Generation Planning using WASP Software

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Abstract – *In this paper the optimal plan for developing a power system over the next 15 years is determine. The system's load over the past 36 years, along with the characteristics of the power plants is given. First, according to the methods presented in the literature, by using the courier information of the past 36 years, the network load in the next 15 years should be estimated. Then, by using the WASP software and entering the characteristics of each power plant, all possible modes of supply can be determined using these generating units and the combination that produces the best efficiency and the lowest objective cost function. It is necessary to determine the best objective function by changing the composition and arrangement of the units added each year.*

Key Words: Power system, power system operation and planning, Distribution system

1. INTRODUCTION

Power systems are one of the largest and most complex systems known to provide electricity to consumers [1, 2]. Electricity is one of the most important and widely used forms of energy used by various consumers, such as home and industrial consumers, so it is important to know how to supply and cost electricity[3]. One of the most important challenges of the power system is the technical and technical issues of the components of these systems and the provision of low electricity cost to consumers, as the price of electricity is strongly influenced by other costs[4]. In order to analyze the transient behavior of any uncertainties in the system, state-space model of the system need to be obtained[5, 6].

The issue of power generation planning (GEP) involves identifying production technology options (wind coal, etc.) to add to the existing power generation system and the time and place they need to be installed. In a time horizon meet the planning[7]. Scheduling of power systems includes determining the time, location, size and other technical specifications of the equipment that must be added to the grid to be responsive to consumption in the coming years[8, 9]. Power system planning includes topics such as production development, transmission network development, energy harvesting [10], substation development, maintenance and reactive power planning, generator entry and exit, economic dispatch[11]. Production planning plays a major role in the design of daily operations of power systems[12]. The program of generators entering and leaving the economic grid and dispatching production are two major parts of this complex issue. Production planning requires the above two tasks to effectively meet the projected load demand over a given time horizon[13, 14]. Our main objective in the production planning issue is to make decisions about the generation and entry of generators into the grid and to make available power sources according to the planning horizon to minimize overall production costs. The issue of production planning is constrained by the demands of system and storage requirements. Generally, the purpose is to design, implement, and develop a power grid or, in other words, power systems, to generate electrical power and deliver it to the consumer[15]. Therefore, the consumer is one of the most important components of power grids and is influenced by changes in network parameters such as voltage, frequency, and the parameters themselves. Therefore, sustainable operation (the ultimate goal of designing, implementing and developing an electric power grid) of power systems requires their ability to maintain a balance between the electrical power output of the power plants and the electrical loads of the system. Therefore, maintaining balance in an electric power system is of particular importance and in load modelling due to the variety of residential, commercial, industrial and sensitive loads [16, 17] and so on with an important, effective and complex process[18, 19]. Therefore it is difficult to approximate and estimate the exact composition of the load [5, 20]. On the other hand, this combination may be influenced by factors such as time (hour, day, and month), weather and economic situation[5, 20]. If the exact load combination is present, it is not possible to show every component of the load that millions of samples across the network have in the studies. For these reasons, the need for simplification in network studies and even in modelling is clearly seen and necessary. Wind Power Generation due to the constant change and difficulty of wind forecasting, there are many uncertainties in the operation of the power system[21]. Due to the variable nature of wind and the inaccurate prediction of systems with large wind units, there is a considerable amount of storage required, which should usually be provided in conditions other than wind power requirements[22]. Therefore, according to the prediction error of the wind power and the required system consumption, determine the objective function[23]. Therefore, this thesis first deals with a comprehensive and thorough review of production planning issues, and then discusses the methods for dealing with this issue. In the next step, an efficient and effective method is presented and investigated among the methods available to counter this problem in order to reduce overall production costs.

In this study, we examine how the development plan of an electric power system is determined by integer linear programming [24, 25]. Multi-purpose multi-period production development planning issues to determine the options for power generation technology to be added, and where on the grid to be created to simultaneously minimize multiple objectives such as cost and air pollution. Unmet demand is also considered as a cost in the objective function[26]. The proposed method considers the reliability of the system[27].

