Application of FACTS Devices in Transmission Expansion to Overcome the Problems Related to Delays

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1. Brief introduction

This paper has taken delays in transmission projects into consideration. Owing to the fact that low voltages and congested lines are the main problem in the case of delays, FACTS devices have been chosen as the best choice to overcome these problems. In this paper, a complementary procedure has been introduced as a mean to investigate the transmission expansion candidate plans, and find the most robust plan against probable delays. During this procedure the worst scenario for each candidate is determined, and FACTS devices are allocated to it via an optimized method. The proposed procedure has been applied to two case studies, Garver's system and RTS network, and significant results have been concluded.

Key words: Delay, FACTS, Scenario, Sensitivity analysis, Transmission Expansion Planning (TEP)

2. Delays; Causes and Effects

Due to technological complexity and great cost of the transmission expansion, hundreds of papers have been published, and tried to provide a model for this problem, and solve it as optimally as possible. However, all above mentioned researches encountered the TEP totally theoretically. So, the models are still far from what happens in practice. One of the most serious problems, with which power system planners and investors often face, is delay in construction and commissioning of new plans. Such delays force the system operator to utilize the system in a risky way. Congestion of existing lines, and low voltages at receiving ends, especially during contingencies, are direct results of these delays. However, the case may even be worse, and ends in cascade forced outages, and finally, black out. Some major causes of these delays are listed bellow [1]:

a) Evolution of financial parameters
b) Licensing for new facilities
c) Obtaining right-of-way
d) Delay in decision making

Not only developing countries but also well developed prosperous countries like U.S. and European countries suffer from delays in transmission expansion. The problem is so serious and commonplace that Western Electricity Coordinating Council has assigned the Planning Coordination Committee the responsibility to identify the types and investigate the impact of delay on the timing and availability of power generation and transmission facilities [2]. Also, European Union's Energy Committee announced that twenty out of the thirty two prior projects in Europe that are power-related are already delayed. Twelve of those twenty face a one- or two-year delay, while eight are looking at delays of three or more years.

3. FACTS devices and their unique ability to provide flexibility to network

As it was mentioned before, the great impacts of delay in expansion of the network are loading of some lines higher than their limits and decreasing voltages of some nodes below the standard limits. In such cases control of power flow, i.e. the ability of diverting excessive power of overloaded lines to others can play a key role in utilizing the network securely. In addition, low voltages of the nodes can be raised to their standard limits by injection of reactive power locally. Flexible AC Transmission System (FACTS) devices are the most suitable means of network security enhancement in such case.

Series FACTS devices can operate in such a way to decrease or increase the power flows trough a certain line according to the scenario happened, and then, predetermination of the scenario, which is impossible in expansion planning, is not necessary.

Another important advantage of the FACTS devices which makes them appropriate means to handle problem related to delays is their relocatability. Consequently, planners can order such devices from the beginning of expansion process to twelve month before the horizon without allocating them. By reaching the horizon of planning, and near precise determination of uncertain parameters and delays, planners will decide when and where to utilize them.

4. A complementary strategy to remove negative impacts of probable delays

Regardless of the objectives and concerns of each planning model, in most cases, optimization of the model will leads to a set of quasi optimal candidates of transmission expansion. The procedure proposed here is simulated for each candidate, and finally the most flexible candidate will be introduced. The procedure is as below:

Step1: All possible scenarios should be simulated for each candidate, and the worst condition should be determined. Each scenario includes the delay in commissioning of one of the future lines, and a single contingency simultaneously. The severity of each scenario is determined by calculation of performance index (PI) [3].

Step 2: In this step FACTS devices are optimally located in the worst scenario of each candidate in order to eliminate the congestions and under voltages. TCSC or TCPAR will be located in order to decrease PI as much as possible. Method of optimization is a slightly modified version of those in [4-5].

Step 3: The ability of each candidate to be robust, by using FACTS devices, against the possible delays will be determined.

Step 4: The plan which is both satisfactory for the planners' objective, and flexible enough to deal with the delays, will be chosen in this step.

5. Case study

In this part, the proposed complementary procedure is applied to 17 candidate plans for expansion of Garver's system. These plans have been obtained from a Genetic Algorithm (GA) - based method in a vertically oriented environment. Besides, the procedure is applied to four candidates obtained in [6] under a competitive market environment.

6. Conclusión

In this paper, the authors tried to study the delay in transmission projects, its causes and effects. After that, a complementary procedure proposed to overcome the problems related to such delay, using FACTS devices. After case studies, following conclusions are obtained.

5.a) The complementary procedure proposed in this paper should be applied to candidates of future plan to evaluate their ability to gain the advantages of FACTS devices in front of the probable delays.

5.b) The best solution for the traditional TEP problem is the most vulnerable candidate in cases that a delay occurs. Moreover, in small networks, FACTS devices can not overcome the delay-related problems. So, the overdesign is necessary. However, these devices help decrease the overdesign.

5.c) Planners of deregulated systems try to minimize congestion and provide more paths in order to remove the market power. As a result, the market-based plans have ability to be secure by utilizing FACTS devices when the delay happens.

5.d) Although TCSC can effectively decrease or even totally remove the congestions, it may end in overvoltage of the compensated line.

Special ability of FACTS devices to manage both active and reactive powers makes them unique means to overcome the impacts of the delay in transmission projects.

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