ELSEVIER
Available online at www.sciencedirect.com
SciVerse ScienceDirect
Energy Procedia 17 (2012) 1452 – 1459
Energy Procedia

2012 International Conference on Future Electrical Power and Energy Systems

Calculation of PV Power Station Access

Hua Lan, Zhi-min Liao, Tian-gang Yuan, Feng Zhu

Electrical Engineering College, Northeast Dianli University, Jilin Jilin Province China

Abstract

With the PV system capacity continues to expand, they identify a given network to bear the largest photovoltaic power generation into power, it is an urgent need to address the problem. This paper analyzes the PV of the distribution network voltage distribution and the impact of the trend line. From the perspective of network security, it creates access to computing power PV model. This is combined with two sub-enumeration method for solving the mathematical model and its analysis by the actual distribution system, which verify the correctness and effectiveness. In addition, it analyzes the location of the PV power plant access to the power of access.

Keywords:Photovoltaic power generation; access to power;distribution network

1. Introduction

With Urgency of the world energy situation, Energy is the first of the world's 10 major focus of the problem (energy, water, food, environment, poverty, terrorism and war, disease, education, democracy and population). World population at least 100-110 billion by the year 2050, according to an annual GDP per capita growth of 1.6%, GDP unit energy consumption in accordance with the decrease of 1% per year, while demand for energy capacity will be 30 ~ 60TW, daily energy consumption will reach 450 ~ 900 × 106BOE, it will mainly rely on renewable energy to solve. However, the world's potential hydropower resources have 4.6TW, economic exploitation of resources can only 0.9TW; The actual wind energy resources can be developed 2TW; biomass is 3TW. Only solar energy is the only guaranteed source of energy for human energy needs, its potential resources 120 000 TW, the actual exploitation of resources can be up to 600TW [1]. We hope to enlarge the scale photovoltaic power as possible,but its own characteristics make it to the safety of power grid operation stability will certain threat. With the increase in installed capacity of photovoltaic power generation, photovoltaic power generation will be more and more significant impact on the system, not only for security and stability of the system, but also bring some economic loss. Therefore, regardless of PV systems in the planning stage or the actual operation in power system, We identify a given network to bear the largest PV power generation systems into power, it becomes photovoltaic power generation system planning and design phase of the urgent need to solve

 doi:10.1016/j.egypro.2012.02.266

the problem. It has more computing capacity access methods, which are common test method, analytical method, mathematical optimization method. Determining PV power stations to access to power is subject to many factors. It is reasonable to determine the construction of PV size and maximum access capacity. it should adopt the system, combined with the actual calculation of the specific system analysis, it is closely related [2] to Its value which depends not only on the size of the PV power plant system operating characteristics and ability to regulate other power generation equipment, but also photovoltaic power stations with access to the network structure.

From the perspective of network security, it creates access to computing power photovoltaic power stations mathematical model, the combination of the two sub-enumeration method to solve the mathematical model. In addition, it analyzes the location of the PV power plant access to the power of access.

2. Photovoltaic power station on the line flow and voltage distribution

2.1 PV power station on the impact of the trend line [3]

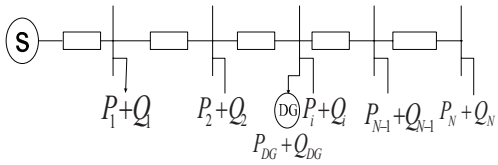

Figure 1. Distribution network with PV power station

It is shown in Figure 1 that Chain distribution network load first i-nodes to install photovoltaic power stations, for the loss of generality,i-nodes do not qualify for the end node. According to the relationship between the size of i-nodes active P_{Di} and PV power stations P_{DGi} ,Load and active power flow between the distribution network has the following three conditions:

a)When $P_{DGi} > P_{Di}$, the node can be regarded as a distribution network to inject active power capacity of $P_{DGi} - P_{Di}$ power node.

b)When $P_{DGi} = P_{Di}$,distribution network and the node does not exist between the active power flow.

c)When $P_{DGi} < P_{Di}$, the distribution network nodes to provide load capacity $P_{DGi} - P_{Di}$ as the active power.

