Research of Evaluation Index System of the Development and Construction of "Two-type Transformer Substation"

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Abstract

The development and construction of power network is the key business affecting national interest and people's livelihood and the development of substation is the important component of that. This paper starts from the concept and importance of "two-type transformer substation", combines the current status of Chinese transformer substation, research in the two aspects of environment-friendly and resource-conserving, build the corresponding index system and research, which provides some assistant effect on implementing the development and construction of "two-type transformer substation".

Keywords: Transformer substation, Environment-friendly, Resource-conserving, Index system

Introduction

According to the proposal of "two-type society" in National "The Eleventh Five-Year-Plan", State Grid Corporation of China proposed the spirit of "two-type three-fresh", namely resource-conserving, environment-friendly, new technique, new material, new craftwork. The concept of "two-type transformer substation" is proposed based on the above theory, namely "resource-conserving, environment-friendly", which is helpful for saving resources, protecting environment, extending advanced techniques and new materials, reducing the engineering cost, realizing the harmonious coexistence of the development of transformer substation and society, driving the developing policy of all kinds of businesses and promoting the development of social economy.

Reference (Peng, Bo. 2005) summarizes the transmission engineering construction of large American and Japanese electric power companies, which include the construction of Japanese Ultra-high Voltage, Indian HVDC transmission line and Thailand GIL. Reference (Yin, Yonghua. 2009) introduces the green level of construction of power networks and the methods adopted for constructing the green power grids of resource-conserving, ecological protection, standard specification, advanced techniques and high economic efficiency. Reference (Zhao, Biao, Han, Feng, Ji, Xiaoling. 2008) introduces the necessity of constructing "two-type" power grids proposed by State Grid Corporation of China according to the current status of the construction of power grids, proposes the initial index system of constructing "two-type" power grids and discusses some aspects of new techniques, the development of power grids and environmental protection.

What we should do to evaluate the fruit of constructing "two-type transformer substation" effectively? Now we do not have the quantitative index system, therefore, the effect of constructing the transformer substation is not evaluated yet. This paper combines the whole process of constructing transformer substation, considers all kinds of influencing factors and does comprehensively analysis to study the evaluating index of constructing "two-type transformer substation" and evaluate combining the special testing cases, which provide the uniform evaluating standard for constructing "two-type transformer substation".

1. The current situations of the development and construction of China's substation

At present the development tendency of the power transmission line in China is based on 220kV power system, the 500kV power network structure is becoming mature gradually and developing ultra-high voltage technology. The 750 kV transformation demonstration project in northwest district marked our country's AC power transmission project has entered world advanced range. In the aspect of high voltage direct current transmission, after ±500 kV Geshang DC transmission project is completed and put into production in 1990 and the DC transmission project in construction put into operation, the total length of our country's ±500 kV DC transmission project has reached 4691km and ranked in the world in scale. The development target to build 1000kV ultra-high voltage power system put forward by State Grid Corporation of China shows the transmission voltage grade is improving continuously. With 1000kV UHV power transmission project from Jincheng to Jingzhou via Nanyang completed and put into production from 2009 to now, the first 1000kV UHV AC pilot project, which is developed, designed and constructed by China independently with independent intellectual property rights, has been in safe and steady operation for one year. Our country has formed two kinds of principal voltage series including 1000/500/220/110/10/0.4kV and 750/330/110/10/0.4 kV. The grid structure of power system and the transmission capacity have been strengthened further and the capacity of cross-regional resource allocation optimization is improved greatly.

Currently, the construction of extra-high voltage power grid project has obtained periodical development and the "one-special four-big" developing strategy will be carried continually for the future, which aims to enhance the capacity of optimizing resources. According to the requirement of forming "two vertical two horizontal", the

construction of extra-high voltage power grid and large energy bases is pushed to realize the harmony development of power grid and power source(Du, Zhigang. 2008).

