

Coordination of Wind and Pumped-Storage Hydro Units for Managing Transmission Security

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Abstract— This paper proposes a coordination methodology for wind and pumped-storage hydro (PS) units in the day-ahead operation planning of power systems. The proposed coordination is incorporated into the security-constrained unit commitment (SCUC). The results which include the intrahour variability of real-time wind speed show the applicability of the proposed wind-PS coordination approach to the short-term power system operation.

I. INTRODUCTION

IN this paper, an hourly solution based on security-constrained unit commitment (SCUC) for the day-ahead coordination of PS and wind units is proposed. We consider the intrahour modeling of wind energy in the hourly coordination of wind-PS. Since the ISO is in charge of coordination, the owners of wind and PS units could be different. The coupling constraints could be added as required in order to link wind and PS units.

II. NUMERICAL RESULTS

A 6-bus system is shown in Fig. 1 which is composed of three thermal generation and one wind units. A PS unit is placed at the same bus as wind unit. The total installed capacity of wind generation is 75 MW which is about 30% of the peak load and the generated wind energy during the operation period is 12.7% of the total energy consumption. The thermal generation and PS unit characteristics are shown in Tables I and II respectively.

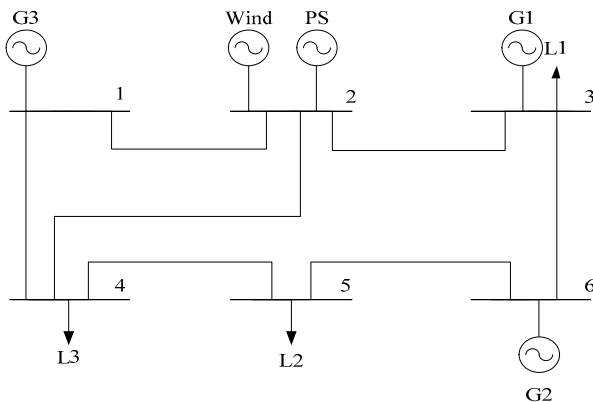


Fig. 1 6-bus power system

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As shown in Fig. 1, loads are located at buses 3, 4 and 5. The transmission line characteristics are shown in Table III. Any transmission flow congestion may increase the operation cost. The hourly load profile of the system is shown in Fig. 2. Here, the peak load occurs at hour 17 while the off peak hours are in early morning and late evening.

TABLE I
THERMAL UNIT CHARACTERISTICS

Unit	a (\$/MW ²)	b (\$/MW)	C (\$/h)	P_{\min} (MW)	P_{\max} (MW)	SU (\$)	SD (\$)	Min Up (h)	Min Dn. (h)
G1	0.099	6.589	211.4	100	320	100	50	4	3
G2	0.203	7.629	217.4	10	160	200	40	3	2
G3	0.494	10.07	102.8	10	100	80	10	1	1

TABLE II
PS UNIT CHARACTERISTICS

Unit	Vol_{\max} (Hm ³)	Vol_{\min} (Hm ³)	q_{\max} (Hm ³ /h)	q_{\min} (Hm ³ /h)
PS	10	1.5	0.75	0.05

Unit	$P_{G,\max}$ (MW)	$P_{G,\min}$ (MW)	$P_{P,\max}$ (MW)	$P_{P,\min}$ (MW)
PS	240	16	300	20

TABLE III
TRANSMISSION LINE CHARACTERISTICS

Line ID	From Bus	To Bus	Impedance (P.U)	Capacity (MW)
1	1	2	0.17	40
2	1	4	0.258	79
3	2	4	0.197	92
4	5	6	0.14	94
5	3	6	0.018	72
6	2	3	0.037	96
7	4	5	0.037	68

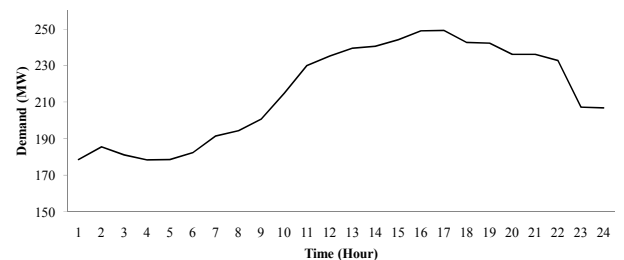


Fig. 2 Hourly load in 6-bus system

In this case, the wind unit generation is coordinated with a PS unit. As a fast response unit, PS will follow the volatility of wind generation to firm up the hourly wind generation. In this case, the system operation cost is \$107,992 and the wind curtailment is 0.616 MWh. In addition, load curtailment will not occur in the system. Tables IV and V show the hourly

