarities and restrictions that should be taken into account in each particular case. For instance, the deeply we would like to go during planning process the more costly, timely and complicated will be the process of planning and the investigated object of planning.

3.3.3 OTSM "Tongs" model

"Tongs" – model is a very helpful tool to clarify problems and split some problems into a set of sub problems or a sub-net of problems. "Tongs" model contains four main components: (1) Initial problem situation description shows what Evaluation parameter makes stakeholders unhappy; (2) the Most Desirable Result (MDR) presents a goal that stakeholders would like to achieve; (3) Barriers that prevent us from achieving the goals; (4) Typical Solutions that usually help overcome the barrier but could not be used in the particular case.

Some other appropriate techniques from Altshuller's ARIZ (ARIZ-85-C) and "OTSM Axiom of Impossibility", Classical TRIZ Law of Ideality should be involved for the effective use of "Tongs" model. These techniques support the practical application of the general theoretical statements.

4. Implementation of OTSM-TRIZ

The dynamics of complementary use of OTSM-TRIZ with other planning and modeling instruments in RIEP is shown in the picture Fig. 2.

Different elements and multiple connections exist in this modular package. The small top left rectangle presents the “problem owner” area e. g. his problems, cooperation with OTSM-TRIZ experts for analyze an initial situation. At the same time the area of “problem owner” links OTSM-TRIZ with MCDA (Multi Criteria Decision Analysis) methods in order to find conceptual solution (Fig. 2).

The central big rectangle presents a domain of OTSM-TRIZ experts and it is overlapping with the domain of “problem owner”. The area of overlap shows relationships between all the elements in the areas and the link between MCDA and OTSM-TRIZ.

The acquisitions of knowledge have to be processed in detailed analysis phase II for the deep understanding of a problem situation and for generating initial solutions (Fig. 1 and 2). Here several other tools or knowledge systems can be implemented. In our case we use Long range Energy Alternatives Planning System (LEAP) to analyze the past current and future situation and to generate the initial alternative solution for future development of the region.

In the traditional energy planning there is no specific narrative or modeling tools to guide the whole planning process or to use for the preparation and orientation phase yet (Fig1). In some planning cases business management tools like SMART (Specific, Measurable, Achievable, Relevant, Time-bound) or SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis have been used [10, 11]. These methods could not be used to describe the initial situation in the way which can be directly implemented during the following phases of detail analysis (Phase 2) and can not identify the evaluation or target parameters and barriers in the way suitable for the third phase for multi criteria analysis (Fig.1.).

