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EFFECTS OF GENERATION SCHEDULING ON VAR PLANNING

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ABSTRACT

For Transmission System Company, planning of reactive power compensation placement (Var Planning) must be performed. But it is too complicated to dealing with all terms in the power system even only ones that to be considered in the operation planning period. In this paper, a study of generation scheduling effects to reactive power planning is presented. This study uses existing Var planning tool to analyze modified IEEE-30 buses system how generation scheduling effects to planning results. Then consideration terms is reduced or dealt with in an appropriate way.

KEY WORDS: Power System Planning; Generation Scheduling; Var Planning

1. INTRODUCTION

In transmission system company, planning of reactive power compensation is importance. It can reduces transmission losses, improves voltage profile hence ease to system operator, lower risks of voltage collapse, increases voltage stability, etc., so many studies of such planning has been presented for over 20 years. Many optimization techniques have been applied to such a problem [1]-[3]. Some studies are using more than ones in combination [4]-[6]. All of those techniques have shown the satisfied results and some were developed to computer programs. It's difficult to compare which technique is the best because the results of the planning program are varied on many factors in consideration e.g. planner, base case used, [7] etc.

Power system planning can be divided into three categories based on time frame under consideration and decision: long term planning, operation planning, and short term planning. Planning of reactive power in transmission system is in operations planning period that the time frame is typically few months to a year. This planning period has terms to be considered such as fuel purchase and transportation decisions, generation and transmission scheduling, maintenance decisions, emission control strategies, inter-utility power transaction contracts, demand-side management, non-utility generation planning and pricing [8]. Operations planning decisions could either be made by a central agency or be made by each utility where the inter-utility transmission scheduling or fuel supply allocation from a common source are the linking elements.

For the transmission system company, these terms is too complicated to considered for reactive power placement because many terms is depended on power generation company and can be represented by generation scheduling terms which planner should do forecast it for Var planning consideration. As the energy market moves from a government or state enterprise organization regulated monopoly to a competitive free enterprise industry, the analysis of generation scheduling is importance because running chances of each power plant are depended on how low of the energy price bided in the market. Hence the transmission companies who must keep the voltage level at any delivery point within the range e.g. ±10 % of nominal voltage, should plan for voltage compensation device – reactor or capacitor, to minimize the Must Run Plant and Var purchased from plants.

Normally, the objectives of reactive source optimization is to determine a minimum cost expansion plan that guarantees feasible operation both in normal state and under contingency situations. In this paper, the objectives of Var planning is mainly focus on voltage level control or another word is to flatten voltage profile of the system. The additional advantages are lower losses and lower voltage collapse risks. This paper finds out how Var allocation calculated from each forecast generation scheduling differs from each other. The planning uses an interactive satisfying method to minimize energy losses in the period of 1 year. First, the methodology overview on how to calculated the effects of generation scheduling is presented. Then, the case study has implemented in a software package. Simulation results on the IEEE-30 bus are discussed. Finally, the conclusion of this study is also presented.

2. METHODOLOGY OVERVIEW

This section presents the methodology overview that is used in Var planning for this paper. The software package that uses in this paper is called Real and Reactive Optimization for Planning and Scheduling Program (ROPES). The ROPES is a security constrained optimal power flow (SCOF) software program which is a tool for optimal sizing and sitting of Var devices such as reactor, capacitor banks, static Var systems, series capacitors, etc. ROPES in SCOF mode finds an operating point that optimizes a given objective function and satisfies a set of physical and operating constraints for base case and contingency situations.

Investment subproblems part initially produce a trial set of Var capacity additions, which decisions about the location and size of new VAR sources are made. The effect of these additions in terms of operation feasibility is evaluated by the operation subproblems. These sources are used to optimize the system operation. With respect to solution algorithms, in ROPES the investment subproblems is solved by a mixed integer programming method and the operation subproblems is solved by a mixed integer programming method and the operation subproblems by a customized nonlinear primal-dual interior point method. When contingencies are specified the operation subproblems is further decomposed into base case operation and contingency operation subproblems as shown in Fig. 1.

