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Power System Planning and Analysis Data Model Research

Zhanfeng Cao*[1], Jian Zhang[2], He Hao[1], Xinghua Zhou[3]
[1]Beijing china-power information technology CO. LTD., China
[2]State Grid Corporation of China, China
[3]Beijing Join Bright Digital Electric Power Technology CO. LTD., China
*Corresponding author, e-mail: caozf2013@163.com

Abstract

Power system planning is according to the demand of the social and economic development, energy resources and load distribution, determine the reasonable power structure and strategy. Power grid voltage grade, transmission mode and reasonable space truss structure, etc. Although a large number of literature have studied various aspects of the power planning, but there are few literatures on power system planning comprehensive study, and just theoretical analysis, useless for practical application. This paper analyzes the load forecasting of power system planning, evaluation of power grid and economic evaluation, gives the basic data needed for the analysis and calculation,and provides theoretical guidance for the actual planning work.

Keywords: *power system planning, load forecasting, grid assessment, economic analysis*

1. Introduction

It is only through the basic construction of electric power industry, growing power system planning to sovle the question that users' growing demand for electricity. To satisfy the need of the national economy development, power industry must come first, so making a good preparation for the prophase of power engineering construction, implementing the generate electricity, send electricity, substation ontology engineering construction conditions, coordinate the construction schedule, optimizing the design scheme, is particularly significant. Power system planning is an important part of electric power engineering prophase work, is about the overall planning of single ontology engineering design, is the guidelines and principles for the implementation of specific projects, is a strategic work [1].

Power system planning by the power system load forecasting, supply planning and network planning structure, power load forecasting is the basis for power system planning, which provides electricity demand growth conditions, the load curve and load distribution. To make the grid construction to adapt to social development and their own development needs, you must select the proper planning program, so network planning and economic evaluation of program evaluation grid construction is an important task before [2].

It is according to the space dimension and time dimension, the equipment dimensions, constraints and optimization index dimension to classify power system planning, And combining with the planning method dimension, the required data can be gained. Although there are lots of research literature on all aspects of the power system planning, but the research literature about basic data that power system planning overall calculation and analysis needs are very few, and the lack of practicality. According to the above problem, this article has carried on the cover, according to five dimensions of the power grid planning analysis, analyzes three parts of the power system planning business: power load forecasting, power grid evaluation and economic analysis, and gives the basic data for calculation and application.

2. Power Load Forecasting

Power load forecasting is an important part of power system planning, also is the basis of power systems economical operation, at any time, load forecast is extremely important for power system planning and operation.

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Power load forecasting sets power load core to a series forecast work, from the point of prediction objects, it includes the future electricity demand forecast and the future electricity prediction forecast and the prediction of the load curve characteristics. Main work is to predict the future power load time distribution and space distribution, to provide decision-making basis for the reliability of the power system planning and operation [2-3].

According to the time dimension, power load forecasting needs the following five kinds of load forecasting:

1) Meet user reporting requirements. Very specific requirements, meet the next six months to 2 years new load requirements.

2) The short-term load forecasting.Time limit is 1~5 years, it mainly services for electric power system planning, especially distribution network planning, and is very important for the capacity expansion and planning of distribution network.Combining with the spatial dimension, it can be divided into the total load forecasting andspatial load forecasting.

Total load forecasting is forecasting strategy is to power the entire planning area and the load as a predictor of the object, the result determines the future of the entire supply area and the future demand for electricity in the total electricity supply throughout the supply area. The methods include the total elastic coefficient prediction method, time series, regression analysis, gray prediction method, fuzzy prediction method, experts predict, artificial neural networks.

Spatial load forecasting is the total amount allocated to the power load forecasting process area, mainly in the following three phases:

a. spatial information Collection
b. land-use decisions
c. load growth forecasts

Spatial load forecasting methods are: load density, analogy to pass data based prediction method, evolution projections.

3) Medium-term load forecasting.Predicting period is 5~10 years and set year as the prediction unit, the medium-term forecast period is in line with power engineering project construction period, therefore, the deadline forecast is very important for the electric power planning departments, according to the prediction results. Making plan of power transmission and distribution project construction is crucial for power grid planning, capacity expansion and reconstruction work and is one of the important work of electric power planning.