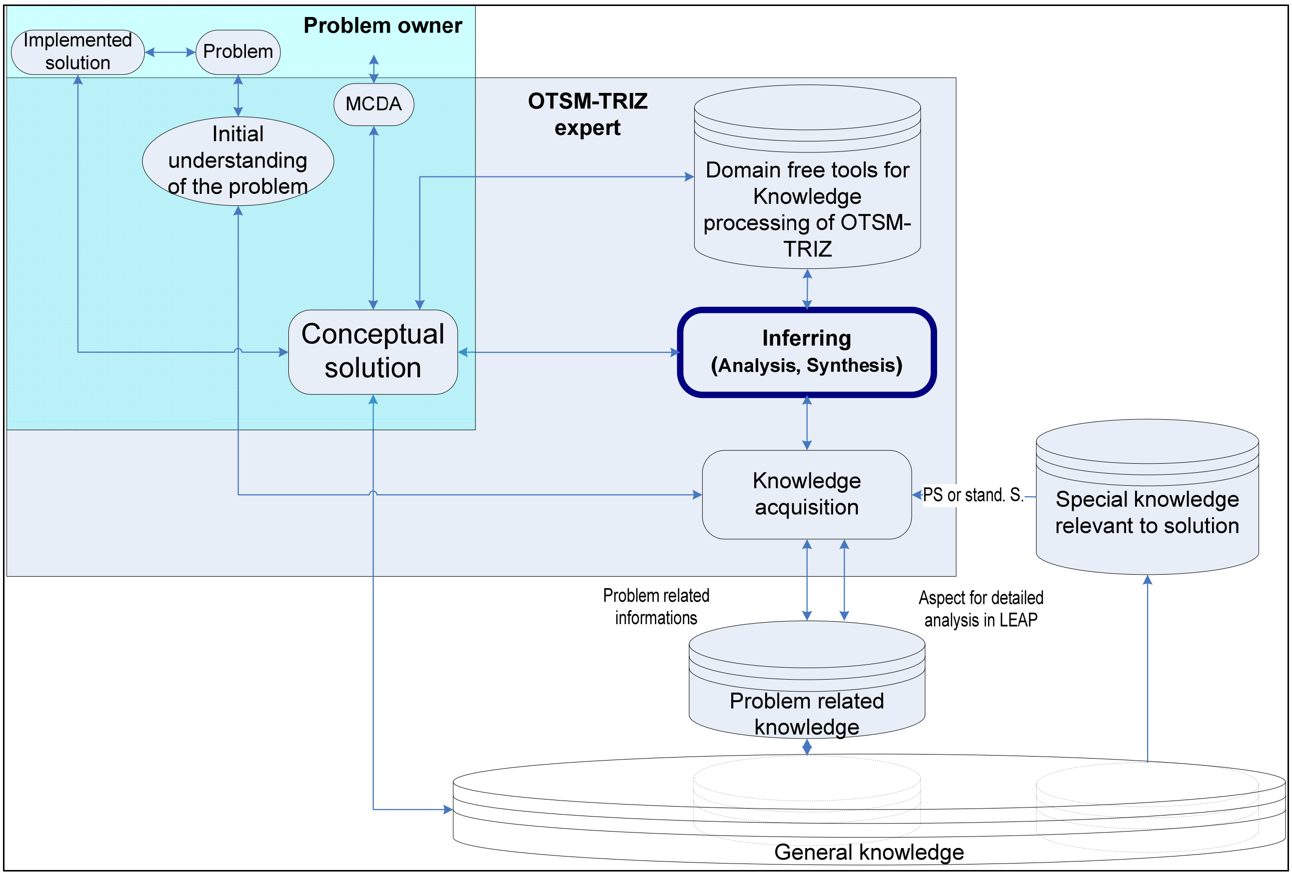

Fig 2. OTSM-TRIZ model of knowledge processing in RIEP

The identification of most important evaluation parameters, barriers etc. using “Tongs”- model and OTSM “network of problems" allowed us focus on the core of problems at the early stages of analysis and avoid unnecessary efforts e.g. collecting of data that are not necessary, consideration of aspects which are not relevant for solving the problems etc.

Following steps have been processed at the beginning of planning phase I:

- Build network of problems

- Identify Partial or standard Solutions and the Most Desirable Result (MDR)
- Identify barriers
- Generate a set of Parameters and aspects for a detailed analysis during the phase II

In our case study we have developed the network of problems to analyse the initial and historical situation and present the potential partial or standard solutions. These solutions can not be done in a “problem tree” analysis [12] where you have only a causal network of problems (where you have to find only the fundamental causes of a focal problem) without any solutions.

Some interesting partial solutions like “there is a need to involve a third party, an independent expert or the scientific institution for analysis of environmental impacts” were immediately visible from the analysis of network of problems.

When the network of problems was developed, special rules were applied for its analysis and making conclusions about a set of problems that underline the problem situation. In this specific case the problem network included a lot of problems connected to each other. OTSM “network of problems” instrument has helped to discover a set of the most relevant problems which needs to be solved for regional sustainable development that is environmental friendly, technical reliable, social acceptable and economic effective.