The investment on power grid of State Grid Corporation of China has increased to 213.02 billion yuan in 2007 from 78.76 billion yuan in 2003. The accumulative investment is 672.05 billion yuan, which accounts for 30% of electric power investment. Among the investment of power grid, 330kv and above accounts for 26%, 220kv accounts for 42.8% and 110kv and below accounts for 42.8%. The property of 220kv and above of the company has increased to 38.1% in 2007 from 34.2% in 2003 and the configuration of power grid property has improved further.

2. The environment-friendly evaluation index system of "two-type transformer substation"

The environmental affection of transformer substation is the potential difference existing between transmission lines, high-tension apparatus and ambience during the operation, which may produce low frequency electromagnetic radiation, meanwhile, the electromagnetic noises produced by the conductor surface of **power transformer equipment** discharging to the air around and corona discharge resulting from the manginess or damage of insulators may bring radio interference; domestic sewage produced by the watch men in the power station, mainly washed and fecal sewage, may affect the water environment. The vegetation deterioration and soil erosion which may exist in the constructing period may affect the environment during the operation.

2.1 The environmental influencing factors of "two-type transformer substation"

The main influencing factors include the below aspects:

(1) The influence of electromagnetic environment

The main environmental problem of constructing project of power networks is the influence of electromagnetic environment, therefore, the affecting index of electromagnetic environment is the index which can reflect the influence of planning environment mostly. It mainly includes **power frequency** electric fields, **power frequency magnetic fields** and radio interference.

1) The power frequency electric fields around transformer substation

The electric energy is transferred depending on the moving electric charges, while the electric field and magnetic field existing in the electriferous electric transmission and transformation equipment is produced by the moving charges carried on the conductors. A changing magnetic field produces a changing electric field and a changing electric field produces a changing magnetic field. The superstratum of power distribution equipment in the power station are crossed lines and the substrate contains all kinds of electriferous equipments and connecting lines. The poles are extremely complex and have a lot, around which a extremely complex high electric field forms, which bring some magnetic field producing some magnetic radiation around the environment in the power station. The electric equipments, lines, armour clamp and insulators may all produce local corona discharge and are the corona radio interference source.

2) The power frequency magnetic fields around transformer substation

The intensity of power frequency magnetic fields is used to evaluate the intensity scale of the magnetic field of one point around the space on some direction and the corresponding measuring unit is A/m. The intensity of magnetic field can be denoted by the intensity of magnetic induction and the corresponding unit is T. The magnetic induction of power frequency magnetic fields produced by the electric transmission and transformation equipment is commonly very small, which is denoted by mT or μT. Currently, the level of magnetic field measured in the high voltage transmission line and transformer substation is commonly below the public exposed limit.

3) The radio interference of transformer substation

The high frequency electric field produced resulting from corona discharge by the leads of transmission lines may disturb the broadcast and communication of radio. When the lines are put into operation at first, the level of radio interference is high resulting from the defection of lead surface produced during the process of manufacture and construction. Along with the increase of running time the interfering level will gradually decrease and reach stable after a period of time. The radio interference of transmission lines is affected largely by the weather and season and the interfering level in a rainy day is about higher 17—24 dB than that in a sunny day.

The radio interference of equipments are produced mainly by power transformer equipments such as transformer, reactor and breaker, disconnector and generatrix. The electric current resulting from radio interference is generally considered to discharge along with the in and out lines of transformer substation because of small scale of equipments.

4) The environmental influence of SF 6

SF 6 has the good **arc extinction** and insulated capability, but it may produce decompositions of toxic substances to the atmosphere because of the action of high temperature electrical arc, which can bring pollution and breakage to the existent environment. The discharge of nitrogen can largely reduce the influence to the

environment.

(2) The influence of acoustic environment

The electromagnetic noise generated by electromagnetic equipment and transmission line may effect acoustic environment. For power system project, the noise influence of high-voltage power transmission line is very little and the problem of noise mainly appears in the substations. Current substations take a lot of technological measures to reduce noise, for example, the extensive use of low-noise generator transformer.

