Considering Promoting the Section Transmission Capacity Utilization Economical Efficiency of Substation Access to Transmission Network

Peng Jia, Yongmin Liu, Junhui Li, Fang Guo, Yuanyuan Wang, Lihua Zhang, Wanxun Liu, Sipei Sun and Jie Ma

State Grid Henan Economic Research Institute, Zhengzhou 450000, China

Corresponding author e-mail: tjujp123@126.com

Abstract. Substation access to transmission network will cause the new distribution of the power flow. This paper propoes the economical efficiency indicators to evaluate the section transmission capacity utilization, on the basis of substations variable costs, calculating the contribution degree of various schemes to determine the recommended scheme. Actual example illustrates the feasibility, effectiveness and applicability of research method.

1. Introduction

Transmission line operation limit is mainly composed of thermal stability limit, voltage stability limit, power angle stability limit. Thermal stability limit refers to the maximum power which is determined by the maximum current that transmission lines can undertake when transmission line maintain the normal mechanical strength and safety sag; voltage stability limit refers to the maximum power when transmission lines can withstand maximum voltage drop under the premise of meeting the end of the power grid voltage quality; power angle stability limit refers to the maximum power when transmission lines can keep system stability and meet the allowed maximum voltage phase difference on both ends[1,2]. For short distance line, the power transmission limit is determined by thermal stability limit; for moderate distance line, the power transmission limit is determined by voltage limit; for long distance line, the power transmission limit is determined by power angle limit [3, 4].

2. The section transmission capacity utilization

Transmission section in operation needs to meet [5]:

1) in normal mode, transmission section not to exceed a variety of operating limits, all equipments within the scope of rated load and voltage level.

2) Transmission section can meet N - 1 check.

At present our country's power grid is in a stage of development, substation access to transmission network is commonly short distance line, operating limit is mainly decided by the thermal stability limit.

Suppose that a tr ansmission section consists of n lines, its transmission limit is M1, M2…Mn respectively. When transmission section achieves the operating limit N0, each transmission line power flow is m1, m2... mn respectively. If in accordance with the operating limit of each transmission line optimal power flow distribution[6,7], each line should be m1/、 m2/……mn/,

$$\mathrm{m}_i^{/} = N_0 \times \frac{M_i}{\sum\limits_{j=1}^{j=n} M_j} \tag{1}$$

At this time, the standard deviation of transmission line actual power flow distribution and optimal power flow distribution:

$$\sigma_0 = \sqrt{\sum_{i=1}^{n} \frac{\left(m_i - m_i^{/}\right)^2}{n}} \tag{2}$$

The standard deviation can reflect the section transmission capacity utilization economic efficiency, the smaller the standard deviation shows that section transmission capacity utilization economic efficiency is higher, the greater the standard deviation shows that section transmission capacity utilization economic efficiency is lower.

3. Considering promoting the section transmission capacity utilization economic efficiency of substation access to transmission network

Considering a new substation access to a transmission section, power flow of each line of the transmission section will be redistribute. Using the BPA program calculates the transmission section limit N_i of various schemes; using the formula (1) calculates the optimal power flow $m_i^{/}$ of each line of the transmission section; using the formula (2) calculates different schemes' standard deviation σ_i which reflects the difference of transmission line actual power flow distribution and optimal power flow distribution; assuming various schemes' variable investment is f_i, using the formula (3) calculates contribution degree T_i which reflects the reduction of standard deviation σ_i,

$$T_i = \frac{N_0}{N_i} \frac{\left(\sigma_0 - \sigma_i\right)}{f_i} \tag{3}$$

Comparing various schemes T_i, take its head as the recommended scheme of considering promoting the section transmission capacity utilization economic efficiency of substation access to transmission network.

4. Case analysis

We assume that a region local grid as shown in figure 1, S is a 500 kV substation, keeping 500 kV and 220 kV contact with external systems, A, B, C and D are 220 kV substation respectively, status quo of the load is 136 MW, 191 MW, 130 MW, 281 MW respectively, 500 kV substation S east transmission section consists of the following lines: I S-D(LGJ-2×185), II S-D(LGJ-2×300, LGJ-2×400), I S-A(LGJ-2×630), II S-A(LGJ-2×630), the transmission line conductor length and cross section are shown in figure 1.
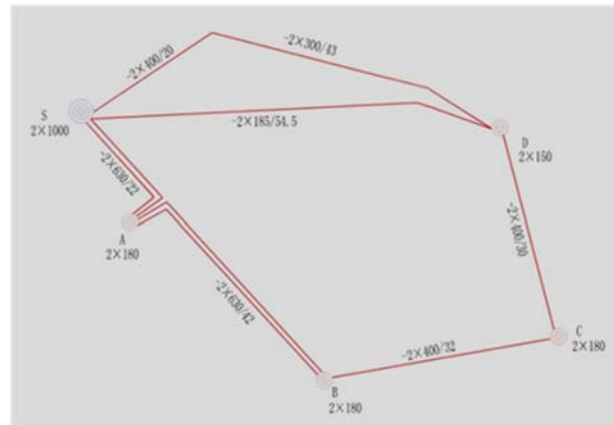
Figure 1. a region local grid.

Using BPA program calculates S east transmission section limit $N_0 = 869$ MW, the related indicators of transmission line are shown in table 1.