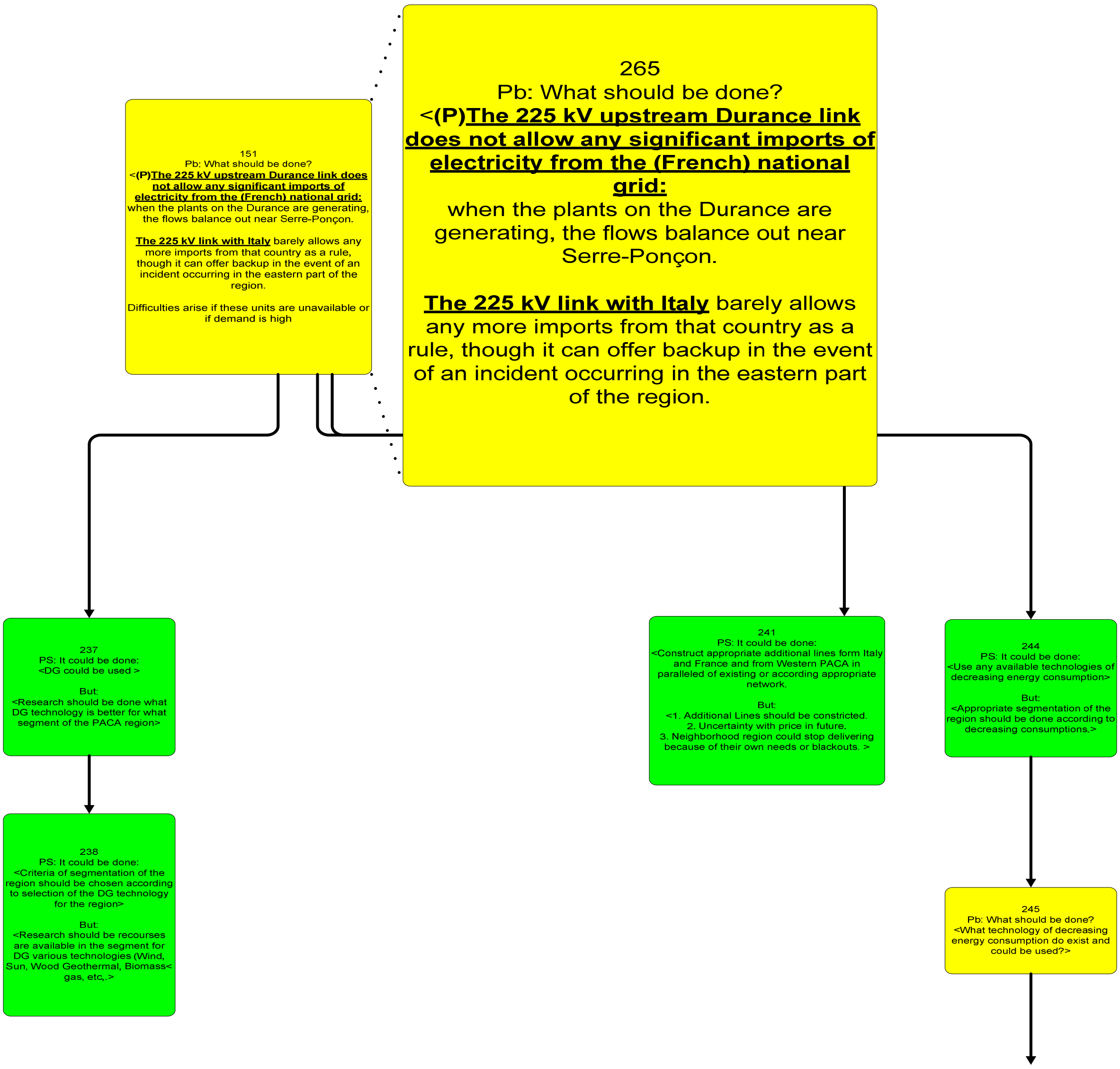

Fig 3. A fragment of network of problems and existing partial solutions

The initial evaluation or target parameters have been taken out from the OTSM network of problems (a bottom up way) and at the same time the stakeholders were asking (a top down approach) in a workshop about their Most Desirable Result (MDR) (Fig. 4).

The set of parameters will be implemented directly during the third phase as a value tree for further analysis.

The development of reference scenario with LEAP has showed the whole range of extended problems in the future. Consequently, there is a need to reformulate the network of problems and redefine the evaluation parameters again. The new "network of problems" has to be created again and a new iteration has to be done.

