Reactive power pricing structure for hydroelectric power station in condenser mode operation

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\textbf{A B S T R A C T}

Reactive power support is critical for system security and pricing of reactive power is a vital issue in restructured environment. Peaking units at hydroelectric power plant in condenser mode operation can provide major reactive power support. Therefore costing structure for hydroelectric power plant incorporating various cost components in condenser mode operation is presented in this paper. Major cost components include capital cost component, changeover cost component and a cost component related to number of service hours in condenser mode operation. A methodology is proposed based on these components. A case study of Koyna Hydro Electric Power Plant (KHEPP) is elaborated.

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1. Introduction

Reactive power is vital in maintaining voltage support and transfer of active power flow. Reactive power support needs to be provided for secured operation of the system. Synchronous machine can provide reactive power support by changing its excitation. Due to the advancement in design and manufacturing technology of a salient pole synchronous machine, it is possible to operate it in condenser mode with a quick changeover. Conventionally various devices such as static capacitors, synchronous condensers, shunt reactors, FACTS devices are employed for management of reactive power in the system. The capital and operating cost of synchronous condensers may be comparable with static VAR compensators. A synchronous condenser can supply a large amount of reactive power up to twice its continuous rating during power swings. It also has 10–20\% overload capacity up to 30 min [1]. Some hydro generators can operate as synchronous condensers [2]. During 1998 an insufficient reactive reserve at some locations was the major cause of outages in USA. This could have been avoided if some of the hydro generators could have functioned as synchronous condensers [3]. A feature of low speed, salient pole synchronous generator at hydroelectric power plant to operate in condenser mode with a wide range of under excited and over excited capability can be fruitfully employed for reactive power management.

In vertically integrated system, a separate reactive power costing and pricing is not done as electricity tariff for consumers covers the cost towards reactive power support. However a separate reactive power pricing becomes necessary in a restructured environment. Substantial work is reported in the literature towards concept of reactive power pricing, algorithms and procedures for reactive power pricing, reactive power marginal price and reactive power markets [4–13]. Researchers have also made contributions for reactive power costing and pricing for generators [14–16]. It is stated that the Transmission Administrator (TA) pays one generation firm to provide voltage support by operating its hydro units in synchronous condenser mode [17]. Developing an appropriate reactive power costing structure for synchronous machines at hydroelectric power plant operating in generator and condenser mode operation is necessary. In present restructured environment, the reactive power pricing structure for hydroelectric power station in condenser mode operation is yet to be developed. In this paper, a pricing structure is proposed when reactive power support is exclusively provided by hydroelectric unit in condenser mode operation. Participation of reactive power support by thermal power plant is not considered in this work. The methodology developed for reactive power pricing for hydroelectric plant for condenser mode operation is applied for Koyna Hydro Electric Power Plant (KHEPP).