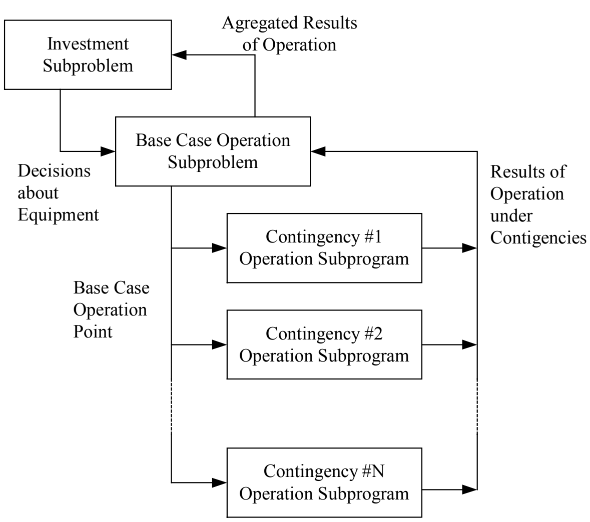

Figure 1. Three-level hierarchical approach [9].

One of the main advantages of the decomposition approach, known as Benders decomposition, is its flexibility. The flexibility and the overall good performance of the methodology were confirmed in a series of tests performed by several utilities.

The objective function specification applies to the SCOF mode of ROPES which is minimized the Var allocation. The constraint specified when run ROPES is only bus voltage limits. The minimization of active losses computes new values for the controls so that active power losses are minimized in the base configuration and at the same time ensure feasibility in the contingency configuration.

2.1 Generation Scheduling Determination

In this part, the system data should be prepared so that it meets the conditions suitable for Var allocation calculation. Lists below are the data items be modified:-

- Minimum and maximum generator Var limits should be set at the real operating point or at the values as specified in the purchasing contract because program will allow generators to reached the limit before placing addition Var to the system.
- Load should be modified to simulate the system in the different seasons.
- Plant type and Cost per unit have to be specified for running probability evaluations.

2.2 Var Planning Calculation

We consider the VAR sources planning problem as follows: identify the locations to install VAR sources, the types and sizes of VAR sources to be installed in the bus, and the settings of VAR sources at different loading conditions such that a desired objective function are met. The objective function usually is the installed cost in conjunction with energy loss reduction. The Var planning calculation has to minimize objective function while load constraints and operational constraints with respect to credible contingencies are met. However, the pre-selection of nodes at which reactive sources additions are possible is a very critical step in the planning process. A poorly selected candidate set may lead to infeasibility of the problem or to an economically unattractive solution. Var planning part presents in this paper using the existing software package program that has the capability to specify some options for planner requirements. Each options effects to the result in significant number.

2.3 Interactive Satisfying Method

This part is very importance because it's a decision making step. System operator experiences in system control are very useful in this step since the results from load flow program can have many errors from many factors such as system parameters, network data used etc. The results should be compared with real system especially on bus voltage level, then more or less of compensations from the results will be make.

3. CASE STUDY

This section presents the case study results runned by software package ROPES program. In this section, a 30 buses with 6 generators of IEEE-30 buses system is modified so that each generator has its minimum and maximum limits of MW and MVar capacity. The IEEE-30 bus has configuration as shown in Fig. 2. Since MVar capacity is effect to additional Var to the system so it must be reduced to about 15-20% of maximum capacity or only half of maximum Var limit of the unit for security reason as shown in Table 1. In addition, demand data in each monthly period and time of days is modified as shown in Table 2.