As a result, it has been discovered that the problems are very heterogenic. There is a need to consider several partial and standard solutions of these problems in the detailed analysis in order to develop an innovative mix of solutions during the phase III.

The barriers to implement these solutions are presented in the table 1.

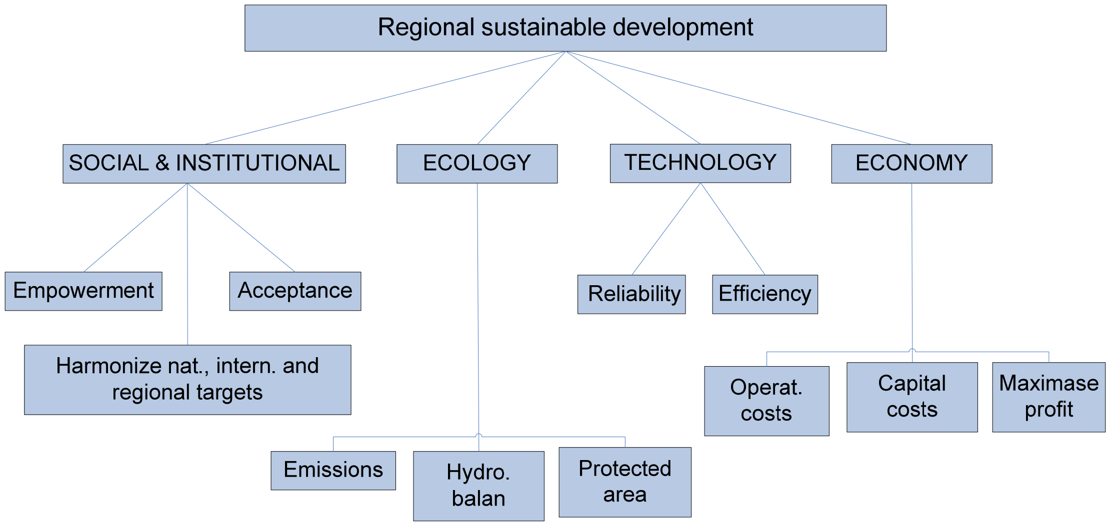

Fig 4. MDR: the set of evaluation or target parameters for a French region case study

Table 1. Initial barriers or potential conflicts of some existing or proposed standard solution

Partial or potential solutions	Technical barrier	Environmental barrier	Economic barrier	Social, institutional barrier	Schedule barrier
Increasing the use of existing hydropower production	X	X			X
Construct new thermal power plants in east PACA	X	X	X?		
Construct new transmission lines	X	X	X?	X	
Increase the installation of PV, wind or other DG			X	For wind X	X?
DSM measures, load management			X?	X	
…					

X = direct barriers, X? = potential barriers

Several defined aspects are potential barriers or conflicts and have been analyzed during the PAHSE II (Fig 1.).

After the second phase of analysis it could be a necessity to go back in order to reformulate the problems and goals and start the evaluation again. This makes OTSM-TRIZ unique. Because it supports the planning process iteratively in a dynamic way, changing and improving the network of problems, target parameters etc. evolutionarily.

Actually the modeling process begins at the very beginning of planning due to the fact that “Models generally considered as an abstract representation of something for someone and for a particular purpose…” [13]. The whole process of model building in the interactive energy planning is shown below in the Fig. 5. The mental models are subjective abstraction of reality. The partial models represent the abstraction of reality of the different disciplines or of planning participants including value systems. The master (the integrated real model) model includes the entire partial models. The future relaxation means simplifications of master model e.g. from nonlinear to linear, from dynamic to static, from a poly-system to a mono-system these artificial processes of model building are very often in a contradiction with an evolution of real system. They represent the formal model which is mostly integrated in the planning instruments. The establishment of the master model is one of the significant parts of model building process. In this model we define our research system and environment like the aggregation level of analysis (time/geographical or sectoral resolution) and making hypothesis etc. “Tongs” model of OTSM-TRIZ (which includes the problem goal relation, barriers etc.) have been implemented in many iterations taking into account available information, recourses etc in order to manage this complex task. An alternative approach for building the master model is the brunch and bound approach suggested by [14].