The method used here explicitly considers the existence of system components and operational planning. Stochastic simulation is used to generate component existence scenarios, and then the problem of linear integer optimization mixed with integers to find optimal expansion or development solutions is solved by considering these scenarios[28]. The method used in the GAMS software environment will be implemented on the sample power system and the results will be analyzed and evaluated. This paper presents a new nonlinear model for multi-year planning of coordinated development of production and transmission, considering the high level of influence of wind farms on the power system[29]. In the proposed approach, uncertainties related to load demand and wind power are modeled using two-level stochastic programming and then the optimal power system development plan between the generating units and the candidate transmission lines is based on minimum analysis maximum regret is selected. Finally, the proposed model is implemented on the 24-bus sample bus reliability model and the effect of the number of scenarios on the computational load of the scheduling problem and the final optimal response is evaluated [30, 31].

2. Load Information

In the power industry, efficient and effective design and operation have always been the focus of attention, so reducing annual network costs is essential[32]. Therefore, parallel capacitors with varying tap ratio are used to control the voltage of the buses in the minimum and maximum permissible range[33, 34]. Despite extensive studies of capacitance shifts in power grids, there is a lack of in-depth investigation into two fundamental issues. First, the simultaneous investigation of other variables at the disposal of the operator, such as regulating the pulse rate and capacitance in power systems, and the relevance of these activities to other parameters at the disposal of the system operator, is more important. Second, economic scrutiny and its analysis as a link between technical and economic decision-making require more attention. In addition, considering uncertainties in the parameters affecting curbside is also a factor that represents a wider and more complete range of choices for network decision makers[35]. For this purpose, the main question of this research is how to plan reactive power considering other variables and parameters of decision maker network. In this regard, considering the effect of load uncertainty with respect to reactive power generator constraints, bus voltage range, tap change range and shunt capacitance size changes have been analyzed. The demand is given in Table 1.

Table -1: Sample Table format

Load	Year	Load	Year	Load	Year
14071	1979	11807	1967	10803	1955
14356	1980	11934	1968	10859	1956
14660	1981	12069	1969	10919	1957
14987	1982	12214	1970	10983	1958
15336	1983	12369	1971	11052	1959
15709	1984	12535	1972	11126	1960
16109	1985	12712	1973	11204	1961
16536	1986	12902	1974	11289	1962
16994	1987	19105	1975	11979	1963
17484	1988	19323	1976	11475	1964
18007	1989	19555	1977	11579	1965
18568	1990	19804	1978	11689	1966
14071	1979	11807	1967	10803	1955

2.1. Assumptions

There are two assumptions about the load. First, the maximum load ratio in spring, autumn and winter is 0.83, 0.92 and 0.8, respectively. Second, the load continuity curve for each season is trapezoidal as defined follows: in spring and fall the load continuity curve is in the form of a trapezoid, with a base load of 60% of the maximum load. In summer the load continuity curve is trapezoidal with a base load of 70% of the maximum load. In winter the load continuity curve is in the form of a trapezoid and the base load is 65% of the maximum load[36]. The specifications of the fuels used are as follows. The gas rate is 8 cents per cubic meter and its thermal value is 10500 kcal / m. The oil rate is 25 cents per liter and its thermal value is 10,000 kcal / liter. Gasoline rate is 30 cents per liter and its thermal value is 11500 kcal / liter[37].

3. Development Units

These units are similar to existing units. The following limitations apply to these units. Only one new hydroelectric unit can be added to the system each year. Only 3 new 325 MW heaters per year can be added to the system. Only 4 new 160 MW gas units per year can be added to the system. Only five new 120 MW gas units per year can be added to the system. Ignores environmental costs. Internal and external interest rates are 15% and 7% respectively. Every kilowatt-hour is 860 kcal.