4) Long-term load forecasting. Forecast period is 10~30 years and set year as the prediction unit. The forecast is strategic planning, including the generation of long-term demand for energy resources is estimated to determine the strategic objectives of the electric power industry, electric power development of new technology and technology development planning, and the development of long-term electricity demand on the estimation of the total funds.

5) Meet saturated load requirements. It is usually need to estimate the condition after 30 years for new urban area, for the mature area, it has been saturated, therefore, when people estimate the area load limit, the process can be not precise.

Load forecasting based data, including economic, social and natural climate data, the higher the planning area network planning load forecasting results of historical annual load and capacity data. Grid planning should accumulate and use of standard loads and electricity historical series of data as a basis for forecasting.

According to the spatial dimension, Load forecast is divided into total load forecast, spatial load forecasting. The basis data that power system load forecasting needs are shown in Table 1. In which time dimension and space dimension arecomprehensive considered.

Table 1. Power Load Forecasting Data Collection Data

Spacedimension	Time dimension	data required to collect
The total load forecasting	Ultra short-term load forecasting	1 electricity consumption of industriesandproducts output value 2 the typical daily load curve, typical monthly load curve 3 population and economic data, including GDP, population, the 123 productionvalueproportions, power consumptionproportion of 123 industries, residents and the government 4the data of local power and maximum load.
	Short-term load forecasting	1 electricity consumption of industriesandproducts output value 2 the typical yearly load curve 3 population and economic data, including GDP, population, the 123 productionvalueproportions,power consumptionproportion of 123 industries, residents and the government 4the data of local power and maximum load.
	Medium term load forecasting	Same as above data
	Long term load forecasting	1 electricity consumption of industriesandproducts output value 2 the typical yearly load curve 3 population and economic data, including GDP, population, the 123 productionvalueproportions, power consumptionproportion of 123 industries, residents and the government 4the data of local power and maximum load. 5 National economic policy 6 Electrical characteristics of various industries
	The saturated area load forecasting	1 population and economic data, including GDP, population, the 123 productionvalueproportions, power consumptionproportion of 123 industries, residents and the government 2the data of local power and maximum load. 3 National economic policy 4 Electrical characteristics of various industries
Spatial load forecasting	Ultra short-term load forecasting	1 The current power and maximum load ofeach community 2 each communityelectricity rate that power consumptionat the same time 3 Spatial information collection 4 Land decision-making 5 The load density of all kinds of land
	Short-term load forecasting	1 The composition description of new communities: population, commercial, industrial, residential, municipal planning area and scale 2 Local meteorological and geographical data: the highest temperature, the lowest temperature, latitude and longitude 3 Model community population, commercial, industrial, residential, municipal area, scale 4 Model community total load and power consumption data 5 Model community classification power consumptionand load data 6 Model community meteorological and geographical data
	Medium term load forecasting	1 More than 5 years mark load historical data: the highest load, power electricity, annual peak load, month power consumption 2 More than two consecutive years daily maximum load and power consumption 3More than two consecutive years active load and reactive load daily curve that has 96 nodes
	Long term load forecasting	1 The current power and maximum load of each community 2 each communityelectricity rate that power consumptionat the same time 3 Spatial information collection 4 Land decision-making 5 The load density of all kinds of land 6 The country's economic policy 7 The municipal planning for a long time 8 Digital map 9 The status quo map 10 the sample data that can be analogy
	The saturated areaload forecasting	1 The current power and maximum load of each community 2 each communityelectricity rate that power consumptionat the same time 3 Spatial information collection 4 Land decision-making 5 The load density of all kinds of land

3. Grid Assessment

The assessment without consider power plants is grid evaluation, the purpose is to identify the weak links of the system, these weak links are specific problems that power planning need to solve, Evaluation provides a heuristic goals for power planning [5-7].

Evaluationgridincludedbalance of electric power and energy, powerflow calculation, short circuit levelanalysis, Optimal Power Flow,Stability analysis.

