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Cost based reactive power participation for voltage control in multi units based isolated hybrid power system

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Abstract

Multi units of wind and diesel based generators in isolated hybrid power system have technical and operational advantages over single units system. They require dynamic reactive power compensation for fast recovery of voltage under load and input changes. In developing countries like India, investors' prime concern is to provide continuous electricity at low rate while quality degradation can be permitted within pre defined acceptable range. The use of static compensator along with dynamic compensator may give cost effective reactive power participation for system. This paper presented pricing of reactive power compensation under steady state and transient conditions of system with fixed capacitor and STATCOM. The main contributions of the paper are; (i) evaluating reactive power balance equation for generalized multi units of wind and diesel based isolated hybrid power system, (ii) reactive power compensation using fixed capacitor and STATCOM in presence of composite load model, (ii) fast recovery of voltage response using genetic algorithm based tuning of STATCOM controller, (iii) evaluation of reactive power compensation cost for steady and dynamic conditions due to probabilistic change in load and/or input demand and (iv) comparison of results with existing reference compensation method.

Keywords: Multi units isolated hybrid power system; Static and dynamic reactive power compensators; Composite load model; Voltage control; Cost based reactive power participation

1. Introduction

In India, distribution of energy resources and consumption centres are extremely unbalanced. The load centres are scattered at far-off places away from resource rich areas. This leads a huge and complex requirement of a transmission system between the generating units and consumers at load centres. Due to which grid connected power system is not economically feasible for remotely located locations. Therefore, high transmission and distribution losses, rapid

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Nomenclature

ΔP_{SG}	Incremental change in real power generated by synchronous generator
ΔP_{IG}	Incremental change in real power generated by induction generator
ΔP_{L}	Incremental change in real power absorbed by load
ΔQ_{SG}	Incremental change in reactive power generated by synchronous generator
ΔQ_{IG}	Incremental change in reactive power absorbed by induction generator
ΔQ_{L}	Incremental change in reactive power absorbed by load
ΔQ_{ST}	Incremental change in reactive power generated by STATCOM
ΔQ_{FC}	Incremental change in reactive power generated by fixed capacitor
V	Load terminal voltage
ΔV	Incremental change in load voltage due to load and/or input disturbances
$(D_v)_{CLM}$	Transfer function of reactive power change to voltage change for composite load model
X_m	Magnetising reactance referred to stator side in induction generator
Q_{FC}^{SS}, Q_{ST}^{SS} and Q_{ST}^{ts}	Reactive power by fixed capacitor and STATCOM at steady state and transient sate
$C1(x)$ and $C2(x)$	Cost function of FC and ST

growth in energy demand especially for far located remote area based consumers and distribution network congestion encouraged the use of renewable based decentralized generating units for rural areas based consumers (Ministry of Power, 2015). Government of India is also promoting to Private investors for installing distributed generating units because of technical and economical limitations of supplying grid connected power system at such far located rural areas (Ministry of Power, 2013).

Due to fluctuating nature of renewable energy sources and increasing cost of non-renewable energy sources, wind diesel based isolated hybrid power system (IHPS) is the most convincing options to supply electricity for these areas (Tao et al., 2015). In such systems, single or multi units of induction and synchronous generators can be connected in parallel for fetching power through wind and diesel respectively (Kassem and Yousef, 2011). Multiple generation units can be incorporated to improve operation performance and benefit from quantities of scale benefits (Xie et al., 2011). In most of the papers, available on multiple generating units in power system, the main thrust is on their optimum sizing, operational issues and technical benefits. On the basis of technical benefits, multi units systems in IHPS have been recommended in literature (Jahanbani and Riahy, 2011). Still the economical issues of multi units system are not touched by the researchers yet.

Private investors' participation in installing renewable energy system (RES) can be better understood through Fig. 1. It has also been noticed that 88% renewable energy sources are installed by private investors in India (Nfaha et al., 2007). The participation of private investors lead a competition in providing electricity and therefore remuneration for ancillary services become more important in the system. One of the important issues in such isolated hybrid power system is the remuneration according to the requirement of reactive power for steady state as well as dynamic state operations.

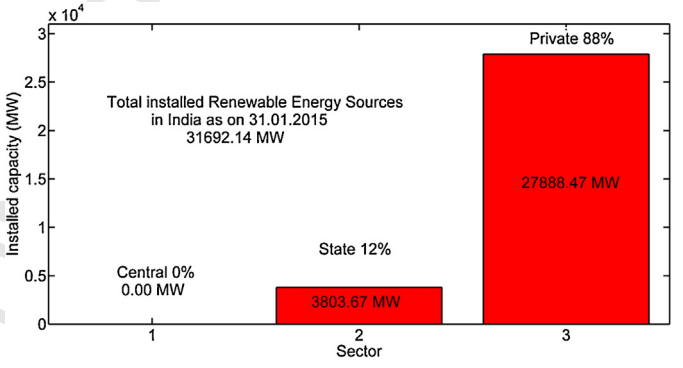

Fig. 1. Participation of different sectors for installing renewable energy system in India.

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