We can see that when the path to node i only have a PV power plant and its active efforts over the line on the node N i to the total active power load, the line direction of the trend of P with the default in the opposite direction, there reverse the trend.If the PV power plant capacity too large, the trend line and may even exceed the allowable value.

2.2 Photovoltaic power station on the voltage distribution

The research results in Literature [4] show that the hair stand in a large number of photovoltaic power grid, the electricity network consists of a radial network into a power source and active network of Internet users, it will inevitably lead to the transmission of active and reactive feederquantity and direction of change, thereby affecting the steady-state voltage distribution.

PV power feeder of position in the outside effect of voltage level [5]. (1) Photovoltaic power station placed in the substation, when the PV power into account the percentage of bus load of 15% to 20%, making the introduction of the power from the main transformer reduced,but the tap is not considered

according to the introduction of photovoltaic power station under the surge strategy to determine adjusted upward adjustment of tap is not enough to make step-down transformer secondary voltage is too low, then the user side of the voltage level of the more limited.(2)Photovoltaic power station access line regulator Vice-side, as the impact of PV power injection, line voltage regulator VR (Voltage Regulator) can not detect the size of the actual load, so the voltage regulator VR, thus pushing the user voltagelevel can not meet the requirements.(3)PV power stations access the user side, a user side of photovoltaic power plant will affect other users of the voltage level.

Photovoltaic power station is located on the feeder voltage levels.Photovoltaic power stations due to the voltage on the feeder from the supporting role, which can help achieve voltage regulation.Photovoltaic power station in the access position does not change the situation, the voltage support the total output from the PV decision.The more total output, and load the higher the ratio, the greater the voltage support, the overall level of the higher voltage.PV power stations closer to bus, on the smaller line voltage distribution.Therefore, the photovoltaic power generation to the position of voltage distribution for the distribution network has a great influence.

3. PV power station when the access point access to the power of mathematical models

Access power model can be expressed as a mathematical model of optimal power flow, but in order to facilitate the analysis, eliminating a lot of constraints, such as photovoltaic power plant output constraints, the line capacity constraints, security constraints, stability constraints, etc ,to highlight the influence of the voltage regulation for access [6].

Assume that a given load level, photovoltaic power station connected to the inverter through a node α, assuming the node is a distribution network to the capacity of $P_{DGi} - P_{Di}$ active power into the power nodes.PV power stations directly into the grid, does not consider the impact on power inverter.Regulator does not consider the role of transformer substations, substation bus voltage constant.The reactive and active efforts to control the ratio of coefficient of f_α.For N-node system, so that U and θ represent the node voltage and phase angle, P and Q represent the node active and reactive power, then

$$P_i(V,\theta) = V_i \sum_{j=1}^{N} V_j \left(G_{ij}\cos\theta_{ij} + B_{ij}\sin\theta_{ij}\right)(i \in N) \tag{1}$$

$$Q_i(V,\theta) = V_i \sum_{j=1}^{N} V_j \left(G_{ij}\sin\theta_{ij} - B_{ij}\cos\theta_{ij}\right)(i \in N) \tag{2}$$

Type of G and B, respectively admittance matrix of real and imaginary parts.Photovoltaic power station is to solve a single point of access to the power distribution network into a mathematical model can be expressed as

$$Max \quad P_{DG} \tag{3}$$

$$ST \quad P_{Gi} + P_{DG\alpha} - P_{Di} - P_i(V,\theta) = 0(i \in N) \tag{4}$$

$$Q_{Gi} + P_{DG\alpha} - Q_{Di} - Q_i(V,\theta) = 0(i \in N) \tag{5}$$

$$Q_{DG\alpha} = f_\alpha P_{DG\alpha} \tag{6}$$

$$V_{\min} \le V_i \le V_{\max}(i \in N) \tag{7}$$

$$\left|I_{ij}\right| \le I_{ij\max}(i, j \in N, i \ne j) \tag{8}$$

Type in: N is the node set; P_{Gi} and Q_{Gi} respectively the power supply node active and reactive output; P_{DGi} and Q_{DGi} access points were a photovoltaic power stations active and reactive output;