3.1. Load Forecasting

In the first part, given the burden of the past 36 years, we predict the burden for the next 15 years. The Box-Jenkins method is used for this purpose. ACF and PACF charts were used to determine the time series static. These two diagrams are for Figure 1 for the past 36 years. For the time series to be static and therefore to be used in the auto regression model, it is necessary to quickly break the autocorrelation function (ACF) curve. According to Figure 1, this occurs after three time derivatives. Therefore, the third derivative of the time series in question is used for the ARIMA model[38,39]. The ARIMA model is obtained using the third derivative as follows:

$$A(q) = 1 + 0.05825q^{-1} \qquad (1)$$

By writing the third derivative in terms of ARIMA model delay and expansion values:

$$\begin{aligned} y(t) &= 2.94175\,y(t-1) - 2.82525\,y(t-2) + \\ &0.82528y(t-3) + 0.05825\,y(t-4) + e \end{aligned} \qquad (2)$$

3.3. Determine the optimal design

WASP software is used to determine the optimal production plan. The different parts of doing this project are as follows: The first sub module of this software is about shared data. The following is completed using the problem data.

Figure 1. Wasp panel

After entering the information on loads and existing units and the units added to the development plan, we proceed to the first 3 modules, to the second 3 modules, which relate to the decision on fixed layout of the plants. The wasp panel is shown in Fig1. The CONGEN module must first specify a fixed combination of power plants to provide the least load. This module produces all the combinations available for system development, subject to the constraints of the problem, providing only one layout per year and no optimization. These arrangements are then given as input to the MERSIM module. This module calculates the reliability indices for each arrangement, depending on the combination of power plants entering each year. Finally, the DYNPRO module extracts the optimal development plan with the information obtained from the previous modules. These steps are performed in WASP software and the corresponding file is available in the report folder. A variable expansion study mode should be used at this stage. In fact, for each year, several different arrangements are considered (depending on the amount of tunneling restrictions). After this module, the configurations as before are transferred to the MERSIM module, where parameters such as production rate, fuel cost and reliability indicators are calculated. After the implementation of MERSIM there is a batch of make-up with almost cost and parameters of LOLP and ENS.

$$U_0 \le U \le U_0 + \Delta U \qquad (3)$$

These configurations are used as input to the DYNPRO module. In this section, using the dynamic programming algorithm, the optimal solution of the development plan is extracted. These steps are performed in WASP software and the corresponding file is available in the report folder.

4. Simulation and Results

Considering the uncertainties in the parameters affecting network decision-making activities, the reactive power scheduling scheme is randomly selected and requires risk-based economic and scenario-based surveys. It should be noted here that in order to have a proper analysis, the planning structure needs a proper problem solving solution. Therefore, reducing the size of the problem and at the same time having accurate answers using common techniques in the literature on the issue of dimensionality reduction such as scenario reduction techniques have been considered in the design of this research. In the literature, the use of smart optimization methods for solving such dimensions is suggested. For this purpose, the particle swarm algorithm is used in this research to solve the problem and provide optimal response to network decision-making activities.

