IMPORTANCE OF ON-TIME DECISION MAKING IN ENERGY SECTOR BASED ON PERSPECTIVES
Case Study New Stavalj Project

by

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Expression "Development conditions and perspectives" became important for numerous analyses in various industrial and social areas. Several strategic documents and studies in last two decades analysed projects with topics on perspectives of future development in Serbia. Various tools are used for development of such documents, based on recent scientific and numerical solutions, thus providing reliable assessment for strategic decision making. Almost all analyses tried to implement the theories and practical experiences through the prism of "sustainable development", which included establishment of most important sustainability parameters. Analysis and ranking presented in this paper considered the potential of the Stavalj coal deposit, near city of Sjenica in Serbia, and feasibility of construction project of new mine and thermal power plant. Basis for analysis was a hybrid assessment model which takes into account principles of sustainable development. The model incorporates quantified SWOT analysis, which applies to active underground mines in Serbia. Special attention was given to the parameters describing potential for development.

Key words: *hybrid assessment model, SWOT, perspective, mining*

Introduction

The world faced numerous problems in financial and business environment during last twenty years. In view of the possibility that bad decisions cost companies vast sums of money, more attention is paid to the improvement of the decision making process and to preparing all employees for quality decision making, [1].

Financial crises are causing serious consequences to the lives of the millions, with negative impact on the economies of numerous countries. Hence, energy policies are exposed to the global challenges, including fossil fuel resources. Estimations based on current consumption level are indicating the sufficient resources until the end of the century [2]. Inappropriate management of fuel resources and energy could also have negative impact [3, 4]. It is understood that the scale of such potential problems should be monitored permanently, since effects could have influence on national level. Serbia had high expectations from one such project – *South Stream* natural gas pipeline, which was cancelled in December 2014.

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Energetics is one of the industries with most intensive investment activities. It has multiple effects on economic and business performances, complete technological base of the society and also it represents the base for overall development of any country [4, 5]. Therefore, it is clear that the focus should be on evaluation of domestic resources, in such manner to enable further development and to reduce the effect of fluctuations on global markets [6, 7].

According to [8], mining is an industry with great importance from an economic point of view, and from the aspect of protecting and preserving the environment and regional development. At the European level, mining and related industries generate about 10% of raw materials for other industries. However, mining industry is facing challenges related to globalization of markets and higher expectations regarding environmental and economic standards. Analysis of global trends in the mining industry and in Serbia resulted in the establishment of technical, technological, and financial indicators, identifying possibilities for improvement in production process and business results [9].

The methodology presented in this paper is based on balance concept (equilibrium) between internal and external aspects, having influence on performances of the mining company/project, thus enabling assessment of individual projects. This approach was selected because of the results achieved during solving similar problems [10-13].

The initial idea was to use this approach for assessment of active projects. However, for the purpose of this research, methodology was adjusted in such way to be applicable for assessments of projects in planning stage. This enabled estimation of sustainable development level of mining endeavour, according to composite indexes of interdependencies between mining and local communities. Therefore, it is possible to review missed opportunities with such projects which indicated significant potential, but never been executed [14].

Considerations in the development strategy for the Serbian energy sector

Energy mineral resources are of significant importance for Serbia. This is manifested through numerous documents related to planning in thermal power industry sector. It is a part of strategic planning for the purpose of management and reduction of uncertainty in the future. The final selection between the options in these documents is most frequently based on multi-criteria analysis methods. These methods are providing quantified selection between the set of alternatives, valorised by numerous criteria. Such methods can provide quality support for evaluation of alternatives, as well as an evaluation of final result in the decision making [15-17].

According to [5], overall dependence from energy imports into Republic of Serbia (33.5% in 2010) in relation to most European countries is not high, but it is very significant in the sectors of oil, oil products, and natural gas. Delays in construction of new thermal power generating facilities could result in higher imports of electricity into Serbia in the future. Expected re-industrialization and increase of industrial production could lead to same, but even more intense outcome. Therefore, promotion of saving and rational use of energy is recognized as national values and principles, but it is also necessary to provide sufficient reserves of oil and natural gas, to diversify directions and sources of supply and to commence construction of new thermal power generating facilities with higher efficiency based on conventional fuels and valorisation of renewable energy sources potential. Criteria for selection of new power generating facilities will enable reliable supply of electricity within the time span of the *Strategy of Energy Sector development until 2025* with lowest costs and the least impact on the environment, and also will serve as an incentive for development of other supporting industries [5].