The balance of electric power and energy is to determine the level of additional substation capacity planning based primarily on size. Should be partitioned, divided voltage level, sub-annual proceed and consider a variety of new energy, electric vehicles, energy storage devices and other effects. Points should be combined with balanced voltage power load forecasting results and the existing substation capacity to determine the voltage level required for the new substation capacity.

The power flow calculation is based onthe givenoperating conditions and determines the topology ofthe network running status, power supply capacity is checked, line loss analysis, short-circuit current calculation, the level of security of supply, reliability calculations and reactive planning basis for the calculation. Shall typical way for planning horizon of more than 35kV power flow calculation. 10kV power flow calculation according tozoning, substation or line compute node to node or equivalent.

Short-circuit current calculation flow through the network topology analysis and calculated the voltage level of the node and each branch impedance and admittance, and then short-circuit current calculation in power system planning and design stage, is generally calculated over the next 10 years or so maximum operating mode single-phase three-phase short-circuit and short circuit current zero seconds, the replacement of the existing circuit breakers shall be excessive Shihai year period. The purpose of the short circuit current is calculated by analyzing the short-circuit current and short circuit calculation grid capacity to evaluate the power grid structure is reasonable, Main Wiring Forms substation electrical equipment as well as a reasonable selection, etc., in order to limit the short circuit current of the grid to take measures to provide a basis.

Reactive power compensation optimization is safe and economic operation of the power system is an important component. Reactive planning purposes of the calculation of the power system power through the rational allocation and optimal reactive load compensation, not only to maintain voltage stability and improve system stability, but also can reduce the active power loss and reactive network losses, so that the power system is capable of safe and economic operation.Reactive Power Optimization of analysis, to be combined with the node voltage tolerance range, the node power factor requirements, transformers, reactive power equipment and lines and other equipment parameters and the different operating modes of the load level, a large load is calculated in accordance with the total capacity of reactive power demand, calculated in accordance with a small load reactive power compensation device grouping capacity to meet the minimum investment in equipment or reactive minimum network loss goals.

Stability analysis is based on the requirements of the power system of the various fault conditions are simulated and analyzed to determine the main power system stability characteristics and stable level. Because many factors affecting stability in the power system planning can only simple consideration.Stability analysis of multi-flow calculation is based on the basis of the results carried out, stability analysis include: power system transient stability, voltage stability calculations and frequency stability calculation. At the planning stage to send the available computing power transmission line by the end of the high voltage bus voltage vector angle between the methods to approximate the system stability. Through a variety of stability calculation, verification of the access system can be operating parameters of the program meets the requirements of stable operation.

Blackout accident prevention needs from planning, operation, management and other aspects of effective measures [4]. Plenty of spare capacity and a reasonable grid structure is safe and stable operation of the power system based on strengthening the unity of the power supply and power grid planning and construction, from the source to protect the power system security. In addition, safety assessment and accident anticipation analysis, timely detection of the weak links in the system, do a good job accident plan, to prevent large-scale blackouts are also very important.Power system risk assessment typically includes the following aspects: 1 Model to determine the best outage; 2 Select the system status and calculate their probability; 3 Assess the consequences of the selected state; 4 calculate risk indicators.

Based on the power system planning four dimensions, this paper makes power grids evaluation into several species, and introduces the several kinds of combination respectively, the specific contents are shown in Table 2.