Table 1. The related indicators of original network S east transmission section   units: MW

Line name	Cross section(LGJ)	mi	Thermal stability limit	mi/
I S-D	2×185	185	300	124
II S-D	2×400+2×300	196	400	166
I S-A	2×630	244	700	290
II S-A	2×630	244	700	290

Using the formula (2) calculates the standard deviation of transmission line actual power flow distribution and optimal power flow distribution, σ_0 =46.91MW.

Due to the higher load rate of substation D, we plan constructing a 220 kV substation E (initial load of 68MW) in the northeast of substation D to alleviate its power supply pressure, there are two schemes as follows:

Scheme I: substation E PI transmission line I S - D, the conductor cross section of PI extension is LGJ - 2 ×400(the cost is 1.1 million yuan/km), length is 30 km, the variable cost f1 = 33 million yuan, the specific scheme is as shown in figure 2.
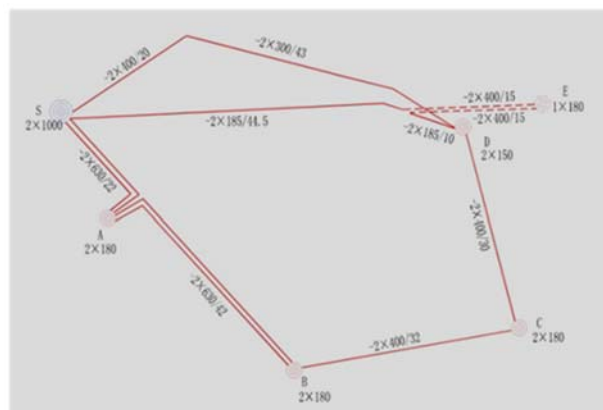

Figure 2. Scheme I of substation E access to transmission network.

The related indicators of S east transmission section of scheme I are shown in table 2.

Table 2. The related indicators of S east transmission section of scheme I   units: MW

Line name	Cross section(LGJ)	m_i	Thermal stability limit	m_i'
I S-E	2×185+2×400	185	300	131
II S-D	2×400+2×300	214	400	175
I S-A	2×630	260	700	306
II S-A	2×630	260	700	306

Using the formula (2) calculates the standard deviation of transmission line actual power flow distribution and optimal power flow distribution, σ_1 =44.09MW.

Using the formula (3) calculates the contribution degree of scheme I T1 = 0.86 MW/ten million yuan.

Scheme II: substation E PI transmission line II S - D, the conductor cross section of PI extension is LGJ - 2 ×400(the cost is 1.1 million yuan/km), length is 26 km, the variable cost f1 = 28.6 million yuan, the specific scheme is as shown in figure 3.
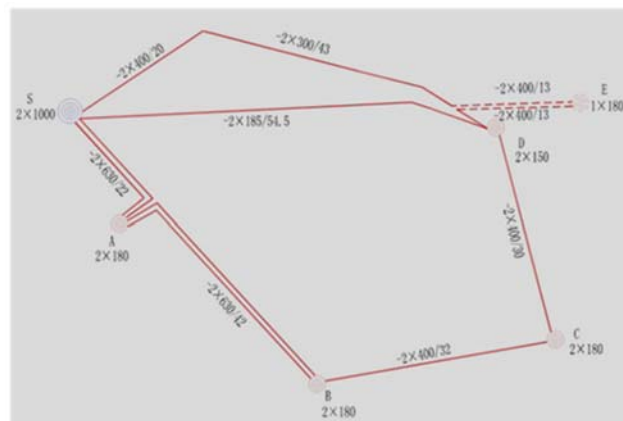

Figure 3. Scheme II of substation E access to transmission network.

The related indicators of S east transmission section of scheme II are shown in table 3.

Table 3. The related indicators of S east transmission section of scheme II   units: MW

Line name	Cross section(LGJ)	m_i	Thermal stability limit	m_i'
I S-D	2×185	202	300	124
II S-E	2×400+2×300	167	400	166
I S-A	2×630	250	700	290
II S-A	2×630	250	700	290

Using the formula (2) calculates the standard deviation of transmission line actual power flow distribution and optimal power flow distribution, σ_2 =47.99MW.

Using the formula (3) calculates the contribution degree of scheme II T2 = -0.38 MW/ten million yuan.

Comparison of contribution degree Ti of scheme I and scheme II, we can get T1 > T2, explaining that scheme I is better than scheme II in promoting the section transmission capacity utilization economic efficiency, we recommend scheme I for substation access to transmission network.

5. Conclusion

There are many schemes for substation access to transmission network, this paper takes the section transmission capacity utilization economic efficiency as the research object, putting forward to economic indicators based on transmission line operating limit, namely the standard deviation σ_i of transmission line actual power flow distribution and optimal power flow distribution, analyzing different schemes of substation access to transmission network impact on the standard deviation, on the basis of considering variable cost fi of substation access to transmission network , calculating different schemes' contribution degree Ti which reflects section transmission capacity utilization economic efficiency, taking Ti as a evaluation index of substation access to transmission network, providing a feasible quantitative research methods for substation access to transmission network. Through the calculation of actual case, the study method can make a scientific decision for substation access to transmission network, effectively enhancing the section transmission capacity utilization economic efficiency.

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