Generation expansion planning in the open electricity market

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Abstract- - **Deregulation of the electricity industry puts important changes on generation expansion planning philosophy. Changes are visible in methodology, modeling and in responsibilities in the planning process.**

Traditional approach in planning was driven by the least cost objective. Before market opening, one was not worried by investment risk. The "market" was without risk because all consumers were captive. In an open market, investment risk is a key element. An electricity company is not limited by country border

Interaction between market parties (generators, traders, customers, government, regulatory body and system operator), their responsibilities and influence on generation expansion planning were analyzed.

This work proposes a new approach for generation expansion planning suitable for an open market environment. Pragmatic solution is a combination of existing models and new models designed for short-term market analysis and risk assessment. Existing models lack market and financial analysis, while new models lack long-term dimension needed for analysis of a power plant life time operation. Possible and suitable solution for generation expansion planning in open electricity market is interaction of existing (traditional) and new (market oriented) models.

Index Terms— deregulation, open electricity market, generation expansion planning, least cost, models, power system, risks, vertically integrated company

I. INTRODUCTION

Adequate supply with electric energy is a prerequisite for economic development and social well-being.

The planning of power plant construction brings a certain amount of anxiety with it. The analysis of realization of any long-term plan done in the past reveals that none were realized in complete. The differences were sometimes greater and sometimes lesser but they always appeared. This sort of experience is without exception characteristic of developed countries but also of undeveloped ones and those still developing. Different kinds of political systems (socialism, capitalism) are also not immune to this as well as ownership types (state, private) and planning methods (centralized, decentralized). The longer the time-period of planning, the greater the anxiety related to the planning process. That anxiety is the result of presuppositions with which one begins the process of planning.

Certain parameters are often used for input variables that are used in electricity demand forecast but their realization is often just as uncertain as the realization of the electricity demand itself. Of course, that does not mean that we should stop planning. However, it is very important to find the methods of planning which would reduce these uncertainties as much as possible.

Planning should be a continuous process which would result every year in one target plan. For that reason, analytics and planners prepare more elaborate variables from which the most realistic ones are extracted to be the basis of decision-making.

What is extremely important in the process of planning is the visualization of the intended goals. Those goals should be as more measurable as possible which means that after choosing one among many plans available you can monitor its realization and the divergences.

II. IMPORTANCE OF ENERGY POLICY ON THE STATE LEVEL

The best way to achieve quality development of the economic sector is an energy policy that combines strategy and a form of its implementation.

The regulatory function of the state in the execution of the energy policy is realized in various ways in different countries; through planning, monitoring, stimulating, mediating and coercion. For that reason, special administrative mechanisms are formed through which the state, in a certain way and in certain circumstances, conducts the energy policy and influences different energy sectors.

The point of having an energy policy is to create optimal conditions for its functioning and development in order to secure enough energy for the country at a reasonable price, to make the costs of the production such that they would represent competition on the world trade market and to cause less damage to the environment and the human health.

In the process of drafting the energy policy various energy sources are compared as well as their parameters, such as price, availability, external dependency and other important factors. The goal is to create a balance between supply and demand, reliable supply and an unimpeded development of the economy and the society in general. When doing so, all connections and mutual effects between the energy industry and economy should be analyzed.

The energy policy of a country is brought to life through a set of actions of judicial, executive and control nature which are realized with the help of many economic means such as taxes, incentives and loans given on a local and national level. All that serves to reconcile the development of the energetic sector with the interests of the national economy and the society in general.

Different stages in the development of the economy, and within that of energy sector are followed with different levels of state influence and diverse methods in the realization of state policy.

III. EXPANSION PLANNING IN DEREGULATED ENVIRONMENT

When it comes to centralized planning of the power system development, in monopoly conditions, the main goal was to secure sufficient amounts of electric energy, with the supply being as secure as possible. Although it could be said, as many claim today, that economy was not taken into account, it was not particularly important like it is in market conditions.

By opening up the market new subjects emerge in the power system. Those are the regulator, the operator of the system, the operator of the market, tradesmen and independent producers of electric energy. Speaking of planning, the interests of all these different subjects is diverse.

The relevant national authorities have the function of the regulator. The national interest is a stable market of electric energy. The system and the market operators have to treat all parties on the market equally. The common goal of the regulator and the system and the market operators needs to be a safe and reliable drive of the whole system. On the other hand, the work that these organs perform has to be independent and neutral in the way that none of the parties competing for production or supply should be favored or discriminated.