According to [5], forecast of electricity consumption until 2025/2030 indicates increasing trend. (In reference scenario, in thousands: 2512.7 toe until 2020, 2644.4 toe until 2025, and 2799.4 toe until 2030, tab. 3.2, p. 19). Thermal power generating facilities with power of 300 MW or lower are 45 years old on average with efficiency significantly below 30%. Successive decommissioning of these facilities-blocks are planned for the period between 2018 and 2024. Average annual production of facilities-blocks planned for decommissioning is around 6000 GWh. Therefore, regardless of meteorological and hydrology condition, it is necessary to introduce new production units with higher efficiency (over 40%). In this context several different scenarios are possible for the development of the energy system and a few projects are on different level of planning and development.

Current activities on CO_2 emission reduction from the thermal power plants (TPP) are mostly related to increase of energy efficiency (better utilization of fuel), maintain operational parameters of boilers and reduction of losses in boiler plant [15]. The application of clean development mechanisms will surely follow construction of new coal and natural gas TPP with higher energy efficiency, as well as continuing activities on the revitalization and modernization of existing facilities.

The new Stavalj project

One of potential projects for construction of new generating facilities in the energy sector, mentioned in [5], is *greenfield project* or new underground coal mine and 300 MW TPP, with construction period of five years and the investment between 650 to 750 million €.

Stavalj, near Sjenica, is located in underdeveloped region in Serbian south-west. Execution of such project would contribute to the development of this region, as well as regional energy market in the Southeast Europe. The biggest development limitation for the existing Stavalj brown coal mine is its isolated geographical position and high coal transport costs to the consumers. Resources and coal reserves, as well as mining and geological conditions are favourable for mechanized mining, thus enabling high production rates. Construction of TPP in proximity of the new mine would secure a consumer for the coal. The Stavalj deposit has over 180 million tonnes of coal reserves, which is considered by the Ministry of Mining and Energy as large energy potential of national importance. Pre-feasibility study was developed for the purpose of evaluation of new underground coal mine and TPP complex during 2007/2008 [18].

According to [18, 19], the mine is designed with two sets of mechanized longwalls, for the production rate of 2.3 million tones per year of run-of-mine coal or 1.68 million tonnes of clean coal. In other words, required amount of coal is 210 tones per hour with lower calorific value of 13800 kJ/kg for the availability of 8000 hours per year. This production is sufficient for TPP of 320 MW, based on circulating fluidized bed combustion boilers and one turbine, with emissions of CO_2 at the same level as power plants operated by the Electric Power Industry of Serbia. It is estimated that full production rate of the mine can be achieved within three years (36 months), while the period for construction of TPP, including engineering, is estimated at 40 months. Since the New Stavalj project is dependent on construction of a new coal mine and TPP, it will be subject of analysis through model of condition evaluation and perspectives of mining in Serbia based on data from [18].

The hybrid assessment model (HAM)

Unlike other methods for analytical assessment, starting concept for definition of model for condition assessment is based on balance concept (equilibrium). This includes establishment

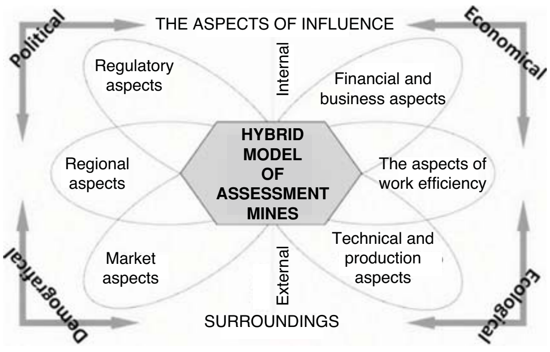

Figure 1. Influencing aspects for evaluation of mines

of influencing aspects and overall relative importance of the groups attributes, relying on internal and external factors which could have an impact on performances, fig. 1 [20, 21].

This leads to the conclusion that forecasting process can not be only mathematically modelled and computerized. Pragmatic solution to this problem can be found in hybrid approach, combining expert knowledge and logistical support offered by mathematical and information techniques [20, 22]. Application of techniques for balancing influencing aspects for evaluation of condition and perspectives enables proper evaluation of internal and external factors impact onto mining activities.