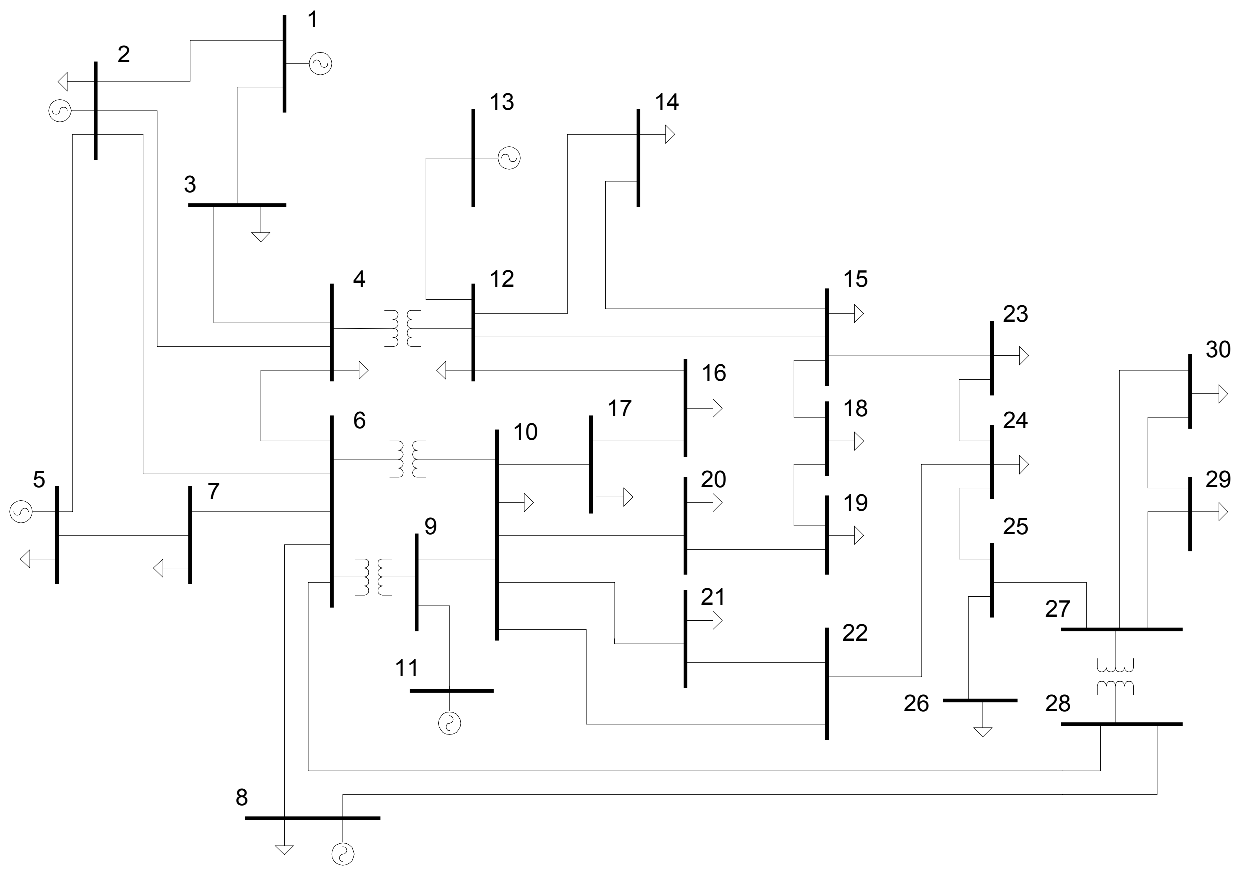

Figure 2. IEEE 30 buses case study.

Table 1 Modified generator data used in the case.

Generator at bus#	1	2	5	8	11	13
Min. P_{min} PU	0.5	0.3	0.2	0.3	0.2	0.2
Max. P_{max} PU	1.5	1.0	0.5	1.0	0.5	0.5
Min. Q_{min} PU	-0.15	-0.1	-0.05	-0.1	-0.05	-0.05
Max. Q_{max} PU	0.3	0.2	0.1	0.2	0.1	0.1
Avg. Cost $/MWh	2.45	3.51	Hydro	4.81	Hydro	Hydro

Table 2 Scaling factors of each month and time of days interval.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Scaling factors	0.8	0.9	1.0	1.3	1.2	1.0	0.85	0.9	0.75	1.1	1.2	1.0
Time of days scaling : Peak, Intermediate, Base is 1.10, 0.80, 0.50 respectively												

In the case of 10th month at peak interval, the planning results when unit at bus number 2 is not running (case 1) compare with the one when unit at bus number 8 is not running (case 2) are different. And when using shunt configuration in case 1 with generation scheduling that unit at bus number 8 is not running results in few more losses but the system is still controllable i.e. Voltage deviation is still kept in 97-107% range. But when using in vice versa the OPF program cannot find the way to keep the system secure or it's infeasible. This is not like when planning with generation contingency because generation scheduling is longer in duration.