In conditions of open market, electric energy producers direct their work and business activities on achieving maximum profit by doing everything that is allowed to be done. On the market, every subject has their motive and that is maximum revenue and maximum profit. It is unimportant for each party whether that will also include minimal overall cost. Every participant faces the strategies of other parties and with uncertainty resulting from not knowing the exact situation of other parties (prisoners dilemma) [1]. The cost and the savings are no longer the only factor to discuss. Managing the risk is also relevant. Appropriate factors for risk evaluation should also be included in all planning methods. The goal is to satisfy the needs with a minimal risk.

Considering the mentioned difference in goals and planning, the planning methods should also stress different aspects when comparing planning in monopoly conditions with those of the open market. It is necessary to find the possibility of using pre-existing models of planning the power system development which would be adapted to new conditions or combined with new models.

When speaking about power system development in this context, it refers primarily to the development of production capacities in the system. But the role of transmission network and the construction of the transmission network should not be ignored considering the importance that the transmission network has in the electric energy market. Planning and expansion of the transmission network is one of the most important issues in the market development [2]. On the open market the construction of the production capacities is more or less in the hands of private producers. In most countries transmission network is still controlled by an independent regulator so it is to be expected that the planning of its development will stay controlled by the regulator in the future as well but in accordance with completely known, clear and publicly available criteria. The transmission network routes are dictated by the location of the power plants and the consumer areas but it also goes the other way around, that is, the transmission network can determine the optimal position for building a power plant.

Planning to build production capacities when private capital is the main drive of the project has a completely different logic behind it compared with social or state capital. The main motive is to gain the money invested as soon as possible and making profits in the process. In order to do that, the market is what needs to be planned. It is necessary to analyze and study the market fluctuations and patterns. The electric energy market is a lot like any other market but it has certain particularities due to the nature of electric energy, that is, the need for constant balance between production and consumption. That balance is just as important short-term (daily, weekly, monthly…work) as it is long-term (planning of building generation and transmission capacity).

Through the long-term planning investments in generation and transmission capacity should be ensured in order to satisfy the needs for electricity consumption in the system and to secure the supply for the buyers. Besides finding a model (tool) for planning it is also necessary to find the ways to realize the plans. That is one of the key problems of planning in market conditions.

A. What Should be Changed in the Planning Methodology

In the open market circumstance where each buyer can buy energy outside the boundaries of his own country, arises the problem of long term control of the balance between generation and demand on the territory of each country. In the cases where only a small number of buyers, with greater consumption, is buying energy from some other power system it is possible to somehow control the electro-energetic balance. However, it is very difficult to do that in the case of a completely open market.

In traditional vertically organized monopolies for production, transfer and delivery of electric energy on national level, state firms dealing with electric power industry had a task and a responsibility in planning the construction of the plant of the system. The issue of central planning whose part is also monitoring the electricity balance is hardly recognized in the new market conditions.

This problem of control can be observed as a problem in real time – current production and consumption balance or as a problem in the planning – the balance in a longer period of time. The key problem is no longer how to predict overall consumption. It is still being predicted by using classical procedure of analyzing the energetic needs of particular sectors of each country. The problem is to predict how much energy will be produced by the observed company, independent manufacturer, small power plant or how much energy will be imported from or exported to other systems. Rounding off of the electricity balance is a long-term problem. By predicting the needs for additional and alternative capacities are established and they need to be put into function. Due to the forecasting of the consumption and the rounding off of the electricity balance, an 'spillover' of production and consumption outside of the country occurs. That means that the connections and the possibility of trading with neighboring systems are observed.

There are already several 'regional' markets of electric energy in Europe. For this analysis the most interesting one is that of South East Europe (SEE) based on The Athens Forum and The Energy Community Treaty. There is possibility of future merging of markets into one huge market. Its size will be limited by physical and economic parameters; the possibility of a portable network, the cost effectiveness of paying indemnity for transfer to a larger number of operators and so on. The regional market (SEE) can be seen as a 'state' in which it is necessary to round off the electricity balance. Although there will be an exchange of energy outside the region, the share in the overall expenditure of the region will be relatively small. This is important for the current and the long-term stability of the market. The interest for knowing the size of the market (electro-energetic balance) is of interest to all of the participants in it because, without a market there is no trade and consequently no profit.

B. The Role of Least-Cost Criterion

Almost all of the traditional methods of planning of the development of the system so far have been based on least cost principle [3]. The goal function is minimum total costs (operating + investment) in the power system during entire planning period. Investment plan for power plant and transmission network, as result of the least cost principle, was almost obligatory for the state owned utility. The obligation for the following of investment plant finished by appearing an new such type of plan. That procedure have been repeated for example in five years.

