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Decision support system for operation, scheduling and optimization of hydro power plant in Jammu and Kashmir region

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ABSTRACT

In operating a complex hydroelectric system in a competitive market the operational as well as the financial risks are high. Decision makers and operators unarmed with rigorous analysis tools and techniques could cause their organization to pay dearly for their decisions. Traditionally the main objective of the system operator was to secure a stable supply of electric power to meet the local system load demand while meeting the system physical and operational constraints. The major driving force in making operating decisions was to ensure the availability of sufficient energy and capacity to meet the system demand while also meeting the non power requirements and operational constraints. This article presents Decision support system (DSS) under Availability Based Tariff Regime for operation, scheduling and optimization of the Sewa Hydro Electric Plant (SHEP) situated in Jammu & Kashmir state of India was developed to assist the SHEP operations engineers in order to improve the operational efficiency of the Sewa hydro system and to make optimal or near optimal operational and trading decisions while meeting the constraints. Use of the software can result in significant improvements to daily energy production and revenues. The hydro power plant historical operation and production is analyzed and baseline methodology of the historical operation is established. Based on the implementation of DSS on actual project site (SHEP), the DSS has demonstrated to be stable and managed to give reliable decisions. The optimal exploitation of the available hydro resources in the State combined with the minimization of the environmental impacts would not only meet the State's demand, but will supply power to the Northern grid to boost the overall development of the State. Also, provide support for sustainable development.

Contents

1. Introduction . . . 1100
2. Study area and data set . . . 1102
3. Various features of decision support system . . . 1102
4. DSS description . . . 1103
   4.1. Inflow module . . . 1104
   4.2. Plant operation module . . . 1105
   4.3. Administration module . . . 1109
   4.4. Demand module . . . 1109
   4.5. Help module . . . 1112
5. MAXSTATION . . . 1112

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6. Conclusion 1112
Acknowledgement 1112
References 1112

1. Introduction

Hydro power is a renewable economic, non polluting and environmentally benign source of energy. Hydro power stations have an inherent ability for instantaneous starting, stopping, load variations, etc. and help in improving reliability of power system. Hydro power stations are the best choice for meeting the peak demand. The utilization of hydro-resources efficiently plays an eminent role in the planning and operation of a power system where the hydro power generation plants contribute a significant part of the total installed capacity. There has been, therefore, an ever increasing need for more and more power generation recently in all the countries of the world. Running costs of the hydropower installation are very low as compared to the thermal stations or the nuclear power stations and the hydraulic turbines can be put off and on in a matter of minutes. Hydroelectric projects have long useful life extending over 50 years and help in conserving scarce fossil fuels. They also help in opening of avenues for development of remote and backward areas. Hydro plants play an important role within the power system security due to their fast response characteristics. The need for DSS for operation, scheduling and optimization of hydro power plant arises due to the following reasons: First, deregulation of the electric industry all over the world increased the complexity of decision making problems, because the system operator is no longer only concerned with operating the system efficiently to meet the load, but also has to make tradeoffs that maximize the value of resources under their control, while respecting all of the physical and operational constraints. Second, the methods for hydroelectric scheduling have become fairly reliable and are becoming a necessary component of the daily operations of organizations. Third, computer technology (both hard and software) has become advanced and user friendly such that the average operator is becoming accustomed to and willing to use them. Fourth, the time spent on preparing the schedules could more productively be spent on other more important tasks (such as attending to emergency situations). Fifth, both the financial and operational risks are too high for any rational operator to handle unaided. Sixth, the hydroelectric scheduling problem is very complex and its solution requires several sophisticated computer models to be developed and linked in a coherent and conceptually correct approach. In managing a complex hydroelectric system, a set of policies, objectives and operational procedures in an organization is usually formulated to direct the system operator in making the day-by-day operational decisions. The operational procedures could typically reflect the policies and objectives of the organization and they could lay out rules and regulations, which in effect outline the way decisions should be made. From operational as well as optimization point of view the hydropower system is very complex. This complexity is due to the non-linearity of the objective function. Optimal operation of hydropower systems, reservoirs and associated power stations depends on a large number of variables and constraints, which interact in a number of combinations. Therefore, it is extremely complex to derive in advance, a universal operating policy that would allow optimal operation in all situations. Real-time optimization using software overcomes the problem by analyzing each combination of variables as it happens in real-time and provides an optimum operating rule for each particular situation. The derived operating rule can be applied immediately. Decision support system (DSS) presented in this article is a software tool to be used for real time operation scheduling and optimization of the Sewa Hydro Electric Plant situated in Jammu & Kashmir state of India. If the requisite data is supplied accurately in terms of value & time and generation is done as per suggestions of the software then it will result in profitability to the generator. DSS conception was first proposed by American Scholar Morton [1]. Over the last 30 to 40 years, major advances have been made in the development and use of a wide range of tools to assist in the planning and management of complex water resource systems. DSSs are intended to provide water resource managers with assistance in making rational decisions. DSS refers specifically to computer tools and there is no common definition of it. For example, DSSs are computer-based tools having interactive, graphical and modelling characteristics to address specific problems and assist individuals in their study and search for a solution to their management problems [2]. Likewise, new advances in computer technology have enabled system engineers to combine software and hardware in an integrated fashion called a DSS, which helps managers/engineers to make better decision [3–4]. Since the early 1980 s, DSSs have been widely used in the area of water resources planning and management [5]. In recent years, many basinwide water resources management tools have been developed that included a module for reservoir operation simulation, such as IRAS (Interactive River-Aquifer Simulation), TERRA (Tennessee Valley Authority Environment and River Resource Aid), CTIWM (Cooling Technology Institute Water Management), and RiverWare [6]. Many of these are generalized packages for simulation purposes, but are limited in capability for development of optimal operation policies and water allocation schemes for the site-specific systems. Besides these general bundles, many investigators have developed decision support systems for site-specific reservoir operation planning.

The application of DSSs for operation of power systems in South Korea, Iran and New England power systems has been discussed in [7–8]. In general the structure of a DSS consists of three components: a hydrologic model, an optimization model and a fuzzy decision model, which was developed to determine reservoir releases in an uncertain environment during the dry season [9]. A control model can be used to determine the dependable power capacity of hydropower systems. The model structure consists of a turbine load allocation module and a reservoir control module and allows for a detailed representation of hydroelectric facilities [10]. A general DSS called Vista for operation of hydropower reservoirs that presents the results of the application of this system to the Nova Scotia power system has been described in [11]. Other case-specific systems for Manitoba [12], British Colombia [13], and Quebec (in Canada) are more focused on short-term planning. This article presents a decision support system for reservoir operation under ABT regime for Sewa Hydro Electric Plant, India. The main objective of the DSS is to provide more flexibility and consistency in supporting the decision making process for operation of hydropower reservoirs. Also the DSS assists the operator in the optimum allocation of flow amongst multiple water turbines existing in multi generation unit hydro projects, to optimize operational efficiency, especially for the optimal generation, scheduling of the run-of-the river project in a multipurpose context.

The rest of the article is organized as follows. Section 2 introduces the study area and data set. Section 3 presents various supporting features of the DSS. Section 4 describes various modules such as inflow module, plant operation module administrative module and help module with different facilities for the real time operation of hydro electric power plant which has been incorporated into the DSS. Section 5 describes MAXSTATION which is an interface between operator/engineer and process control environment Finally, Section 6 outlines the conclusions.