P_{Di} and Q_{Di} respectivelynode i load active and reactive power; $V_{\min}$ and $V_{\max}$ respectively, the maximum node voltage, lower limit; I_{ij} and $I_{ij\max}$ lines, respectively $i-j$ line current amplitude and current limits.Description of the problem can be used combined with two points enumeration method, the basic idea is:Given a photovoltaic power station into the power level, the trend of solving the network equation (3) - (7), if the power flow calculation results satisfy the constraint equation (8) and (9), an increase of photovoltaic power plants into the power level, repeat the aboveterms, until no further increase until the PV power station into the power level.At this time we got into the power level is access to power.Algorithm flow shown in Figure 2, where "large numbers" to make current equation node voltage or line flow violation of constraint a value [7].

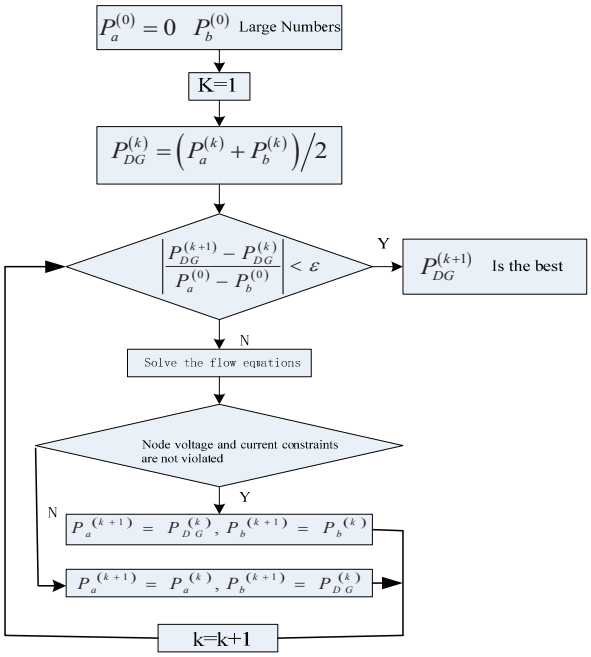

Figure 2 Access to power calculation of the flow chart

4. PV power station access points power when the access model

Now assume a different position in the PV distribution network access system, its location in the node were to determine α and β, the corresponding active efforts which were $P_{DG\alpha}$ and $P_{DG\beta}$.At this point, if the model will be extended access point, solution to $P_{DG\alpha} + P_{DG\beta}$ as the objective function of optimization problem (the solution set for the $\hat{P}_{DG\alpha}$ and $\hat{P}_{DG\beta}$), get access to capacity for the $\hat{P}_{DG\alpha} + \hat{P}_{DG\beta}$.However, it is possible to find another combination of distributed power injection capacity ($P'_{DG\alpha}$ and $P'_{DG\beta}$), to meet the $P'_{DG\alpha} + P'_{DG\beta} < P_{DG\alpha} + P_{DG\beta}$, but in this operation state, the corresponding voltage V' or current I'_{ij} did not meet the requirements.We now want to calculate the capacity of such a level of access:We now want to calculate the capacity of such a level of access:Accessing to capacity at this level, $P_{DG\alpha}$ and $P_{DG\beta}$ can be arbitrarily distributed and will not cause the system constraint violations.That is to say , assuming that the

combination of $P_{DG\alpha}^{(k)}$ and $P_{DG\beta}^{(k)}$ under $P_{DG\alpha}^{(k)}+P_{DG\beta}^{(k)}<P_{DG\alpha}+P_{DG\beta}$, a node k of the voltage $V_k^{(k)}$ and current $I_{kj}^{(k)}$ to the highest, the most severe cases required the node voltage and current to meet the voltage constraints [7], that is

$$V_k^{(k)} < V_{i\max} \tag{9}$$

$$I_{kj}^{(k)} < I_{kj\max} \tag{10}$$

Therefore, node α and β respectively, photovoltaic power station access to power, the set of its reactive power $Q_{DG\alpha}$ and $Q_{DG\beta}$, and active power $P_{DG\alpha}$ and $P_{DG\beta}$ the proportion of control coefficients were f_α and f_β, the access capacity of the solution can belevel optimization model to represent the following:

$$Max \quad P_{DG\alpha}+P_{DG\beta} \tag{11}$$

$$ST \quad P_{Gi}+P_{DG\alpha}-P_{Di}-P_i(V,\theta)=0(i\in N) \tag{12}$$

$$Q_{Gi}+P_{DG\alpha}-Q_{Di}-Q_i(V,\theta)=0(i\in N) \tag{13}$$

$$Q_{DG\alpha}=f_\alpha P_{DG\alpha} \tag{14}$$

$$Q_{DG\beta}=f_\beta P_{DG\beta} \tag{15}$$

$$V_{\min}\le V_i\le V_{\max}(i\in N) \tag{16}$$

$$|I_{ij}|\le I_{ij\max}(i,j\in N,i\ne j) \tag{17}$$

$$\max_{P_{DG\alpha}^{(k)},P_{DG\beta}^{(k)}} \quad V_k^{(k)}<V_{i\max} \qquad P_{DG\alpha}^{(k)}+P_{DG\beta}^{(k)}\le \hat{P}_{DG\alpha}+\hat{P}_{DG\beta}(k\in N) \tag{18}$$

$$\max_{P_{DG\alpha}^{(k)},P_{DG\beta}^{(k)}} \quad I_{kj}^{(k)}<I_{kj\max} \quad , \quad P_{DG\alpha}^{(k)}+P_{DG\beta}^{(k)}\le \hat{P}_{DG\alpha}+\hat{P}_{DG\beta}(k\in N) \tag{19}$$

We now discuss a simple algorithm.For access to the access point power calculation, the algorithm is simple, we just supply the power distribution between the decile percentage from 0-100 (for example, decile 10), and then we use the previous method described in the two sub-Each power distribution under the maximum percentage of access to power, power distribution for different access to power in the greatest percentage of the minimum value for the access to power calculations.When the PV power station and two or more access points, the above method of computation will increase with the power surge in the number, there is no efficient algorithm for solving the above level optimization problem [8].

5. Numerical results and analysis

5.1 PV power station when the access point access to computing power

In this article, 20 node distribution system as an example [9], the examples in each section of line impedance, load nodes, and photovoltaic power stations the size of output data, see Table 1 and Table 2 respectively.System bus voltage is taken as 1.02, the power base to take 10MVA, voltage base value to take 10KV, the system bus voltage obtained 1.05pu.PV power plant and the net, power distribution system operating in the normal state.Select the node and network 1,4,8,10,12,15 as, according to the method proposed in this paper were distributed computing power of the access capacity, the results shown in Table 3.

Table 1. Line impedance and node load information

Node	Resistance	Reactance	Active	Reactive
1	0.0002	0.0005	0.0497	0.0261
2	0.0082	0.0246	0.0034	0.0065
3	0.0006	0.0017	0.0487	0.0002
4	0.0009	0.0027	0.0461	0.0163
5	0.0070	0.0209	0.0479	0.0180
6	0.0015	0.0044	0.0282	0.0497
7	0.0006	0.0017	0.0475	0.0470
8	0.0006	0.0019	0.0159	0.0217
9	0.0072	0.0217	0.0133	0.0468
10	0.0003	0.0010	0.0031	0.0248
11	0.0070	0.0209	0.0166	0.0486
12	0.0022	0.0066	0.0146	0.0479
13	0.0063	0.0188	0.0201	0.0360
14	0.0051	0.0154	0.0017	0.0324
15	0.0058	0.0173	0.0144	0.0481
16	0.0029	0.0086	0.0110	0.0015
17	0.0089	0.0268	0.0283	0.0183
18	0.0009	0.0028	0.0435	0.0047
19	0.0029	0.0088	0.0127	0.0167
20	0.0082	0.0247	0.0296	0.0004

Table II. PV output

DGS	Active efforts	Reactive efforts
PV power station	0.0810	0.0598

Table III. Photovoltaic power station access from the same location when access to power

Grid Node	1	4	8	10	12	15
Access to power	8.3	7.9	7.2	6.7	5.9	4.7

We can see from the Table 3, with the bus around to the feeder from the system after the end of the gradual shift, photovoltaic power station less and less access to power.