After unbundling of electric power utilities, particularly after the open electricity market introduction and privatization, some new criterions for planning becoming more important. The investors consider profit and risk related with achieving this profit as the most important things.

There are some ideas that least cost criterion will not be longer relevant in the planning process. An attempt for setting opposite these is following. Fig. 1 is showing a very simple presentation of the power system. On the left side is generation part of the power system (different types of existing and future plants) expressed by specific cost P_1. In the middle is network (transmission and distribution) expressed by specific price P_2. On the right side is demand expressed by specific price P, what means market price. In this analysis demand is as parameter, is not defined by type of plants or by network tariff. I the other words level of the electricity demand is not under control of generating or network companies. It is more result of many others impacts as economic development (GDP), population growth rate and so on. It means that electricity demand is like exogenous variable.

Market price of electricity is defined by market condition. Any type of plant will have the same price for the same product. In other words, it means that even hydro plant, coal fired plant, gas fired plant or nuclear plant will get equal price per 1 kWh if it is delivered in the same time. Only exception could be so called green electricity (wind, small hydro, solar, geothermal, ..) which can (for now only by limited number of consumers) get higher price. But, this type of electricity is not exposed to the open market conditions., rather it is under special regime. These types of plants have „must run unit“ status. In the most EU countries such type of plants have position of eligible generators. Complete their generation must be accepted with guaranteed price (feed-in-tariff). The share of this type of energy still is not significant and no longer will be. But this is also future problem when share of the part of the market with privileged position is growing. It makes additional trouble for the plants under competition [4].

So, market price depends mostly on competition. Consumers, as buyers of electricity don't see and also are not interested (at least in economical term) which type of plant electricity come from. As market participants, consumers are interested only in price of electricity and security of supply. If we consider above mentioned assumptions, than the revenue for the sold electricity for some generator is defined by market conditions, or in other words it doesn't depend on structure of generating portfolio (hydro, gas, coal, nuclear). Tariff for the network is under control of regulator, what means generators couldn't impact on it. What remain for generators in that case. If they would like to have good profit, big effort should be direct to the cost minimization. In this segment generators have the biggest potential for acting. Finally, with minimum costs (operating and investment) generators, on defined market, could have the highest profit.

From this could be concluded that even in open electricity market for the generation expansion planning the least cost criterion will be very important. Of course, in the open electricity market will be necessary consider wider area than in monopoly conditions. Now, complete market area (whole region) should be consider, instead of only one country as it was in monopoly conditions.

If we look for example Bosnia and Herzegovina, in that case potential market should be all neighboring countries and even more (darker area on Fig. 2). It means Italy, Swiss, Austria, Slovenia and Croatia on the west, Check Republic, Slovak Republic and Hungary on the north, Serbia, Romania, Bulgaria, Ukraine and Moldova on the east, and finally Montenegro, Kosovo, Albania and Greece on the south. Transmission interconnection between countries also should be considered.

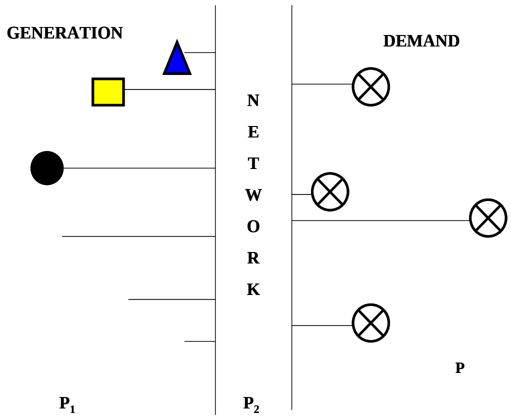

Figure 1. Simple scheme of the power system

Figure 2. Regional electricity market

For the generation expansion plan in Bosnia and Herzegovina existing and possible new power plants from the whole region should be taken into account..

As conclusion about least cost criterion we can say that it will be very important in the future generation expansion planning, but some additional criterions should be analyzed together with the least cost criterion. What else should be analyzed, is described in following parts.

C. Could only Mmarket solve the Problem?

According to the current status, in most countries with a liberalized power sectror, that is, with an open market of electric energy, not one subject is directly in charge nor responsible for building new power plants. The truth is that there are certain companies, organs or institutions that monitor the increase in electric energy consumption and the condition of the production capacities (they monitor the reserve level in the system). Those are most frequently operators of the system (whether they are within a transfer company or completely independent of other electro-energetic activities). Their task is to warn when reserve of the system is close to the acceptable minimum but they do not force anyone to build power plants. They also gain no profits os it nor is it in their jurisdiction to build new power plants. That means that in the countries with a completely open market of electric energy (where all the buyers can choose their providers) everything having to do with building new power plants is left to the market. So far this has mostly been functioning thanks to a relatively large reserve in the production capacities at the beginning of the reform and the liberalization of the power system. On the other hand, such large reserve could indicate bad planning in the past. Someone had to pay for those irrational investments and in monopoly conditions those were the buyers. That is why the price of electric energy is high.

