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Optimal Power Distribution System Planning and Analysis Using Q-GIS and Soft Computing

Shabbiruddin, Sikkim Manipal Institute of Technology, Sikkim Manipal University, Gangtok, India
Sandeep Chakravorty, Indus University, Ahmedabad, India
Karma Sonam Sherpa, Sikkim Manipal University, Gangtok, India
Amitava Ray, Jalpaiguri Government Engineering College, Jalpaiguri, India

ABSTRACT

The selection of power sub-station location and distribution line routing in power systems is one of the important strategic decisions for both private and public sectors. In general, contradictory factors such as availability, and cost, affects the appropriate selection which adheres to vague and inexact data. The work presented in this research deals with the development of models and techniques for planning and operation of power distribution system. The work comprises a wider framework from the siting of a sub-station to load flow analysis. Work done also shows the application of quantum-geographic information system (Q-GIS) in finding load point coordinates and existing sub-station locations. The proposed integrated approach provides realistic and reliable results, and facilitates decision makers to handle multiple contradictory decision perspectives. To accredit the proposed model, it is implemented for power distribution planning in Bihar which consists of 9 divisions. A Cubic Spline Function-based load flow analysis method is developed to validate the proposal.

KEYWORDS

Cubic Spline Function, Power Distribution Planning, Power Map, Q-GIS, STING

1. INTRODUCTION

Method/Analysis: Statistical Information Grid (STING) algorithm is used for clustering of load points and finding optimum location of sub-station. Quantum- Geographical Information System (Q-GIS) is used for finding shortest route of distribution line from sub-station to load points. Work also includes an improvised method for solving nonlinear equations based on Cubic Spline functions, used as load flow analysis in this paper for validation of the developed model.

Findings: The proposed model will help power distribution system planners to increase efficiency and reliability of power distribution. Proposed method can replace the traditional way of location of sub-station and feeder routing in an efficient way.

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Novelty/Improvement: Use of clustering algorithm will replace the traditional way of finding optimal location of sub-station. Algorithm finds location of sub-station at the centre of load points, which has advantage of having shortest route of feeder from load points to sub-station.

GIS use in feeder routing will help to determine shortest route considering all the technical restrictions like sag and land elevation, also avoiding geographical restrictions like river and mountain.

Load flow analysis method using cubic spline function presents an easy and efficient way for validation of the present work. IEEE 33 bus system is used to test the methodology.

Workflow of research in this paper is as mentioned: First work is to analyze the power distribution system of Bihar State consisting area of nine divisions Tirhut, Saran, Purnia, Patna, Munger, Magadh, Kosi, Darbhanga and Bhagalpur. All nine divisions of Bihar are studied for identifying existing sub-stations and load points. Location identification with analysis of load demand will help in finding probable locations of sub-station (probably less in number).

Feeder routing should be with shortest route done by considering all possible restrictions like mountain and rivers in Bihar. Cost and losses can be minimized by optimizing the feeder route. Further, Load flow analysis will help in validation of result.

Chakravorty and Ghosh, 2009; presented an approach to locate sub-station having minimum distance from load points. Further, 'Analytical Hierarchy Process (AHP)' technique is used to connect various load points.

Feeder routing is done in the present work is by using Geographic information System (GIS); it would provide realistic approach in feeder routing.

Chakravorty and Ghosh, 2009; developed a mathematical model for planning of power distribution systems. Feeder line routing is performed on assumed load points on X-Y axis. Factors considered for feeder line routing in this paper are length of conductor, per year feeder failures, per year customer interruption, per year maximum interruption and cost.

Geographic Information System (GIS) is used in the present work to provide the realistic optimized feeder routing path.

Movarej and Rad, 2014; presented an approach for solving power sub-station planning problem using three clustering algorithms: Fuzzy C-Means (FCM), Possibilistic C-Means (PCM) and Hard C-Means (HCM). Objective functions considered in the paper are: i) Cost of power losses in feeder and substation ii) Cost of installing a new substation, iii) Cost of installing a new feeder and Cost of expanding an existing substation.

For clustering the load points STING based clustering could also be used as shown in the present work, which has following advantages over other clustering algorithms: i) Query independent and ii) STING facilitates parallel processing and incremental updating of data.

Kumar, Phunchok and Sood, 2012; presented an approach using GA siting of sub-station and optimal routing of feeder line. Minimal length of distribution lines is considered for feeder routing to reduce cost. Authors have quoted that this kind of approach because of uncertainties associated with future load, is more appropriate for rural areas. Also, GA serves only as a tool for formulating general guidelines for system planning, as assumption is done considering the area with no presence of electrical network.

Kumar, Krishan and Sood, 2013; presented an approach for optimizing annual cost investment for feeder line as well as sub-station with cost of operation. This feeder routing mechanism at the backdrop of GIS would have provided the realistic feasibility and robustness to this approach.

Luo and Semlyen, 1990; proposed compensation method meshed networks which are weak. It broke interconnection points using compensation method so that meshed system structure could be changed to simple tree-type radial system. Adaptability of this method is not encouraging to decide break points, as heuristic method is used. Load conditions at break points may cause difficulties in convergence of load flow analysis.