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ORIGINAL PAPER

Combined design and load shifting for distributed energy system

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Abstract Renewable distributed energy generation (DEG) system plays an important role in future power developments and is one of the options to reduce energy consumption. It is envisaged that energy efficiency of DEG systems can be improved via load shifting (LS). This study proposed a heuristic-based numerical approach to perform LS analysis on renewable stand-alone DEG systems. The technique is an extension from a method known as the Electric System Cascade Analysis (ESCA). The new technique, which focuses on efficient electricity utilisation is able to determine the optimal: (i) load profiles, (ii) capacity of power generator, (iii) capacity and power of energy storage (ES) and (iv) charging/discharging schedule of ES. The stage-wise technique allows user to compare and determine the optimal design in a flexible way while having a better understanding of the selection of options. The application of ESCA-LS on a case study revealed that after incorporation of direct LS (load manipulation) in addition to LS by ES (supply manipulation), the power generators and ES capacity can be further reduced. While reduction of 3.1 % for solar-PV installation area and 3.9 % for biomass power generator is recorded, ES power-related capacity and energy-related capacity managed a higher reduction of up to 19.0 and 13.2 % for the main case study

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Keywords Distributed energy generation (DEG) · Load shifting · Renewable Energy (RE) · Power Pinch Analysis (PPA) · Energy storage (ES)

Introduction

Distributed energy generation (DEG) system [small localised energy generation system (Ghosh et al. 2012) is a pronounced platform to stimulate developments of renewable energy (RE) and is also one of the best options to combat issues of global energy sustainability and global warming worldwide (Topkaya 2012). Although large-scale integration of DEG system into the current power grid may yet be economically feasible, deployment of DEG especially stand-alone DEG in remote areas (Marsden 2011) and islands system (Cosentino et al. 2012) had been increasing. Increments of DEG system in these areas are mainly due to difficulty or non-viability of grid connection or simply due to unjustified cost of constructing a transmission lines from a centralised grid. Countries which provided DEG for rural electrification includes Kenya (Bernard 2012), China (Bhattacharyya and Ohiare 2012), India (Liming 2009) and Brazil (van Els et al. 2012), among many others.

Apart from DEG systems, load shifting (LS), a demand-side management (DSM) technique had been a matter of studies since 1980s (Iglesias et al. 2012). LS is a technique applicable to all utilities globally 'whether large or small; cooperative, municipal, or investor-owned; and urban or rural' (Gellings 1985). In a large-scale centralised grid network, LS is mainly practiced for curve flattening or peak shaving purposes. In cases of stand-alone DEG, depending on the system (type of operating units) itself,