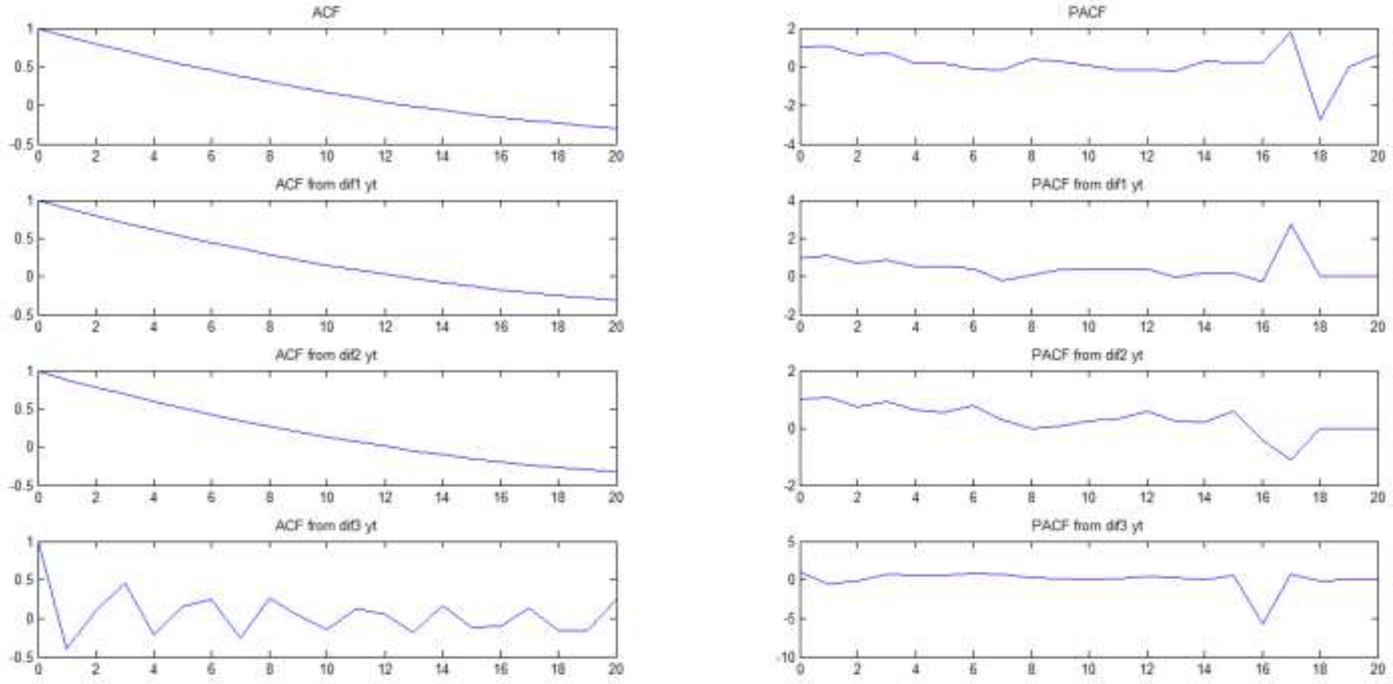

Figure 2. Load and generation prediction

As shown in Fig2. most industrial applications have a considerable number of small consumers of different sizes and it is very difficult for any consumer to use the correct capacitance for each consumer and in addition they are not always connected all at once and as a result installing the capacitor on any motor will be useless. Sometimes installing a central capacitor may be preferable to installing a small number of small capacitors.

5. CONCLUSION

How to use electrical networks is one of the most important issues of electrical engineers and it is always the effort of the designers and users of the network to design and operate the network to provide better service and provide customer satisfaction. Subscribers' low power factor is one of the concerns of distribution network operators as it increases network losses and reduces the limited capacity of line and transformers operation and also reduces the quality of delivery power. Local reactive power generation can also reduce power losses and free up grid capacity, which can increase power quality if the reactive power compensation level is not met.

REFERENCES

[1] M. Khatibi, H. Zargarzadeh, and M. Barzegaran, "Power system dynamic model reduction by means of an iterative SVD-Krylov model reduction method," in 2016 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT), 2016, pp. 1-6.

[2] M. Khatibi, T. Amraee, H. Zargarzadeh, and M. Barzegaran, "Comparative analysis of dynamic model reduction with application in power systems," in 2016 Clemson University Power Systems Conference (PSC), 2016, pp. 1-6.

[3] M. Khatibi and S. Ahmed, "Impact of Distributed Energy Resources on Frequency Regulation of the Bulk Power System," arXiv preprint arXiv:1906.09295, 2019.

[4] M. Khatibi and S. Ahmed, "Optimal resilient defense strategy against false data injection attacks on power system state estimation," in 2018 IEEE Power & Energy Society Innovative Smart Grid Technologies Conference (ISGT), 2018, pp. 1-5.

[5] N. Ghanbari and S. Bhattacharya, "Battery State of Charge Management by Voltage Feedback Modification," in 2019 IEEE Transportation Electrification Conference and Expo (ITEC), 2019, pp. 1-5.