It is an important issue whether the market itself will give enough incentive for investing in new production plants in the future. The experience of the countries which were among the first to implement the open market of electric energy does not give guarantee [5]-[7].

D. Risk as one of the Key Elements

By eliminating the monopoly and introducing competition in the production and the supply of electric energy, many things, and above all the development of the power system planning and the position of the investor changed a lot. In monopoly conditions the costs and the risks were completely transferable from the investor onto the buyer of electric energy.

An important change i planning, in deregulated conditions, is the aspiration to change the function of the aim; potential investors and owners of plants are no longer concentrated on minimizing the costs but on maximizing the profits. In a deregulated system a market price is established and its influence on the expenditure of electric energy and on the profits of the electric power company, the owner of the production portfolio respectively, should be taken into consideration when planning.

The need for long-term planning will not disappear in deregulated systems. However, many small participants emerge here, planning gets more complicated due to the uncertainty connected with the price, economic consequences for commercially focused markets are more meaningful, there is dependence between the process of planning and risk management.

Investors no longer have the guarantee that the buyers will settle all their costs. Something that was not too pondered upon in the past now emerges as the primary issue. That is the risk of cost covering or the risk of investment money return.

Investors are now faced with a certain amount of risk that goes along with any kind of technological option, considering the financial characteristics of each option [8]. For that reason, the risk level and a way of evading it are being assessed in the process of making a decision. Without that, decisions on making an investment cannot be easily made.

Considering the risk of the cost covering or the risk of investment money return as the key problem, investors are more prone to invest in technologies that demand minor investments so that the period of investment return would be reduced as well as the influence of those factors which are harder to predict long-term. A case in point is that technology with combined cycle running on natural gas has been the most frequent among the installed capacities in the last ten years. That is a technology with relatively low specific investment costs.

IV. RISK ANALISYS

Before deciding to build a power plant it is necessary to do additional analyzing. Depending on the legislative regulation of each country, the needed permits and, in connection with that, the needed studies (for example, the study on effects on the environment) are different. In this context, that is not the issue, assuming all permits are incontestable. The final phase in planning, from the investors point of view, is the study on feasibility or construction justifiability. That study should simulate the conditions of the functioning of the power plant in as more details and as more objective as possible. That study is the basis for decision making concerning whether it is financially justifiable to build the power plant. The study should also address the question of the tolerable risk that is involved with building. The making of this study should be approached very seriously; the preparation of the project task as much as the analysis of the study result.

A. Yearly Generation of the Candidate Plant

One of the most important elements for the feasibility study related to the future power plant is expected yearly generation of the plant. If the financing scheme of the plant is known (interest rate, grace period, loan repayment period) it is possible to define monthly and yearly expenditures for the capital costs. With assumed price of fuel (if it is thermal power plant) and operation and maintenance costs, all costs are known, specific generation costs also. For decision about construction power plant revenue (from the sold electricity) of the plant also should be known. In order to calculate revenue of the plant, electricity market price should be supposed and yearly generation of the plant should be calculated.

Yearly generation of the plant is defined by plants position or loading order under load duration curve (LDC). The loading order depends on plants position on the market (selling price from the plant). The estimation of the market price and electricity selling price from the plant for the longer period should be made. The close connection between yearly generation of the plant and selling price from the plant shows difficulties in the planning in the open electricity market. One variable (expected yearly generation of the plant) should be defined by other variable (electricity selling price from the plant) but second variable is as uncertain as first variable.

For the estimation of the yearly generation and financial effects of the new power plant in the open electricity market conditions several models can be used. Those models are based on LDC (Fig. 3) approximated by Fourier coefficients (WASP Model) [9], or by cumulants (SIPRA model) or by a few bars with different height (MESSAGE model).