The quality of future planning depends strongly on the quality of master model.

If the master model is not done properly by using above all qualitative methods like OTSM – TRIZ then using any of analytical approaches in the formal model, in the planning instruments will lead to the results, which will be neither relevant nor helpful (Fig. 5).

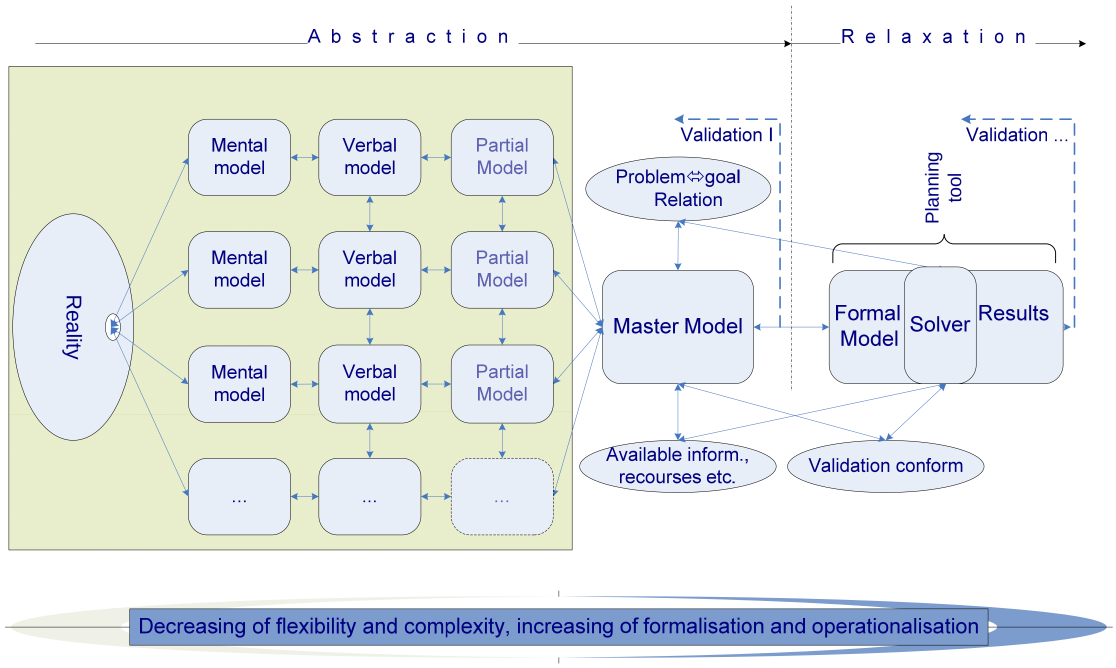

Fig 5. Model building steps in the integrated, interactive energy planning based partially on [15]

5. Complementary use of OTSM-TRIZ and MCDA methods

Multi criteria decision analysis (MCDA) methods have become very popular in the interactive energy planning in the last few decades. Numerous MCDA methods are used in the energy planning [16]. Two methods of MCDA have been implemented here. The first one is HIPRE that supports the group decision making process and allows decision maker to work independently. HIPRE reduces the disadvantages arising in the group decision making (dominancy of some participants etc.). The second one is DAM that gives an opportunity to work with imprecise, vague values fixing only upper and down values. It is also important for some qualitative parameters defined by OTSM-TRIZ.

The set of target parameters defined by the network of problems at the beginning is implemented again in HIRPE which supports a value analysis or DAM which provides the analysis under non prices information [17, 18]. Here we have very complementary combination of OTSM and MCDA methods e.g. to implement different approaches of MCDA for quantification of the evaluation parameters defined by OTSM-TRIZ and to find the best alternative crossings of all target parameters assessed by OTZM-TRIZ. The picture below shows the initial results of value tree analysis. It represents MDR set of target or evaluation parameters.