The selection of objects for consideration is surely dependent on a set of relevant information, available at the moment of analysis. The same approach was used for analyses of mining regions [23, 24]. Their importance is established with existing access roads, settlements, power supply grid, road infrastructure, favourable hydrography, *etc*., thus reducing the requirements for construction of new infrastructure, availability of trained personnel in the area, even considering possibility that most of the workers will demand additional training for operating modern mining equipment [21].

Mines included in the analysis are spread across Serbia, and are different by demographics, type of resource, mining methods, production rates, number of employees, level of mechanized processes, conditions and risks, financial results, markets, and many other parameters [14, 25]. Hybrid model by itself is characterized by identification of performance indicators which are enabling monitoring of continuous changes both in relation to specific mining company/project and its surroundings.

Three groups of performance indicators are used for the purpose of establishment of plan/project quality and regulatory framework of the sector, [26]. These are:

– indicators at national level, are including macro economic factors impacting on project quality during the initial stage and these indicators are the beyond influence by changes of policies or procedures at the level of a sector or project,
– indicators at sector level, are including factors in sector surrounding, typical for specific country, and
– indicators at the level of project or company, these are used for measuring specific risks related to project success.

Analysis of composite indexes of mines and mining regions in Serbia included: 36 indicators in analysis of interdependence of mines and mining regions/municipalities and 23 indicators in the analysis of the condition and perspectives of mines/projects.

Key factors for analysis of internal assessment are mainly related to geological potential, technical capabilities of mine, work efficiency, investment potential, and future development. Key factors for analysis of external assessment are mainly related to the political environment, regional development and geographic location, tab. 1.

Upon selection of factors and definition of indicators which are encompassing all analysed criteria for comparison, next activity for making quality evaluation and forecasting requires involvement of several experts. Scale is appropriate mean value of quantifications of quality parameters (such as ranking from 1 to 5). It is also possible to form standard fuzzy set of linguistic phrases which can be quantified on a given scale. The fuzzification is used to take into consideration some vagueness, used in expressing linguistic variables for the purpose of more objective quantification of quality criteria. Decision matrix became quantified by each criteria and it is called balanced decision matrix.

Table 1. Selected influencing factors and performance indicators of importance in the model

	Factors	Type of data	Performance indicators
Internal	Mineral resources and conditions for mining activities*	Quantified	Composite index of regional dependence
	Level of deposit exploration	Quantified	Level of deposit exploration
	Production system and production trend	Quality	Reserves Geological conditions Operational conditions Trends of operations Environmental protection and safety
	Utilization of constructed capacities	Quantified	Level of planned utilization
	Diversification and quality of product	Quality	Diversification and quality of product
	Designed life of mine	Quantified	Life of mine
	Quality of management	Quantified	Indexes of the engaged workers
	Quality of employees	Quantified	
	Productivity	Quantified	
	Investment potential	Quality	Potential for introduction of mechanics Possible production rates Potential for investment
	Financial strength	Quantified	Zeta Altman test
	Commercial benefit	Quantified	Internal rate of return/dividend rate (CAP Model)
External	Political risk**	Quantified	Composite index of country's risk
	Economic risk **	Quantified	
	Business risk **	Quantified	
	Economic development of local community*	Quantified	Composite index of regional dependence
	Social development of local community*	Quantified	
	Environmental protection*	Quantified	
	Level of high education*	Quantified	
	Demand for mineral produced (local and/or global)	Quality	Expert evaluation
	Competitiveness and stability of prices on market	Quality	
	Suitable transport infrastructure	Quality	
	Industrial connections	Quality	

* These factors are represented by composite indexes obtained by analysis of regional aspects [14, 20, 21].
** These factors are represented by indexes obtained from Agency which evaluates country risk BMI [27].

Analysis of the system is based on interpretation of the equation on systems condition. Condition equation of k^{th} analysed object can be written in a form of non-linear equation:

$$w_k = f_k\left(x_{I1}, x_{I2}, \ldots, x_{IN}, x_{E1}, x_{E2}, \ldots, x_{EM}\right),\ k = 1, \ldots, L \tag{1}$$

where $x_{I1}, x_{I2}, \ldots, x_{IN}$, $x_{E1}, x_{E2}, \ldots, x_{EM}$, are internal ($I$) and external ($E$) performance indicators and L is the total number of observed objects. The value of these indicators can be numbers (quantified indicators) or linguistic (quality indicators), which are used for condition evaluation in the absence of accurately determined numeric value of condition indicators. Also, these indicators must not be interdependent.