[6] N. Ghanbari, P. M. Shabestari, A. Mehrizi-Sani, and S. Bhattacharya, "State-space modeling and reachability analysis for a dc microgrid," in 2019 IEEE Applied Power Electronics Conference and Exposition (APEC), 2019, pp. 2882-2886.

[7] E. Jun, W. Kim, and S. H. Chang, "The analysis of security cost for different energy sources," Applied Energy, vol. 86, pp. 1894-1901, 2009.

[8] A. Pantoja and N. Quijano, "A population dynamics approach for the dispatch of distributed generators," IEEE Transactions on Industrial Electronics, vol. 58, pp. 4559-4567, 2011.

[9] Z. Bo, O. Shaojie, Z. Jianhua, S. Hui, W. Geng, and Z. Ming, "An analysis of previous blackouts in the world: Lessons for China′ s power industry," Renewable and Sustainable Energy Reviews, vol. 42, pp. 1151-1163, 2015.

[10] I. Aminzahed, Y. Zhang, and M. Jabbari, "Energy harvesting from a five-story building and investigation of frequency effect on output power," International Journal on Interactive Design and Manufacturing (IJIDeM), vol. 10, pp. 301-308, 2016.

[11] B. Morvaj, R. Evins, and J. Carmeliet, "Optimization framework for distributed energy systems with integrated electrical grid constraints," Applied energy, vol. 171, pp. 296-313, 2016.

[12] H. Pourgharibshahi, M. T. Andani, Z. Ramezani, K. Yousefpour, T. Pourseif, and L. Ghorbanzadeh, "Controller Design of Voltage Source Converter Using Nyquist Array," in 2018 Clemson University Power Systems Conference (PSC), 2018, pp. 1-6.

[13] N. Ebrahimi, S. Nugroho, A. F. Taha, N. Gatsis, W. Gao, and A. Jafari, "Dynamic Actuator Selection and Robust State-Feedback Control of Networked Soft Actuators," in 2018 IEEE International Conference on Robotics and Automation (ICRA), 2018, pp. 2857-2864.

[14] N. Ebrahimi, "Simulation of a Three link-Six Musculo Skeletal Arm Activated by Hill Muscle Model," 2019.

[15] N. Ebrahimi, "Modeling, Simulation and Control of a Robotic Arm."

[16] H. Mehrabi and I. Aminzahed, "Design and testing of a microgripper with SMA actuator for manipulation of micro components," Microsystem Technologies, June 19 2019.

[17] H. Mehrabi, M. Hamedi, and I. Aminzahed, "A novel design and fabrication of a micro-gripper for manipulation of micro-scale parts actuated by a bending piezoelectric," Microsystem Technologies, pp. 1-9, 2019.

[18] O. Ciftci, M. Mehrtash, F. Safdarian, and A. Kargarian, "Chance-Constrained Microgrid Energy Management with Flexibility Constraints Provided by Battery Storage," in 2019 IEEE Texas Power and Energy Conference (TPEC), 2019, pp. 1-6.

[19] F. Safdarian and A. Kargarian, "Time decomposition strategy for security-constrained economic dispatch," IET Generation, Transmission & Distribution, 2019.

[20] A. Esmaili Torshabi and L. Ghorbanzadeh, "A Study on Stereoscopic X-ray Imaging Data Set on the Accuracy of Real-Time Tumor Tracking in External Beam Radiotherapy," Technology in cancer research & treatment, vol. 16, pp. 167-177, 2017.

[21] O. J. Guerra, D. A. Tejada, and G. V. Reklaitis, "An optimization framework for the integrated planning of generation and transmission expansion in interconnected power systems," Applied energy, vol. 170, pp. 1-21, 2016.

[22] H. Kanchev, D. Lu, F. Colas, V. Lazarov, and B. Francois, "Energy management and operational planning of a microgrid with a PV-based active generator for smart grid applications," IEEE transactions on industrial electronics, vol. 58, pp. 4583-4592, 2011.