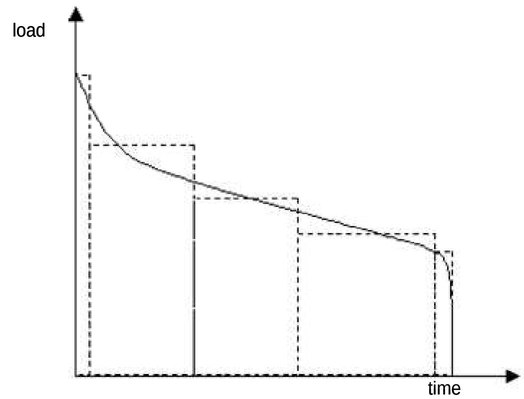

Figure 3. Load duration curve

The above mentioned models are traditional. We need to couple with them some new models developed for market conditions. The most of them are suitable for short-term planning or for operating planning. It means that their main purpose is not to optimize long term expansion planning than optimize operating of existing plant. Even by using the newest models (EMCAS, GTMax, PLEXOS) uncertainties are very big. It is very difficult (practically impossible) to have correct electricity market price projection and fuel price projection for long period in advance (up to 30 years). There are also additional factors what increasing uncertainties, but only two mentioned before are enough for illustrating how difficult problem is.

Methodology used in monopoly conditions was looking only variable costs for loading order calculation (Fig. 4), while methodology used in open electricity market should take selling price from several plants as criterion for loading order (plant generation) calculation (Fig. 5)

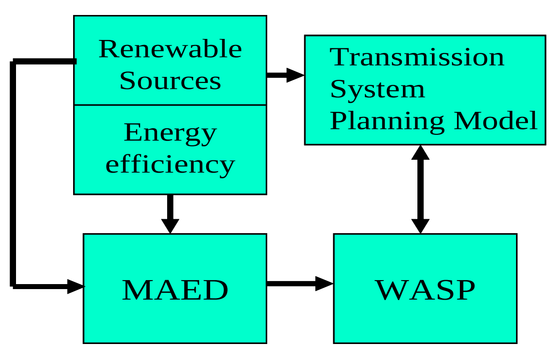

Figure 4. Traditional generation expansion planning approach

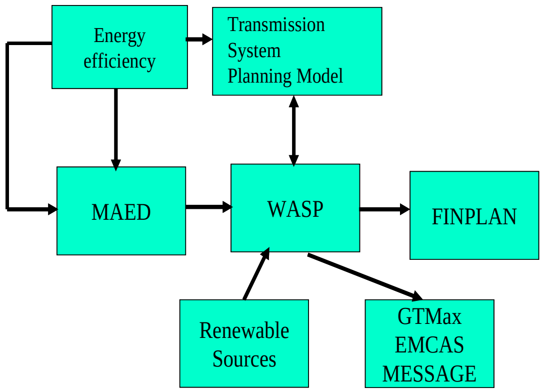

Figure 5. Concept of generation expansion planning adapted to the open market conditions

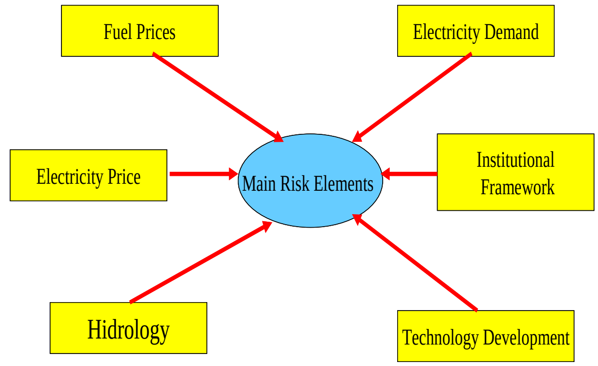

Figure 6. Risk elements connected with power plant

From the Fig.4 and Fig 5. is possible to see the basic difference of two concepts, planning in monopoly conditions and planning in open market conditions. It is evident that planning in the open electricity market environment is much more difficult.

Calculation of the yearly generation of the plant was stressed as one of very important elements in planning process. But it is only one step in feasibility study design. Based on calculated yearly generation, assumed fuel prices, assumed capital cost and financing conditions, based on required rate of return (RoR), minimum selling price when project of the plant is feasible (bankable) can be calculated.

With this price it is necessary to run one of the new models (market oriented). Those models have shorter basic period (even on the hourly base) and calculations inside those models are more precise. In such way the results of the long term models can be checked. Of course it would not be so practical to make such detailed calculations for each year of the planning period (up to 30 years). That's why such procedure could be done for each fifth year (so called crossing year). Except energy calculation, it is necessary to make financial calculations (analysis). For doing that some financial model should be introduced in planning procedure. Only after such complete analysis one who is potential investor can estimate if that project (plant construction) is feasible or not.

But even after so complex analysis uncertainties are still so big . Risk what potential investors are faced with is such that they are looking for risk hedging instruments, or they intend to share risk with somebody else. Because of that methods of risk management are very important in generation expansion planning procedure. There is intention to build up tools for risk management in long term and short term electricity market analysis models.

