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PLANNING OF POWER DISTRIBUTION NETWORK CONSIDERING GENERATION EXPANSION

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Abstract

The addresses of multistage distribution network expansion planning considering the power generation. The generation are utilized to save the peak demand and to reduce the planning cost. Load forecasting is considered to evaluate the impacts of the generation on the planning. . The model considers the stochastic natures of distributed generation and load in the power systems. More importantly, this model addresses the probabilistic voltage constraints in the network expansion planning stage. The problem is formulated as a constrained mixed-integer, and nonlinear programming. Simulation results demonstrate the effectiveness and viability of the proposed method to consider the generation in distribution network expansion planning. The uncertainties related to power generation and load response growth must be taken into account in order to plan a safe system at a minimum cost. Thus, two different methodologies for uncertainties incorporation through the use of multiple scenarios analysis are proposed and compared. The multiple objectives optimization algorithm applied in the model takes into account the costs of reliability, losses, power imported from transmission, and network investments. The results indicate that integrating the generation in distribution network expansion planning reduces the planning cost significantly, as well improves the technical parameters of the network such as bus voltages and line loading.

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Keywords: Dynamic programming, generation expansion,geographic information systems,mixed-integer linear programming, power network planning, routing.

I. INTRODUCTION

The expansion planning problem of power systems is highly important because of the growing needs on electricity. The discrete nature of the installation states of new power facilities makes the power system expansion planning problem a large-scale mixed integer programming model. The power system expansion planning problem includes generation expansion planning and transmission expansion planning as two distinct problems. Recently, more and more studies have focused on the coordination of generation and transmission expansion. Nowadays, increasing concern son environmental protection have attracted interests of the public opinion. Environmental impacts need to be carefully considered in power system planning problems. However, it is a challenging issue due to complex and diverse environments. Existing literatures usually ignore or simplify the impacts of complicated environments by assuming that locations of candidate generators and routes of electric power lines are given. Although this assumption avoids the computational complexity brought by the complicated environments, it increases the gap between the planning and the erection because of ignoring the environmental information. Geographic information systems (GIS) organize, analyze, manage, and present all types of geographical data efficiently, which have a significant potential in solving spatial power system expansion planning problems with the consideration of complicated environments By using vector graphics for representing concrete objects, such as regions and infrastructures, studied the optimal electric line routing problem in the vector map. However, there are two major drawbacks with the vector map: 1) non-concrete environmental elements, such as weather, sunlight, and pollution, may not be easily represented in vector graphics; 2) irregular vector graphics used in the vector map bring difficulties for developing comprehensive methodologies on power network expansion planning problems. Reference presented a dynamic programming (DP) approach for automated power lines route selection in a raster map. In, by dividing the map into square cells, a sitting methodology incorporating the GIS technology, the statistical evaluation methods, and the stakeholder collaboration was developed for producing quantifiable and consistent transmission line sitting decisions.

I. RESEARCH PROBLEM

Although the line routing, the generation sitting, and the power network planning have been studied using the raster map and GIS data, integrating power network expansion with generation expansion while considering complicated environmental information in raster map is still an open challenge. Generally, the objective of power system planning in regulated environment is to economically serve the future demand, while satisfying system reliability requirements.

In restructured electricity markets, however, the misaligned interests of stockholders, participants, independent system operators, and customers make the power system planning an even tougher challenge.

The proposal initiated in has been extended to illustrate the importance of the selection of the economic criteria for planning transmission investment. By investigating a two-node network, revealed how financial transmission rights affect generation firm's incentives to support transmission expansion, while indicated that an optimal open-loop transmission investment policy has a multi period structure.

II. OBJECTIVES OF THE PROJECT

We proposes an MILP formulation on co-optimized generation and transmission expansion planning problem based on a raster zed map in regulated environment. Therefore, the strategic interaction between power generation expansion and power transmission expansion decisions is ignored. In order to relieve the huge computational burden brought by the electric line routing, a two-step approach is presented. DP is applied to solve the optimal line routing in the first step. The second step solves a MILP problem for obtaining the final optimal generation and transmission planning strategy based on the optimal electric line routes derived from the first step. The major contributions of the paper are as follows. Candidate plants could be built on any cell in the map, which means that terminals of candidate lines connected to candidate plants are not fixed.