Figure 3 has shown Var placements result from two different generation scheduling. As seen from Var placement result, total Var compensation required in case 1 is lower than is case 2 ie. about 20% and also lower losses about 45%. But this is because calculation did not dealing with installation costs. In case 1 we should have Var installation at all buses except swing bus so maybe higher installation costs.

The planning of the generation scheduling for each plant is different for each case. Thus, the Var placement is also different. The optimization point for each case is different. It also effects the total loss of system. If only one system is chosen, it may has the security and quality problem. Hence, the planner should study effects of each plant to the network and plan to serve it. This situation resulted in excessive Var placement required and resulted in some idle of compensating devices in the system.

4. CONCLUSIONS

A study of generation scheduling effects to reactive power planning has been present in this paper. It's shown that different generation scheduling resulted in different optimal Var size and location. This paper may not shown how to find out the optimal solution but it's shown that generation scheduling has the strong effects to Var placements in the system. The well forecast of generation scheduling means cost reduction to Transmission Company because it's reduced the needs to have excessive Var placement in the system. Planning tools may guided to optimized system configuration at each instance but the planner experiences with effects of system elements could optimized the system in longer period of time ie. more profits.

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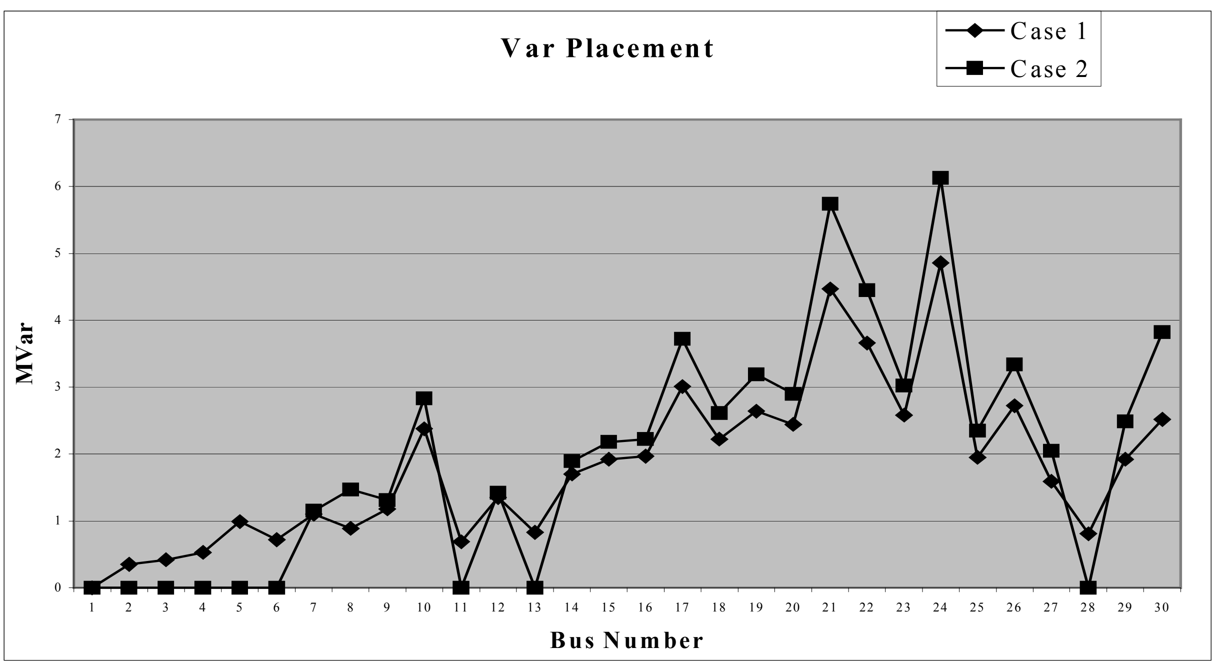

Figure 3. Var placements result from two different generation scheduling.

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