Quantified indicators are numerical assessment of main condition indicators. Frequently these values can not be accurately determined (this is the reason for assessment of indicators which can not be accurately determined). Final condition assessment in multi-criteria analysis is based on large number of criteria (attributes) and composite indexes. Conflict between some of criteria is expected, which is typical in any real technical problem. Solving of such issues basically can be multi parameter problem, *i. e.* multi-criteria assessment, as it is presented in case study [14].

The problem has L alternatives (mine/project), which are associated with N + M criteria. Best alternative a* is selected from the finite set of alternatives, *i. e.* in the form of a matrix:

$$w = A_I \cdot x_I + A_E \cdot x_E \tag{2}$$

The HAM performs normalization of indicator values, meaning that their values are reduced to the interval from 0 to 1. Therefore, if we use standard set of expressions and appropriate quantification scale for a single quality criterion, and another set for second quality criterion which differs by the number of elements in the set and scale span, there is a possibility not to establish a proper relation between those criteria. This is the reason for determination of unique method for quantification of quality indicators.

The suggested method for indicator normalization, applied both to internal and external performance indicators, is described.

(1) Normalization by the criterion of benefit (more is better):

$$\bar{a}_{ij} = \frac{a_{ij}}{\max\limits_{j} a_{ij}}, \quad \forall j \tag{3}$$

In case that normalization criterion is in the complete range from 0 to 1, this can be written:

$$\bar{a}_{ij} = 1 - \frac{\max\limits_{j} a_{ij} - a_{ij}}{\max\limits_{j} a_{ij} - \min\limits_{j} a_{ij}}, \quad \forall j \tag{4}$$

(2) Normalization by criterion of costs (lesser is better):

$$\bar{a}_{ij} = \frac{\min\limits_{j} a_{ij}}{a_{ij}}, \quad \forall j \tag{5}$$

In case that normalization criterion is in the complete range from 0 to 1, this can be written:

$$\bar{a}_{ij} = \frac{\max\limits_{j} a_{ij} - a_{ij}}{\max\limits_{j} a_{ij} - \min\limits_{j} a_{ij}}, \quad \forall j \tag{6}$$

(3) Normalization by the criterion of the average value (closer to average is better):

$$\overline{a}_{ij} = \frac{\min\left\{a_{ij}, a_0\right\}}{\max\left\{a_{ij}, a_0\right\}} \tag{7}$$

Identification of external and internal factors and their systematization into opportunities and threats, *i. e.* strengths and weaknesses, enables the SWOT analysis which is a tool for strategic planning based on analysis of internal strengths and weaknesses of the mine with external opportunities and threats. In this way SWOT analysis combines assessment of internal factors with those coming from external sources on the market, in business and regional environment, out of control of analysed subject. The SWOT analysis is the key process used in the analysis of the situation. Analysed subject, should activate strengths, overcome weaknesses, use opportunities, and defend itself from threats. This is one of the most important segments of the whole planning process, where SWOT analysis enables interested parties to review whether the mine/project would use potentials and what obstacles will be present [14].

The combination of principal component analysis, analysis of variance and analysis of covariance, fuzzy logic, and balanced scorecard are providing objective weighting and execution of complicated simultaneous comparison of several objects-projects/mines/municipalities (regions), even countries with SWOT analysis.

Quantified SWOT is used for improvement of mentioned methods and their development according to decision matrix. Analysed objects are placed in four quadrants according to the co-ordinates suitable to their categories. The rule is to place the external indicators on vertical (Y) axis (possibilities-threats) and internal indicators on horizontal (X) axis (opportunities-weaknesses). A similar procedure is accepted for assessment of country risk, which has direct impact on credit rating and therefore on interest rates and the level of the required internal rate of return of the project [27, 28]. Beside this, analysis of results, together with the determination of the importance of mining for development of local communities, indicates that mines to larger extent are representing initiator of business activities and important employer [14, 21, 25].

Results and discussion

The time period of the analysis of mines, mining regions, and governmental reform begin at 2007, while perspectives were estimated for +5 years. Results of quantified SWOT analysis are showing condition of the underground mines in Serbia, where the position of each mine in relation to other mines is very clear. Condition analysis and perspectives, *i. e.* opportunities for change of performances (positive or negative) could aid in selecting development strategy.