This is a remarkable difference between this paper and the existing literatures in which terminals of candidate lines were fixed.The holds one assumption that for a candidate line connected to a candidate plant only one terminal is moveable and the other terminal is a fixed-location bus in the existing power grid. It can be justified by identifying that candidate lines with two moveable terminals directly connect two candidate plants, which is not common in real world.

III. SCOPE OF WORK

The scope of project at first focused on the proposed two-step approach would derive the same global optimal solutions as those by solving the original formulation directly.

Thus, the two-step approach can significantly improve the computational efficiency while maintaining the solution optimality, and is more suitable for the raster map with high resolutions.

V.IMPROVED FORMULATION

The formulation proposed in Section II integrates optimal investment and routing decisions of candidate lines, optimal investment and siting decisions of candidate plants, as well as the power network security evaluation. The complicated optimal electric line routing introduces considerable computational challenges in the proposed formulation, especially when considering relatively high resolutions in the raster map. To solve the co-optimized spatial power network expansion and generation expansion problem in a reasonable computation time, a two-step approach integrating MILP with DP is presented. That is, DP is first applied for solving the optimal electric line routing problem, and the second step solves the remaining MILP problem for the co-optimized power network expansion and generation expansion with optimal electric line routes from the first step.

A. OPTIMAL ELECTRIC LINE ROUTING BASED ON DP

DP is a suitable optimization technique for solving the optimal line routing problem using the GIS raster structures. The sequence of cells along a line route represents the stages in the DP terminology, and the accumulated transition cost between the two neighboring cells of $c_{i,j}$ is optimized in the objective. From any starting cell, if optimal routes of $c_{i,j}$ the eight neighbor cells of are known, the optimal route of can be determined.

The DP optimization process selects the consecutive stages by choosing the cell links that would lead to the minimum accumulated transition cost over the entire map. That is, one single DP process can obtain all optimal routes between the origin cell and all other cells over the entire map.

Terminals of all candidate lines are given as input parameters except those connected to candidate plants. Since additional candidate lines connected to candidate plants are to integrate plants into the existing power moveable and the other terminal is a fixed-location bus in the number of fixed-location terminals.

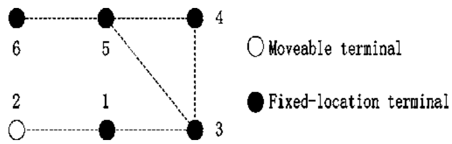

Figure1.simple network example

B. MILP PROBLEM WITH OPTIMAL LINE ROUTES

With the optimal line routes obtained via DP, the co-optimized spatial power network expansion and generation expansion problem can be reformulated by eliminating the line routing related constraints. Furthermore, the line length equation and the line investment cost equations are reformulated for candidate lines with two fixed-location terminals. Similarly, for candidate lines with one moveable terminals can be reformulated to indicate that the investment cost and the length of a line with two fixed-location terminals depend on the line installation state, while that the investment cost and the length of a line with one moveable terminal depend on the line installation state and the location of the candidate plant to which it is connected.

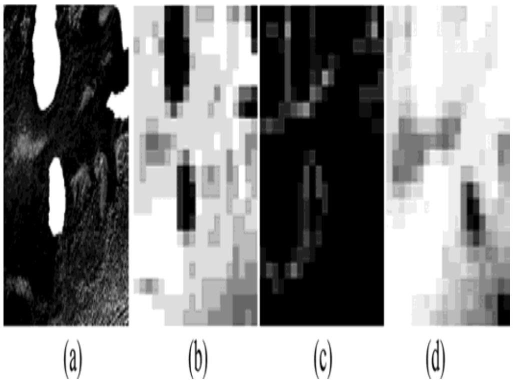

Figure2.image and raster maps of planning region

The DP optimization process selects the consecutive stages by choosing the cell links that would lead to the minimum accumulated transition cost over the entire map. That is, one single DP process can obtain all optimal routes between the origin cell and all other cells over the entire map. The details of the DP-based optimal electric line routing problem can also be found in.

