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Role of spatial analysis technology in power system industry: An overview

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ABSTRACT

Power system networks are the largest and most complex systems ever devised by human being. The networks are associated with huge amount of investments where the success of the sector heavily depends on appropriate planning and management. Spatial analysis technologies play very important role in planning, monitoring, and managing of the network by comprehensively considering social, environmental, and economic issues. Spatial analysis, the heart of geographic information systems (GIS) provide an integrated platform for proper management and planning of power systems. The major role of GIS technology includes: (i) developing spatial model for power generating stations, transmission networks, and distribution substations; (ii) determining suitable locations for power generation and distribution stations, and optimal routing of transmission networks; and (iii) integrating renewable energy resources with the planning and management system. Parallel to GIS, global positioning systems (GPS) has introduced new dimensions in spatial research because of its increasing availability with reduced price. The integration of GPS in data measurement techniques made a paradigm shift in (i) monitoring of the power system network with time synchronized data and (ii) finding fault locations as well as taking corrective actions with better accuracy. This paper investigates the evolutionary role of GIS and GPS technologies in different components of power system networks. These technologies are expected to provide a smart and promising platform for integrating virtually all the relevant information and systems required to develop and maintain a sustainable power system networks at local, national, regional, and global levels.

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1. Introduction

Spatial analysis is the heart of geographic information system (GIS), which is a computer aided system. The system helps users to capture, check, process, store, analyze, predict, update, and display/present spatial data related to positions on surface of the Earth. It is capable of presenting different kinds of data on one map as well as helps users to understand patterns, trends and relationship [1–5]. Although the spatial technology was initially limited to cartography, the widespread use of computer along with pervasive nature of spatial technology has been contributing to the development of integrated three-dimensional spatial and temporal model based expert systems including augmented reality. The increased availability and flexibility of the technologies have been encouraging widespread applications even in the developing nations. As almost every sizes and types of organizations get benefited from GIS technology, successful implementations of it has been well documented in different sectors of engineering such as construction scheduling and progress control [6], forest assessment [7], land use and cover mapping [8–11], natural hazard and biodiversity mapping [12,13], natural resources and disaster management [14,15], environmental protection [16,17], selection of tourist spots [18,19], mobile computing [20,21], power system planning [22–24], transportation modeling [25–27] and decision making process [28]. Parallel to GIS, Global Positioning System (GPS) is an operational navigation system based on earth-orbiting satellite to provide three-dimensional position worldwide with precise and standard global time [29–31]. GPS has many special features like depiction of location by longitude, latitude and altitude, precise timing, determining distances, working in any weather condition and so on. Due its attractive features it can also be used for a wide range of applications such as in surveying, logistics, traffic management, marketing, fishing, banking, weather forecasting and assisting power system monitoring and protection [30].

Power system networks generally consist of generating units, transmission routes, distribution substations, distribution feeders, and consumers. The modeling of the geographical dimension of a power system network plays a very vital role in power system planning and management. Additionally, integration of new customers, generating units, substations as well as managing the network for optimal usages, monitoring the networks and finding the fault locations are very frequent phenomenon for power system industry which can also be managed in a very efficient way with the proper utilization of GIS and GPS technologies. The application of GIS in power system networks is demonstrated in [13], whereas the applications of GIS in generation, transmission and distribution services as well as optimal scheduling and dispatching of loads are reported in [32–39]. Because of environmental issues and shortage of fossil fuels, the policy makers throughout the world have been forcing power system industries to integrate renewable energy sources to the networks. Accordingly, the application of GIS can also ease the work of designers in appropriate planning for integrating those sources [40–42]. GIS can be used for better operation of smart grid [43]. In general, the implementation of GIS is prevalent in different parts of power system as summarized in Fig. 1. On the other hand, GPS has been contributing to (i) monitoring and measurement of wide area of power networks and (ii) determining the fault locations in transmission and distribution grids [44–46].

The objective of this paper is to review the role of spatial analysis technology in Power System Industry (PSI) in determining suitable places of system components with maximizing assets. The rest part of the paper is organized as follows: Section 2 illustrates the applications of GIS technology in traditional power system industry i.e., selection of optimal generation sites, identification of optimal transmission routes and selection of best locations for distribution substations. Section 3 demonstrates how renewable and clean energy resources can be assessed and managed with minimal cost by considering socio-environmental factors. The role of GIS technology in the decision making process of electricity markets is analyzed in Section 4. Section 5 presents the application of GPS technology in protecting and securing power systems. The last section briefs the relevant concluding remarks.

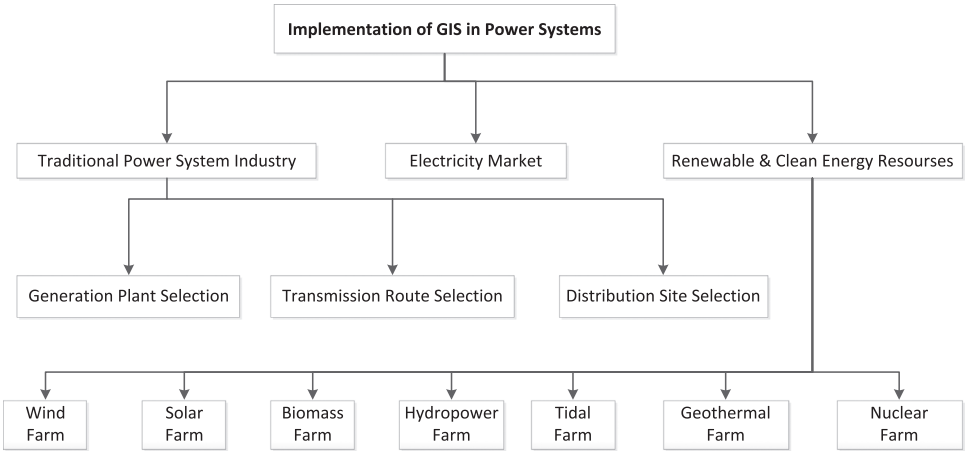

Fig. 1. Implementation of GIS in power system industry.