The noise of the equipment of substation in operation is generated mainly by large energy transformation equipments such as transformer, reactor, filter and so on. The noise of transformer is made up of the noise of transformer and the noise of auxiliary cooling equipments. Electromagnetic noise is produced by core magnetostriction vibration under the magnetic flux and it increases with the increase of power and radiates from transformer to outside especially the noise will become stronger while sympathetic vibration generates. The fan of transformer mainly includes air power noise, mechanical noise from machine shell, tube wall, motor bearing et.al and the solid noise from vibrations radiation. The vibration of transformer is delivered from base ground to neighboring architectural structure and the noise which causes their vibration is called "the secondary noise".

The sources of noise not only include the noise of equipment in operation but include the noise in the construction of substation, which are mainly the noise from construction machinery and the construction site noise, especially for the substation in the city the noise in the period of construction has rather severe influence on surrounding's inhabitants.

(3) The influence of ecological environment

The main aspects of the impact of substation's construction on ecological environment:

1) The impact of land resource use. The choice of the location of substation has impact on land use: the implementation of the project of substation will take certain land resource inevitably, in which includes basic farmland protection areas and may affect agricultural production; The construction of substation may restrict or alter neighbouring land-use patterns and functions, which may lead to vegetation deterioration with limits.
2) For the environment sensitive areas such as natural preservation zones, scenic spots, the world nature and culture heritage sites, the source of drinking water and basic farmland protection areas et.al, the construction of the substation should be prevented in sensitive area and get the approval from the administrative department with corresponding level. Meanwhile it should try to avoid taking farmland and forest and wireless interference area such as wireless launch pad. Besides, the choice of location should try to be far away the inhabitants.
3) The various pollutant emissions generated by the operation of substation mainly include domestic sewage, waste water (refer to comprehensive standards on waste water emission) and solid waste et. al as well as oil pollution of transformer brought by the construction and the operation of substation with various voltage classes in service. In normal circumstances, the electric equipments such as transformers, HV reactor et.al don't often leak oil and there is also no abandoned oil. But when examining and repairing the abandoned oil may occur. Meanwhile the pollution in the process of construction of substation mainly includes the waste water, waster residue, solid waste, dust, massive and the domestic sewage of constructor et.al.

2.2 Environment friendly index system of "two-model substation"

Based on the identification of environmental impact, combined the specific implementation situations of the project of substation with regional environment protective aim, referring to the foreign study result, according to the four kinds of main influence of the construction of substation on environment, here gives the environment impact assessment indicator system of power system project as shown in figure 2.1 below:

According to the indicator system given above and mutual relevance between the indictors, the article confirms specific standards of each indictor which mainly put forward higher requirements based on original environmental impact standard and aiming to the development and construction of environment friendly "two types power system", ensuring the environment friendly aims of the construction of substation through the harmonious development with environment.

3. The evaluation index system of resource-saving construction of "Two-oriented substation"

The resources of substation during construction period main includes materials consumed in practical project main body such as medium sand, stones, cement, steel bar, water, electricity, coal, oil and so on. In the aspect of resource conservation, the conservation work on the construction site is done well and the electronic equipments are marked with labels of water saving and power saving so as to avoid waste and form a good habit of opening anytime and shut up immediately after using them. In addition, to do well in the power saving of mechanical equipments in the construction stage, to ensure save resources and reasonably optimize and lay out the site materials under the premise of quality and efficient work. Meanwhile during the operation of substation, to plan the site reasonably and improve the watchmen's water and power saving consciousness.

There are some problems in the construction of substation including high proportion of investment in equipment, complex construction materials in the process of construction and many impact factors in the construction situations. The participants of construction include mainly construction unit, working unit, designing unit, supervision unit and equipment manufacturer et.al. In the current building market, general construction contract will stipulate the construction materials are purchased by second party and the electricity equipments are purchased by the first party. The second party fulfills according to the first party's requirement of equipment strictly so in the construction of substation, the resources conservation mainly includes adopting reasonable construction technique, advanced construction methods and technical materials while taking the impact factors during construction period into account reasonably. So the resource conversation in the construction is realized under the control of the construction side and the owner unit mainly plays a role in supervision and inspection. Because the research content of the article is the development and construction of "two-models power system" mainly, the indictors adopted in the article mainly includes resource conservation analysis from the view of construction unit considering the conservation of substation equipment, the conservation of land, the conservation of electricity, the conservation of water and the evaluation of other resources' conservation.