The HAM was used for calculating rank of 12 active mines, together with project of the new Stavalj. Project, mines and mining regions are ranked according to selected performance indicators, which are represented through composite index and the capability of comparative evaluation of projects and mines. All these indexes, including HAM, are presenting mines and potential projects through the necessity of establishing of strategic decisions at national and local level, including those decisions made by investors [14]. Review of the results of the mine conditions through fuzzy assessment, tab. 2, SWOT and benchmarking analyses is providing a rank of the mines, according to specific criteria in relation to consolidation line, *i. e.* minimal number of *positive scores* which are indicating business success for a considered mine.

Perspective analysis is using performance indicators for information about the mine potential quality and the possibility for its placement on the market. Indicators are important since they are showing a degree of goals achievement (success or failure, good or bad plan). Most dominant role in change potential is related to indicators related to better utilization of capacities, productivity, and longer operational life. Among important indicators are economic and financial indicators, as well as indicators related to political and business environment and markets.

Table 2. Fuzzy assessment of mines perspectives

+5	Performance assessment of the mines potential						
	Mine	Very strong	Strong	Intermediate	Weak	Very weak	
M1	Soko	0.181	0.179	0.133	0.282	0.224	
M2	Rembas	0.148	0.183	0.179	0.174	0.316	
M3	Stavalj	0.127	0.147	0.109	0.165	0.452	
M4	Lubnica	0.143	0.217	0.157	0.229	0.254	
M5	Jasenovac	0.090	0.109	0.170	0.286	0.345	
M6	Ibarski mines	0.116	0.141	0.140	0.129	0.474	
M7	Bogovina	0.063	0.144	0.039	0.232	0.523	
M8	Bor mine	0.164	0.267	0.136	0.232	0.201	
M9	Rudnik	0.288	0.387	0.036	0.086	0.203	
M10	Grot	0.171	0.288	0.157	0.118	0.265	
M11	Lece	0.112	0.385	0.102	0.138	0.263	
M12	Veliki Majdan	0.016	0.301	0.282	0.112	0.290	
D1	New Stavalj	0.561	0.137	0.080	0.146	0.076	
Results							
	Mine	Fuzzy assessment of logic matrix					Performance assessment
M1	Soko	--	True	--	--	--	Strong
M2	Rembas	--	--	True	--	--	Intermediate
M3	Stavalj	--	--	--	True	--	Weak
M4	Lubnica	--	True	--	--	--	Strong
M5	Jasenovac	--	--	--	True	--	Weak
M6	Ibarski mines	--	--	--	True	--	Weak
M7	Bogovina	--	--	--	--	True	Very weak
M8	Bor mine	--	True	--	--	--	Strong
M9	Rudnik	--	True	--	--	--	Strong
M10	Grot	--	True	--	--	--	Strong
M11	Lece	--	True	--	--	--	Strong
M12	Veliki Majdan	--	--	True	--	--	Intermediate
D1	New Stavalj	True	--	--	--	--	Very strong

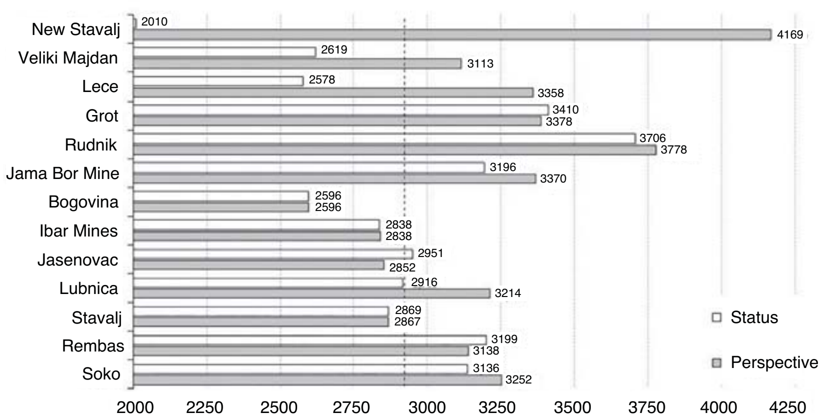

Figure 2. Final assessment ranking of status and perspective of mines by HAM

Comparison of these results, in the same way as it is done during condition analysis by using fuzzy assessment and SWOT vectors, benchmarking and establishment of the profitability threshold value, tab. 3, is providing condition and perspectives of mines in relation to success of plan/project, fig. 2.