[23] K. P. Detroja, "Optimal autonomous microgrid operation: A holistic view," Applied energy, vol. 173, pp. 320-330, 2016.

[24] O. Salari, M. Nouri, K. H. Zaad, A. Bakhshai, and P. Jain, "A Multi-Source Inverter for Electric Drive Vehicles," in 2018 IEEE Energy Conversion Congress and Exposition (ECCE), 2018, pp. 3872-3879.

[25] O. Salari, K. H. Zaad, A. Bakhshai, and P. Jain, "Hybrid Energy Storage Systems for Electric Vehicles: Multi-Source Inverter Topologies," in 2018 14th International Conference on Power Electronics (CIEP), 2018, pp. 111-116.

[26] A. Khalkhali, M. Afroosheh, and M. Seyedi, "Modeling and Prediction of FRP Composite Cylinder tubes Crashworthiness Characteristics," 2014.

[27] A. R. Sadat, S. Ahmadian, and N. Vosoughi, "A novel torque ripple reduction of switched reluctance motor based on DTC-SVM method," in 2018 IEEE Texas Power and Energy Conference (TPEC), 2018, pp. 1-6.

[28] N. Lidula and A. Rajapakse, "Microgrids research: A review of experimental microgrids and test systems," Renewable and Sustainable Energy Reviews, vol. 15, pp. 186-202, 2011.

[29] F. Safdarian, A. Mohammadi, and A. Kargarian, "Temporal Decomposition for Security-Constrained Unit Commitment," IEEE Transactions on Power Systems, 2019.

[30] G. Xu, V. Vittal, A. Meklin, and J. E. Thalman, "Controlled islanding demonstrations on the WECC system," IEEE Transactions on Power Systems, vol. 26, pp. 334-343, 2010.

[31] P. Trodden, W. Bukhsh, A. Grothey, and K. McKinnon, "MILP formulation for controlled islanding of power networks," International Journal of Electrical Power & Energy Systems, vol. 45, pp. 501-508, 2013.

[32] K. Sun, D.-Z. Zheng, and Q. Lu, "Splitting strategies for islanding operation of large-scale power systems using OBDD-based methods," IEEE transactions on Power Systems, vol. 18, pp. 912-923, 2003.

[33] K. Sun, D.-Z. Zheng, and Q. Lu, "A simulation study of OBDD-based proper splitting strategies for power systems under consideration of transient stability," IEEE Transactions on Power Systems, vol. 20, pp. 389-399, 2005.

[34] N. Senroy, G. T. Heydt, and V. Vittal, "Decision tree assisted controlled islanding," IEEE Transactions on Power Systems, vol. 21, pp. 1790-1797, 2006.

[35] I. Genc, R. Diao, V. Vittal, S. Kolluri, and S. Mandal, "Decision tree-based preventive and corrective control applications for dynamic security enhancement in power systems," IEEE Transactions on Power Systems, vol. 25, pp. 1611-1619, 2010.

[36] M. Manfren, P. Caputo, and G. Costa, "Paradigm shift in urban energy systems through distributed generation: Methods and models," Applied energy, vol. 88, pp. 1032-1048, 2011.

[37] G. Kyriakarakos, D. D. Piromalis, A. I. Dounis, K. G. Arvanitis, and G. Papadakis, "Intelligent demand side energy management system for autonomous polygeneration microgrids," Applied Energy, vol. 103, pp. 39-51, 2013.

[38] C.-S. Karavas, G. Kyriakarakos, K. G. Arvanitis, and G. Papadakis, "A multi-agent decentralized energy management system based on distributed intelligence for the design and control of autonomous polygeneration microgrids," Energy Conversion and Management, vol. 103, pp. 166-179, 2015.

[39] Qi, Zhongang, Saeed Khorram, and Fuxin Li. "Embedding deep networks into visual explanations." arXi preprint arXiv:1709.05360 (2017).