3.1 The types of resources of "two-modes substation"

Substations are classified into hub substation, regional once substation, regional twice substation and terminal substation according to their positions and roles in power system. According to the location of installation substations are divided into outdoor substation, indoor substation, underground substation, cubicle-type substation and mobile substation. According to duty ways they are divided into attended substation and unattended substation.

The resources types of substation are divided mainly into such aspects as power transformer equipment analysis, land analysis, water analysis, electricity analysis and so on (Cao, Shuchun. 2009).

(1) Substation equipment resources. The equipment which plays a role in transforming voltage in substation is transformer. Besides the equipments of substation includes switching device, bus bar which is used for collecting current, mutual inductor used for measuring and controlling, meter, protective relaying devices & lightning protection devices, power dispatch and communication system et.al. Some substations have reactive-load compensation equipment. The main equipments and connection methods of substations are different according to different functions. In the transformer room the main equipments of substation are divided into duplex winding, three-winding and auto-transformer, electric current and the voltage transformer, the circuit breaker, the isolator, the switch-disconnector, the high-voltage fuse and mine equipment. Current main circuit breaker includes Sulphur hexafluoride circuit-breaker and air circuit breaker.

(2) Land resource mainly means the area of land which is occupied by the construction main body of substation. To implement resource conservation and environment friendly in all round in order to realize largest social profits, there are three aspects as follows:

a. to plan systemically and take standards as pilot to change traditional electric layout and abolish traditional building structure forms. To spread general design of civil engineering and beauty design in accordance with local conditions so as to coordinate it with city development and surrounding environment and integrate into natural environment.

b. to implement building energy conservation, materials saving, water saving and land saving policies, the structure is safe with accurate degree and the durability of the building coordinate with the operation life of substation in order to make the structure of the building light. In the aspect of substation design, carry out innovative design. Substation adopts sand-stone ground and the main control building adopts industrial design. The construction adopts Shimizu wall technology and materials of energy-saving environmental protection, which embodies the essence of industrial facility.

c. Change cast in situs, masonry, paint to assembly quickly according to standard technology after industrial standardized quality control; Change series construction to parallel construction; Simplify and purify construction site accordingly and reduce dust, noise, sewage pollution and water resource consumption. The main body of building and wall adopt prefabricated construction. The field base, pillar, beam, board and roof frame arrive all at once so as to cut down half construction period.

(3) Water resource, mainly means the water used in the process of construction and after going into operation. The water used in the process of construction includes mainly the water used in the site and fire fighting. The temporary water in the site includes mainly the water used for production, life and fire fighting. The water used for life mainly means the water used for life in site and in the living area. The water used in the operation of substation mainly includes daily life water and some water demand in the production.

(4) Electricity resource mainly means the electricity used in the constructional machinery and electric equipment, the electricity used for life in the process of construction and the electricity consumed in all kinds of spare auxiliary equipments in the operation of substation.

3.2 the index system of resource saving "two-model substation"

The introduction of the index system of resource-saving "two-mode power system" substation is below:

(1) Equipment saving mainly means to make a comparative analysis according to the preliminary design estimation of the equipment and the investment change after completion acceptance and find out the percentage and scope of changes in order to evaluate the degree of saving through the scope of changes.

(2) The conservation of land resource is mainly realized by saving and optimized measures of electricity layout method, the construction area of unit investment and main building. Main electricity layout method should make a professional analysis according to preliminary design to ensure whether there is design optimization and saving plan. To make use of the construction area of unit investment to analyze the proportion of land resource saving in the total investment and make an analysis on the changes of the proportion between preliminary design estimation and final accounts design after completion. To make use of the ratio between land area and total investment to make analysis on whether there is problem of saving land.