Table 2. Power Balance Analysis Sheet

	Balance of electric power and energy	Power Flow calculation	Optimal Power Flow
Generator	1 The capacity of generatorand voltage level 2 Output of the generator 3 Generator forced shutdown rate parameter	1 The capacity of generatorand voltage level 2. Output of the generator 3. Candidate balancing machine 4 The unit transient reactance	1. The capacity of generatorand voltage level 2 .Output of the generator 3 .Output of the generator limits 4. Candidatebalancingmachine
Equivalentsource	1. The node load sizes thatthe load is maximum 2. Each nodeload sizesat several times 3. Typical day 96 points curves of each node load or every day 96 points curves throughout the year	1.System output and voltage levels 2.System outputlimit 3. Candidate balancing machine 4.Systemequivalent impedance	1.System output and voltage levels 2.System outputlimit 3. Candidate balancing machine 4.Systemequivalent impedance
Main transformer	1 Maintransformer capacity and voltage level 2 Three sides of main transformerreactance and nodes	1 Main transformer capacity and voltage level 2 Threesidesofmaintransformer reactance and nodes 3 Themaintransformerresistance 4 Main transformer tap and the gear ratio 5 Main transformerconnection mode 6 Main transformer neutral point grounding way 7 The zero sequence reactance of main transformer	1 Main transformer capacity and voltage level 2 Threesidesofmaintransformer reactance and nodes 3 Themaintransformerresistance 4 Main transformer tap and the gear ratio 5 Main transformerconnection mode
AC Line	1 Line capacity and voltage level 2 Line length, reactance, the first and final points	1linecapacity andvoltage level 2line length, reactance, the first and lastnodes 3line impedance 4linereactance 5line zerosequence impedance 6line zerosequence reactance	1linecapacity andvoltage level 2line length, reactance, the first and lastnodes 3line impedance 4linereactance
Switchgear	1 The first and final points of switch equipments, and usually states 2The switches states that the load is maximum 3 The states of the switches at multiple time	1. The first and final points of switch equipments, and usually states 2. The switches states that the load is maximum 3. The states of the switches at multiple time 4The Switches breaking capacities	1 The first and final points of switch equipments, and usually states 2 The switches states that the load is maximum 3 The states of the switches at multiple time 4The Switches breaking capacities 5 The action timeparameters of the switches
Reactive power compensation	None	1.The amountof reactive power compensation 2.Reactive power compensationlimit	1.The amountof reactive power compensation 2.Reactive power compensationlimit
Bus	None	1.Voltage level 2.Voltage limits 3.The initialvoltage value	1.Voltage level 2.Voltage limits 3.The initialvoltage value
Load/User	1. The node load sizes thatthe load is maximum 2. Each nodeload sizesat several times 3. Typical day 96 points curves of each node load or every day 96 points curves throughout the year	Same as above data	Same as above data

4. Economic Analysis

Technical and economic analysis refers to the assessment of their life cycle in planning projects for technical comparison of the alternatives, economic analysis and impact assessment, its purpose is to assess the planning project (new construction, renovation and

expansion) in the technical, economic feasibility and reasonableness, provide the basis for the investment decision-making. Maximize investment benefit, namely, how to use less investment, less time to maximize production efficiency.Economic analysis includes economic benefit evaluation and investment analysis.

Economic evaluation specified by selecting the planning project economic evaluation evaluation, including static total investment, dynamic total investment, the project payback period, internal rate of return and other indicators, economic indicators of the project and engineering calculations. Investment Analysis estimates based on typical equipment investment and typical project investment, including estimates on the total amount of investment in a single project investment, project investment in batches to summarize and analyze such situations.

Table 3 summarizes the economic evaluation and investment contents and basic data [8-10].

Table 3. Economic Analysis Data Collection Sheet

Economic evaluation content	Calculation content	collection data
Economic benefits evaluation	assets calculation	1 existing assets 2 new equipment assets
	income	1 Forecast power consumptions of various industries 2 kinds of Industries electricity price table
	Cost analysis	1 All kinds of cost index name 2 Index values
	Equipment efficiency analysis	1 Equipment investment 2 The actual power/Average power/Daily load curve
Investment analysis	The static investment	1 Equipment capacity 2 Cost estimate table
	Dynamic investment	1 Equipment capacity 2 Cost estimate table 3.lending rates, reimbursement deadline, reimbursement means 4 loan/investment proportion
	Return on investment	1 Equipment capacity 2 The actual power/Average power/Daily load curve 3 Equipment investment 4Cost estimate table 5 lending rates, reimbursement deadline, reimbursement means 6 loan/investment proportion

5. Summary

Power system planning is on the basis of the existing power system, according to the given constraints or optimization index, to give new increased power system equipment construction plan, satisfy power consumption demand within a certain scope of space and time. Power system planning is full of uncertainty, so the planning should consider many conditions. Data collection is the basis of the power system planning analysis, so information collection becomes the key that the plan is success or failure. This paper analyzes the various planning scheme calculation and basic data need to collected, and provides practical guidance for power system planning.

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