5.2 PV power station when the access points access to computing power

When the PV power stations to grid points, for the analysis of relevant factors affecting access to power, the paper design of the four kinds of access solutions [3]: 1) photovoltaic power station near DGS1 access system bus (Node 1), photovoltaic power station in central DGS2 access feeder (node 10); 2) photovoltaic power station access node 4 and 15, respectively; 3) photovoltaic power stations were central access feeder (node 10) and end (node 20);

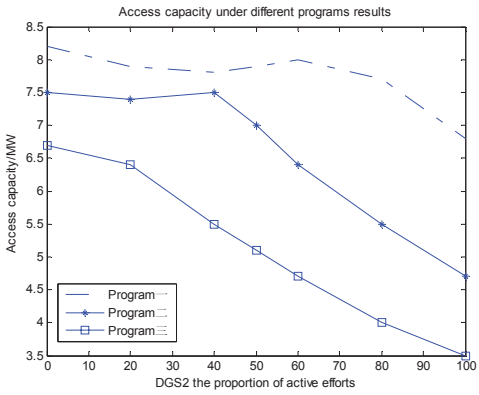

Figure 3

We use the program 1-3, the access capacity of the wind do the calculation: 8.2MW to 6.8MW between, 7.5MW to 4.7 between, 6.7MW to 3.5MW, with corresponding minimum value of interval 6.8MW,4.7MW, 3.5MW, 4.4MW, that is, three kinds of access to the capacity required by the program results

Program access capacity of 1,2 and 3 results show that with the position of PV power stations and networks around the feeder bus from the system after the end of shift, that access capacity significantly decreased access to this and a little way to the conclusionIs is the same.

6. Conclusion

a）We have established photovoltaic solar power station access to power calculation model, the design method using two access points power optimization model of algorithms.

b) access to power by the PV power plant system, the structure of distribution network, power factor and grid location and other factors.The case study, it is found when the PV power stations scattered distribution network can access greater access to power.

c) In this article we propose access to power calculation model can easily consider a variety of operating constraints, when the system compared the number of photovoltaic power station is low, the optimization method can give the result.However, when compared with the number supply for some time how to solve level optimization model, there are no more effective way to further study.

References

[1] Wang Chang-gui,Wang Si-cheng Practical solar photovoltaic echnology[M]BeiJing: Chemical Industry Press,2009

[2] Lei Jin-yong,Huang Wei,Xia Xiang. Consider alternate access to short-circuit capacity of the power of distributed computing[J]. Automation of power systems.2008,32(3):82-86

[3] Wang Zhi-qun, Zhu Shou-zhen, Zhou Shuang-xi. Distributed generation on distribution network voltage distribution[J].Automation of power systems.2004,28(16):56-60

[4] Holdsworth L, Jenkins N, Strbac G. Electrical. stability of large offshore wind farms Seventh International Conference on AC-DC Power Transmission,2001,156-161

[5] Zheng Zan. Wind power and photovoltaic power generation and Research Network[D].Shang Hai,Shang hai jiao tong Universit

[6] Zheng Guo-qiang ,Cheng Shu-yong. Approximate linear programming based wind power penetration limit algori Thm[J]. Chinese Society for Electrical Engineering.2004,24(10)

[7] Hu Hua ,Wu Shan ,Xia Xiang..Consider the voltage regulation constraint access multiple distributed power powercalcul Ation[J]. Chinese Society for Electrical Engineering.2006,26(19)13-17

[8] T.E.Kim,J.E.Kim.A method for determining theintroduction limit of distributed generation system in distribution system,in Proceedings of IEEE PES Summer Meeting,July 2001

[9] Xia Cheng-jun ,Cui Hong ,Wang Qiang, Zhang Rao .Considering static security constraints of the distributed computing power access capacity[J]. Network Technology.2009,33(16)