(3) The conservation of water resource is analyzed through the discrepancy between the designed value and the actual value of water for life, water for production, the water in the construction site and the water for fire fighting, and the change of the demand of substation is reflected by the actual change of the demand of water. The difference of water demand=actual water demand-designed water demand. Different substations have different volumes so the indictors adopted in the article will be analyzed combined with the volumes of substations.

(4) The analysis of electricity resource is mainly in line with construction machinery electricity, power equipment, household demand and auxiliary facility consumption and its analysis is the same as water resource, which is mainly from the difference of electricity resource=actual power consumption-designed power consumption while make an analysis according to different substation volumes.

4. Conclusions

The development aims of "two-model substation" which are put forward based on the analysis of the current situations of the development of substation and "two societies" begin with the analysis of main resource-saving and environment friendly impact factors and establish the evaluation index system of "two-model substation" so as to play a very good auxiliary analytical role in the development of "two-type power system".

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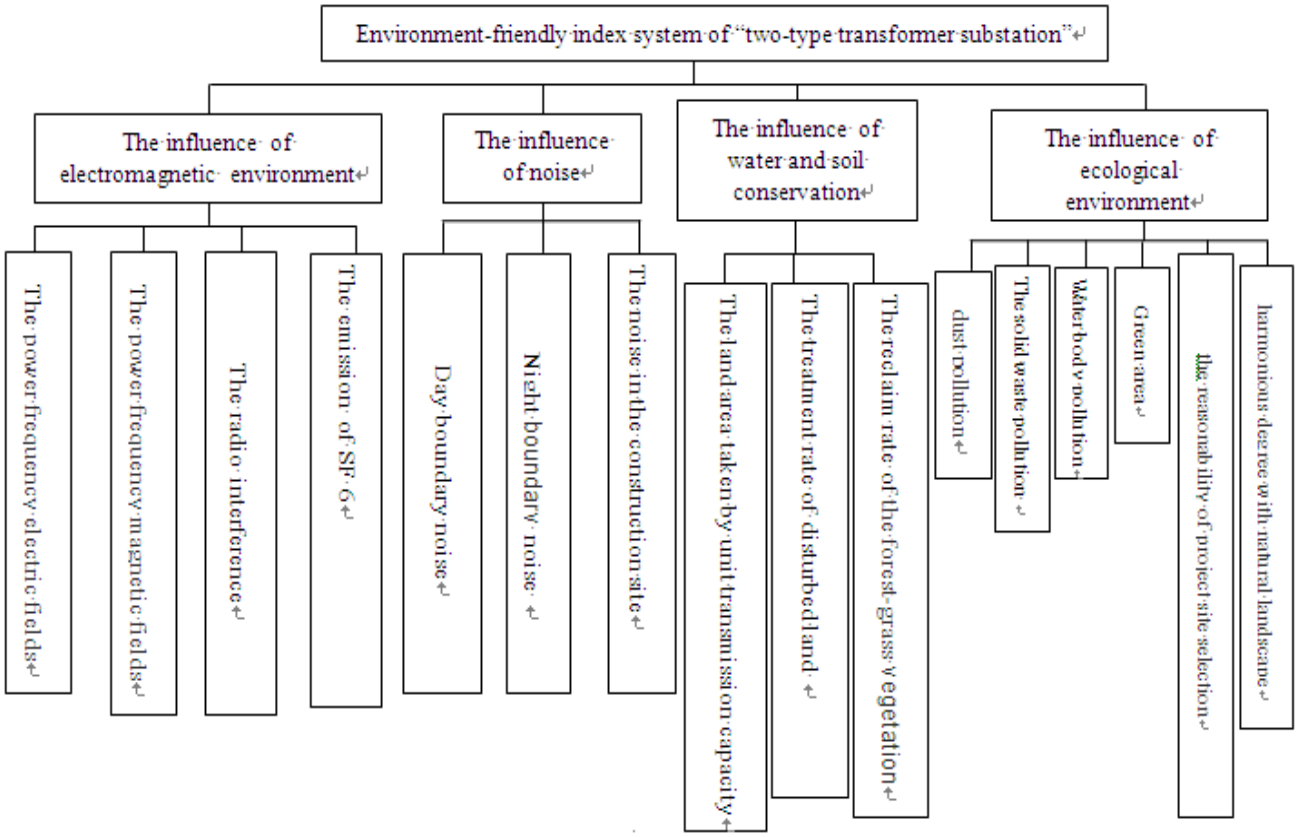