Some of the important risk elements connected with power plant position on the market shows Figure 6.

It is very interested to analyze how can several risk components affect a new power plant?

B. Electricity Demand

Usually, electricity consumption trend on a specific market does not comply with forecast for a certain period. In a certain year actual consumption can be greater or less than the predicted one. If the actual consumption is greater then the forecasted one an extra opportunity for a potential (candidate) power plant and at the same time decreases the risks of a facility's pay-off. On the other hand, if the forecasted consumption is overestimated the operating aspects of considered power plant are getting narrow and the actual production is lesser that the one produced by the feasibility study. According to that the risk of cost effectiveness of the considered power plant is increasing. It is obvious that the latter case is significantly adverse then the first one.

C. Fuel Prices

Fuel prices can be a significant factor that can increase risk level concerning power plant pay off. Although it is possible that price dynamics of different fuel types can be unrelated (some fuel prices could increase, while some others' could stay constant or even decrease), it is more likely that the prices of all fuels follow the same trend therewith that some fuel prices could have a time shift regarding other fuel types. Clearly, on the real market all sorts of combinations could occur. A decrease in fuel price of a new power plant, if a greater decrease in other fuel prices does not occur, strengthens the market position of a new power plant. On the other hand, an increase in the fuel price for the new power plant weakness new power plants market position (increases the risk) if a relative greater increase in other fuel type prices does not occur.

D. Electricity Market Price

Market electricity price has significant influence on the position of the considered power plant. In periods when costs of production are lower than electricity market prices the considered power plant increases possible production and risk lever is getting lower. In the *vise versa* case the production is decreased and risk level is getting higher.

E. Hydrology

Hydrology is a factor with a specific character in the sense of influencing risk level of a potential power plant. The amount of hydrology influence on the risk level is dependant on the share of hydro power plants in the total installed power of all production units, not just in the power system of a country in which it is located, but on the power system on a whole potential market region. In the planning process hydrology is analyzed more then one level (usually three, low, medium/average and high) and to each level probability factor is attributed. Usually, average hydrology is used when calculating. Same hydrology values are used for complete lifetime. If the 30-year period is considered there is a great probability that the average actual hydrology will be very close to the assumed average hydrology used in design and planning phase and on which the future production of a potential power plant was defined. Here, a question could be raised: What is the problem with hydrology? Or, in other words, how does hydrology influence risk level?

Actual yearly hydrology change and dynamic, considering amounts, is never the same as the average one used in planning phase. For several years hydrology can be actual drier or wetter then the average one. When considering potential new hydro power plants, a wetter hydrology regime implies greater production and lower risk of capital return. On the other hand, wetter hydrology could give a false impression that a considered power plant has a smaller market share because all of the other hydro power plants increase their production as well. That would be a fact only if the market would be consisted only of hydro power plants. Typically the market consisted of mix of hydro and thermo power plants. In such systems in the case of a wetter hydrology hydro power plants production prevail and market take of hydro electricity is usually certain. When the hydrology is extreme wet a cause of losing a share of production could occur as a amount of water is lost by overflow.

If potential thermo power plant is considered hydrology impact is somewhat different. In the case of a wetter hydrology, hydro power plant production increases and the share of thermal power production is decreasing. Nevertheless that this isn't a long term problem (over the longer period hydrology is getting closer to statistical average), if wetter hydrology occur for a several years that could put thermal power plant cash flow under question and its solvency could be at risk. The problem is greater if considered power plant is the only power plant in the portfolio. If the power plant is a part of a larger portfolio this problem is not so significant. Though, never minding the portfolio volume, market conditions cause that the only criteria for a potential power plant construction is certain profitability.

F. Technology Development

Technology development, as one of the risk factors, should be evaluated when estimating risk for a potential (candidate) power plant. Under the term technology development, in this context, the development of technologies for electricity production is considered. The development could be achieved in the directions. The first one is to increase the level of efficiency of an existing technology, and the other one is to develop a new (competitive) technology. Today we are witnessing a great efficiency increase of gas fired power plants. While in some power systems there are still gas fired thermal power plants operating at 30% efficiency level the newest combined cycle gas fired power plants have the efficiency over 55%. Expectations are that this efficiency levels will rise to 60% in a very near future. If there is a cogeneration production (electricity and heat) the overall efficiency levels rise to 80%.

A great step forward was made in technologies of coal fired thermal power plants. An average efficiency of these facilities on the global level is 35%, while the new coal fired power plants that are in operation of around 43%. By the year 2015 a next step in technology development is expected with coal fired power plants with efficiency of 47% (700°C).