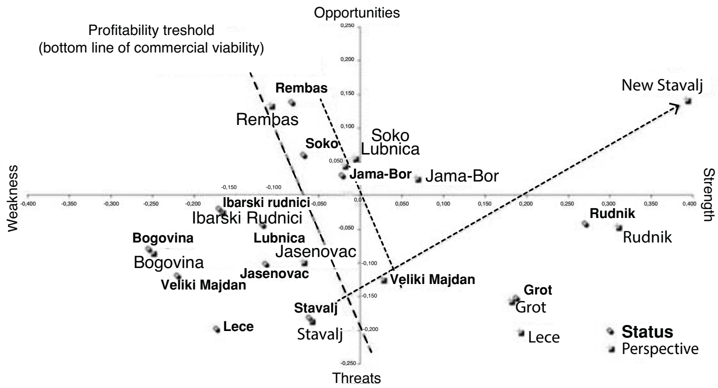

Figure 3. Quantified SWOT analysis of status and perspectives of mines

Co-ordinates of condition and perspectives are synchronized, meaning that perspective co-ordinates are translated in such way that phase shift of mines position from condition into perspective are shown on the same graph. The purpose of this is to clearly present positions of mines obtained by the quantified SWOT analysis together with conditions and perspectives on the same graph. The profitability threshold line representing the lower boundary of commercial viability of the mine is also shown on the graph, fig. 3.

Shifts are noticeable for those mines with potential for modernization, and with existing comparative advantages and internal strengths to counteract own weaknesses.

This research is focused on the position of the Stavalj coal mine and its replacement capacity the New Stavalj mine, as a perspective for future development. As already concluded, base for sustainability is the change in market structure, which in this case is mainly related to large consumer.

Table 3. Assessment of mines perspectives

Mines			Assessment of mines performance +5 years			
	Name	Minerals	Swot vector		Fuzzy	
			Bench	Assessment	Bench	Assessment
1	Soko	Coal	3183	Business success	3252	Business success
2	Rembas	Coal	3125	Business success	3138	Business success
3	Stavalj	Coal	2666	Failure	2869	Failure
4	Lubnica	Coal	3138	Business success	3214	Business success
5	Jasenovac	Coal	2675	Failure	2852	Failure
6	Ibar mines	Coal	2712	Failure	2839	Failure
7	Bogovina	Coal	2434	Failure	2596	Failure
8	Jama Bor mine	Copper	3306	Business success	3370	Business success
9	Rudnik	Lead-Zink	3819	Business success	3778	Business success
10	Grot	Lead-Zink	3328	Business success	3387	Business success
11	Lece	Lead-Zink	3306	Business success	3358	Business success
12	Veliki Majdan	Lead-Zink	2973	Business success	3113	Business success
13	New Stavalj	Coal	4296	Business success	4169	Business success
			Profitability threshold = 2918			

A further operation of existing Stavalj mine, according to the results of HAM, retains a weak rank in productivity, financial strength and commercial viability, despite high rank for utilization of existing capacities and life of the mine. Assessment of perspective of this mine will not be changed in relation to starting position and what is destiny of most active underground coal mines.

Conclusions

Review of the subject period of *Development Strategy for Serbian Energy Sector* clearly indicates that construction of new power generating facility in Serbia will continue to be based on conventional fuels, but with significantly higher energy efficiency, together with valorisation of renewable energy sources potential.

One of the important issues will be which criteria to use for decision on selection of new facilities/projects. Such decisions are usually highly complex, due to their dependence on numerous factors. Uncertainty is caused by fact that decision makers are not provided with sufficient information or analyses.

One of the possible solutions is use of a HAM, which is described in this paper on an example of project for construction of mine and TPP Stavalj. The HAM provides complete quality analysis in function of possible risks influencing analysed object. It is necessary to select most favourable solution which encompasses a myriad of natural, regional, technical, economic, market, ecological, demographic, and political aspects. Security risks and protection of critical infrastructure was not included into the analysis [28].

According to the results of HAM analysis it is noticed that there are investment opportunities for sustainable operation of some analysed active mines. Case study the New Stavalj project is best ranked alternative among all of the analysed objects. Analysis of local communities identifies the connection between the coal mine and TPP, which can be expected in case of execution of this project.

The New Stavalj project was not commenced until today. Having in mind that the conditions for its realization were created during 2008, it can be comprehended that this facility could be operational today at its full capacity. This project completely fits to targets and dynamics defined by [5], although almost 10 years passed since it was developed.

Finally, it should not be neglected that missed opportunities are not creating new ones. Failure to commence this project on-time is cancelling benefits, caused by delay, from electricity supplier in Serbia based on conventional fuel.

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