Figure 2.1 The environment impact assessment indicator system of power system project

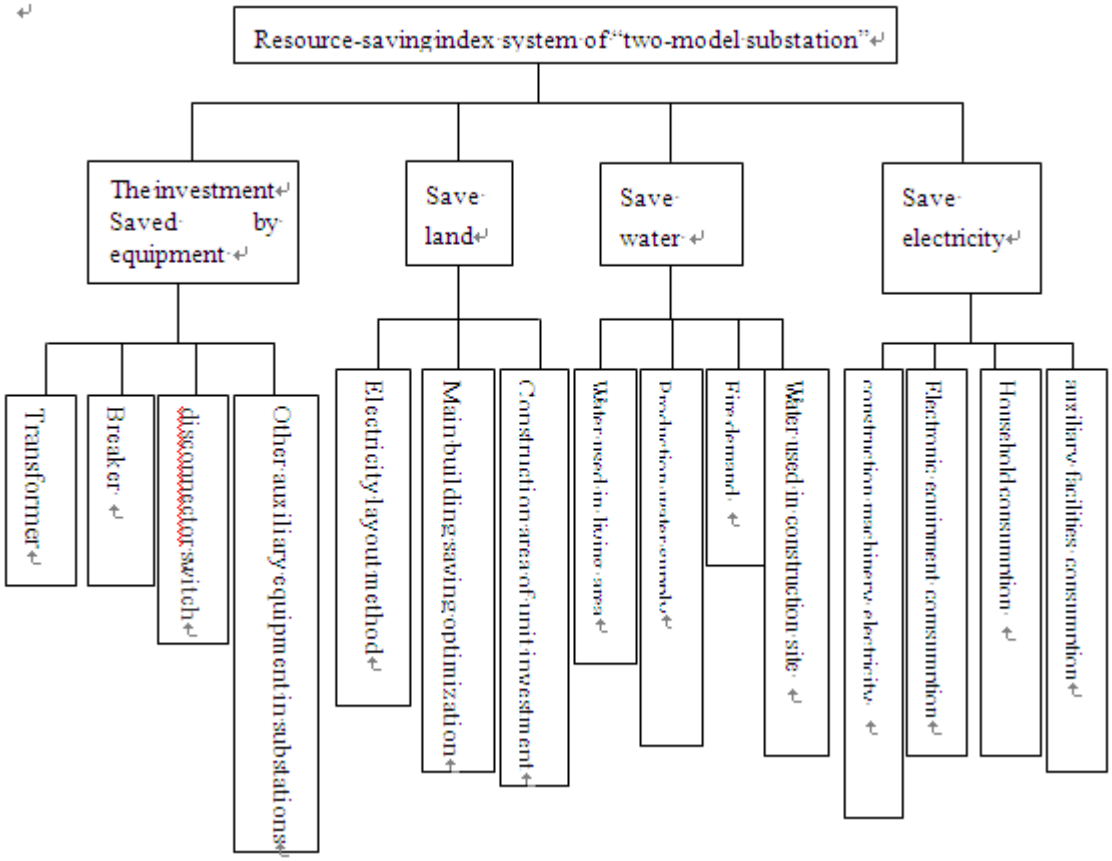

Figure 3.1 The index system of resource-saving substation project