VI. OVERVIEW OF ETAP SIMULATION

Simulation is well suited for educational purpose. It is an efficient way for designer to learn how a circuit and its control are working. It is normally much cheaper to do a thorough analysis than to build the actual circuit in which component stresses are measured. A simulation can discover the possible problems and determine optimal parameters, increasing the possibility of getting the prototype. New circuit concepts and parameter variations are easily tested. Destructive tests that cannot be done in the lab, either because of safety or because of costs involved, can easily be simulated. Response to faults and abnormal conditions can also be thoroughly analyzed. The software tool used for the simulation studies is ETAP.

ETAP is a high performance language for technical computing. It integrates computation, visualization, and programming in an easy to use environment where problems and solutions are expressed in familiar mathematical notation .ETAP is the most comprehensive analysis platform for the design, simulation, operation, and automation of generation, distribution, and industrial power systems.

ETAP Energy Management System (EMS) is a suite of energy management software tools used to monitor, control, and optimize the performance of generation and transmission systems. This intelligent energy management software control system is designed to reduce energy consumption, improve the utilization of the system, increase reliability, predict electrical system performance, and as well as optimize energy usage to reduce cost. ETAP (EMS) Energy Management System applications use real-time data such as frequency.

There are many objectives of energy management software, including an application to maintain the frequency of a Power Distribution System and to keeping tie-line power close to the scheduled values.

In ETAP's Energy Management System, scheduled values will be maintained by adjusting the MW outputs of the AGC generators so as to accommodate fluctuating load demands. The energy management software application will also calculate the required parameters

The 4-bus system shown in Fig. 3 is applied for comparing optimal solutions derived from the original formulation (OM)

The existing system is shown with solid lines, and candidate facilities are shown via dashed lines. Capacities of all lines are 100 MW. Capacity of existing plant 1 is 300 MW, with the variable cost of 45 $/MWh. Capacity of candidate plant 2 is 100 MW, with the variable cost of 30 $/MWh. For simplicity, one load block is considered, with the magnitude of 2.9 times of the base load and the time duration of 8760 h. The base load of D1 is 40 MW. The base load of D2 increases from 0 MW to 66 MW. Optimal line routes derivedfrom OM and IM are compared in Fig. 4, when the base load of D2 is 54 MW. In Fig. 4, all fixed buses are shown with red squares, and locations of moveable buses for new plant installations are represented as red circular frames. Curves with different colors indicate optimal routes of constructed lines.Capacity of existing plant 1 is 300 MW, with the variable cost of 45 $/MWh. Capacity of candidate plant 2 is 100 MW,with the variable cost of 30 $/MWh. For simplicity, one load block is considered, with the magnitude of 2.9 times of the base load and the time duration of 8760 h. The base load of D1 is 40 MW. The base load of D2 increases from 0 MW to 66 MW. Optimal line routes derived from OM and IM are compared in Fig. 4, when the base load of D2 is 54 MW. In Fig. 4, all fixed buses are shown with red squares, and locations of moveable buses for new plant installations are represented as red circular frames. Curves with different colors indicate optimal routes of constructed lines.

Image map of the planning region is rasterized by 20× 20 cells. Accumulated costs of lines and plants are shown in Fig.2(b)and (c), respectively. Altitude information of cells is shown in Fig.2(d). Table I lists the colors as well as their corresponding accumulated costs and altitudes. The 4-bus system shown in Fig.3 is applied for comparing optimal solutions derived from the original formulation (OM) and the improved formulation (IM).

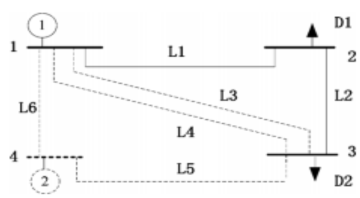

Figure 3.the 4-bus system

VI. CONCLUSION

The spatial power network expansion planning considering generation expansion, which explores optimal generating plant sizing and siting as well as the optimal electric line investment and routing, and integrates them into the power network evaluation in the raster map.

- Easy to consuming of equipment loading of cable in line parameters to analyzed.
- To analysis of a load foresting to reduce of a future demands.
- Reduce an estimation cost.
- Significantly improve the computational efficiency, and is more suitable for the raster map with high resolutions.

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