On the other hand, some renewable energy technologies (predominately wind energy) are developing at the accelerated pace so a competitive decrease of advantages of classic technology concerning electricity prices could be expected.

The influence of technology development is much greater in thermal power plants then in hydro power plants. If a potential (candidate) power plant is going to be gas fired it is logical to expect that it should have the efficiency greater than the last power plant of the same type built in the past. This opens the space for somewhat lower market prices and results in the case that the older power plant losses a market share. The same could be stated for coal fired thermal power plants, as they have greater capacity factor and lower costs.

Technology development in hydro power plants is much slower. Yet, it is hard to believe that a operating hydro power plant is going to be pushed off the market. Thermal power plants are usually those which get pushed off the market because hydro power plants, specially for a shorter period of time and if it is a case of a run-of-river hydro power plant, can offer the price of electricity a little greater then 0 (zero) cts€/kWh, which is unthinkable for a thermal power plant.

G. Institutional Framework

Financial stability of a power plant can be influenced by the institutional framework in several ways. One way is special for partly open markets where some consumers (eligible) can choose the energy supplier while the others (tariff costumers) are regulated. In such environment, particular power plants can be contracted for the provision of public service obligation and receive a regulated but fixed price. With further market opening some power plants that were under the public service obligation will have to participate in the open market where the conditions for some of them may become more difficult.

The second way that administrative measures can influence on production of power plants and their market status are different incentives for renewable energy sources. Subsidies for RES may decrease the market share of conventional power plants. The case is similar if there are obligatory quotas of renewable energy for suppliers, i.e. obligatory provision of green energy.

Institutional framework also includes different environmental constraints, e.g. environmental protection legislation and different international conventions and protocols. Administrative measures can make some power generation technologies less competitive in the market. For instance, a coal power plant can sometimes be forced to reduce its electricity production or invest in costly emission reduction technologies or a government can impose a relatively high tax on coal. European Union member countries have very clearly determined obligations considering The Kyoto Protocol, as well as the EU accession countries and other countries that have ratified The Kyoto Protocol that puts coal power plants in very unfavorable circumstances. European Union Emission Trading System (EU ETS) was established in the beginning of 2005. All power plants receive emission allowances according to National Allocation Plans. Companies that need to increase their emissions have to buy allowances from those who can offer them on the market. Since this mechanism was introduced, the prices of emission allowances varied from a few Euros per tone to 30 EUR/tone. For instance, the need to buy emission allowances for 20 EUR/tone may have a strong impact on the competitiveness of a coal power plant, and even threaten its market position.

Any of the above measures weakens the market position of coal thermal power plants.

Some risk elements for new power plants are described above, but there are also other risks, e.g. delays in the construction of power plant. Elements described above are of the major risk impact and not under control of investors in power plants.

V. EXAMPLES OF APPLICATION OF METHODOLOGY

The methodology analyzed in this paper was used for several projects and studies in the region of South and East Europe (SEE) carried out in recent years.

The first project was the Energy Sector Technical Assistance Project for Kosovo (ESTAP), financed by the UNMIK (United Nations Interim Administration Mission in Kosovo). One of the objectives was to prepare a generation expansion plan for Kosovo, taking into consideration fully integration in the regional electricity market. The operation of Kosovo's power system (dominantly thermal) was simulated integrated with the power systems of Albania (dominantly hydro) and Serbia (mixed hydro-thermal).

The next project was Generation Investment Study (GIS) that included nine SEE countries (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, FYR Macedonia, Montenegro, Romania, Serbia and UNMIK) [10]. The main aim of the GIS study was design of an indicative least-cost generation expansion plan for the region which balances the needs for economic development and environmental protection together with the requirements related to the establishment of a regional electricity market and EU accession. Three scenarios are examined in the study. In scenario S1 all the countries were examined separately (isolated). In the second scenario (S2) all countries are analyzed together without transmission constraints, both cross-border and internal. In the third scenario (S3) all countries are also analyzed together, but with transmission network constraints. The WASP model was used in this study together with GTMax model. Scheme of scenario S3 is shown in Figure 6.