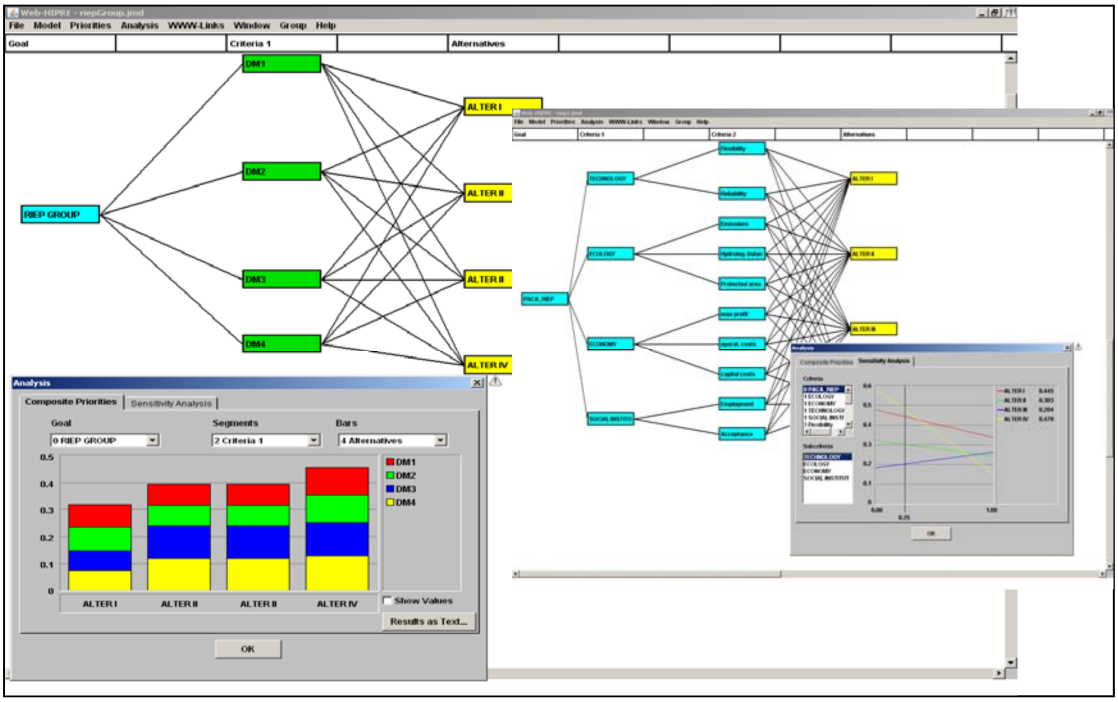

Fig 6. MDR with a set of target or evaluation parameters implemented in HIRP as a value tree for multi criteria analysis

6. Conclusion

The research project (the European region case study with very complex energy supply and demand structure) is still in progress. At the moment the final conceptual solution is not complete. However, we can make some conclusions based on the obtained experience.

The initial use of OTSM-TRIZ in a case study provides useful guidelines for the planning and modeling processes, developing not only typical solutions but an innovative mix of solutions which fit to the specific regional conditions

In the framework of RIEP approach various modeling tools and methods have been implemented complementarily with OTSM-TRIZ in the course of presented study, during different phases: LEAP, DAM and HIRP. Therefore we can say that OTSM-TRIZ tools can be considered as a basis for integration of various approaches and tools into an unified system.

Some instruments of OTSM-TRIZ namely “Network of problems” and Tongs”-model have been implemented very successfully.

“Network of problems” provides the essential analysis of initial situation taking into account all existing and potential problems, partial or standard solutions etc.

“Tongs”-model supports the establishment of MDR and the identification of barriers in the case study. It supports also the establishment of models in order to save time, resources and at the same time to create a model which can give us satisfactory output results representing the model as close as possible to the reality and at the same time not too much complex for operationalisation in the other planning instruments without over simplifying.

OTSM-TRIZ is a qualitative approach. The complementary use of OTSM-TRIZ with appropriate quantitative tools or methods provides a consistent platform for the development of long- term integrated sustainable regional energy plan.

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Presenter's Profile

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