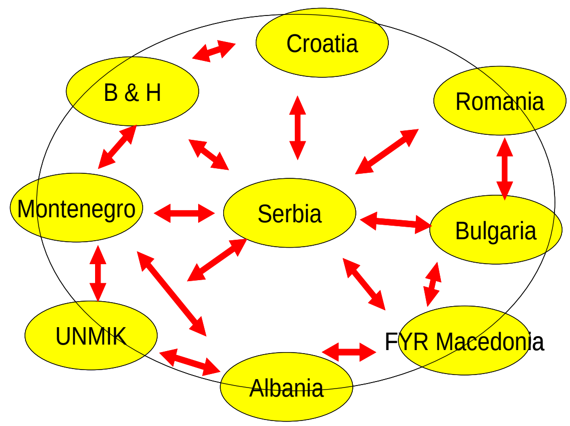

Figure 6. Scenario S3 in the Generation Investment Study

The next project was the Energy Strategy of the Republic of Montenegro till 2025 where joint operation of power systems of Montenegro and Serbia was analyzed.

Finally, the Energy Sector Study for Bosnia and Herzegovina is finished in 2008. There are three electricity utilities in Bosnia and Herzegovina and the country is divided in two „entities“. Optimal generation expansion plans were made for each utility separately, each entity separately and the country as a whole.

VI. CONCLUDING REMARKS

The standard procedure and steps of the decision-making process in generation expansion planning are shown in Figure 7. Each power plant, including those planned in the future, will work in the environment called the electric power system. Operation of any particular power plant in the system influences the operation of all other power plants and vice versa. To properly analyze the position of any future power plant in the system with the lifetime of 25, 30 or even 50 years, it is necessary to take into consideration wider environment (e.g. Figure 2). Studies that try to determine generation technologies, installed capacities and construction sequence schedule of new power plants are called Master Plans (step 1, Figure 7). The Master Plan results with the construction schedule of new power plants that meets preset criteria. In new deregulated environment there is no obligation to built new power plants. Investors interested in construction of new power plants can choose its best candidate plant from Master Plan results (step 2).

When the best candidate power plant is chosen, investors undertake a prefeasibility study. This study analyzes position of the potential power plant in the market and financial risks associated with the construction, taking into consideration as much as possible it is in this stage, future development of electricity consumption, competition in the market, and price movements at potential market. This is the last stage of analyses and calculations, where the decision has to be made whether or not to proceed with the project. Therefore, different methods are used and combined in this step – models for long term planning, assessments of environmental impact, simulations of market operation, and models for financial analysis.

If the analysis in this stage clearly show unacceptable level of risk, any further analyses and activities are aborted and this candidate power plant is no longer taken into consideration (at least for some period of time).

Detailed analyses are undertaken if the prefeasibility study determines the candidate plant would be a worthwhile project (step 4). Further analyses include the location of power plant (step 5), more precise parameters of the power plant, its impact on the environment and related investments (step 6). The feasibility study of power plant construction (step 7) results in new data and arguments for reviewing the decision made in prefeasibility study. If the results show high level of risk the further activities related to the construction of power plants are aborted.

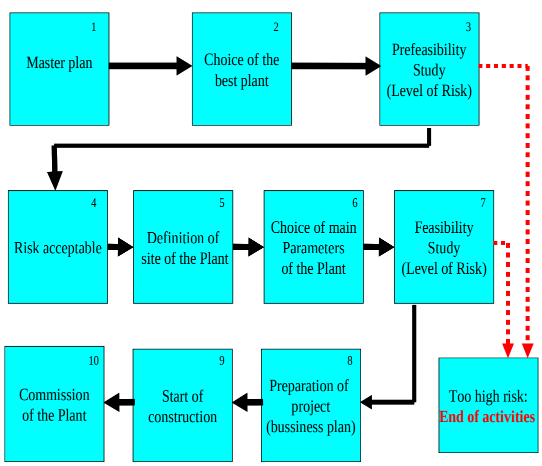

Figure 7. Power plant planning and construction procedure

If the level of risk is acceptable, preparation for construction of power plant follows (construction plan, sources of funding, building permit application etc.) (step 8). When the preparation activities are done, the construction of power plant can begin (step 9). To finish the project on time it is important that the construction process is well organized and financial flow is carefully controlled. When the construction is finished, the power plant has to pass tests and trial operation to start the commercial operation (step 10) and become a market participant. Only the real operation of power plant in the market makes it possible to value the quality of previously made assessments of market position, financial analyses and risk assessments.

It is obvious from above mentioned that the degree of uncertainty for many essential parameters of decision-making is still very high, regardless how complex evaluations are undertaken and what methods are used. It is very difficult to assess the level of risk, in a way that will, after the construction and commissioning of the power plant, guarantee that the evaluations in the planning stage were correct. Planners have a difficult task to merge two different concepts, one that is based on one-hour or even half-hour market competition, and the other that is based on the need to operate power plant with certain load factor (equivalent number of hours with full power) for relatively long period of time (25 to 50 years).

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VII. BIOGRAPHY

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