Optimal design and modelling of stand-alone photovoltaic-wind hybrid system with adaptive-fuzzy controller *

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SUMMARY: *This paper proposes an optimal approach for design of a hybrid photovoltaic (PV)-wind generating system with adaptive-fuzzy controller, which is based on discrete optimisation and energy balance calculations. The total capacity of the renewable system is determined based on estimated annual power consumption, average wind speed and sun radiation. Different structures of each unit are examined, and a discrete cost function is defined and optimised to determine the minimum number of PV and wind units. To improve system reliability under different operating and environmental conditions, a self-adjustable controller capable of maximum power point tracking (MPPT) of PV units and blade angle pitch control of wind turbines is designed, and energy balance calculation is performed. Using reference adaptive tables, the fuzzy controller allocates each decision unit and activates the required number of units in each farm to supply the average demand power. Simulation results are used to show the validity of the design and system behaviour under different environmental and loading conditions. Main contributions are the inclusion of renewable system configurations, capacities, environmental factors and maximum power point tracking in the optimisation procedure, as well as the utilisation of an adaptive-fuzzy controller.*

1 INTRODUCTION

Considering the rapid consumption of fossil resources, renewable energy systems are about to have a greater share in future energy supply. Alternative energy sources are inherently non-polluting, free in their availability and continuous (Green, 1982). However, their applications are limited due to high initial cost and reliability issues (Hill & Baumann, 1993; Ashok, 2007). An easy and effective solution to overcome the energy crises is to directly convert solar energy to electricity using photovoltaic (PV) technology (Algora & Diaz, 1998; Ogawa & Aratani, 2002). Other methods, such as wind power plants, fuel cell batteries and solar-heat plants, are also considered and are usually combined with PV energy in order to improve system performance and reliability (Chen & Liu, 2001).

An important and growing concern is the optimal design and control of renewable hybrid systems. Different approaches with the combination of two or more renewable energy resources are possible (Masoum & Mousavi, 2002a). The most important issues about these environmentally-friendly systems are optimal design and control with low cost, high reliability and acceptable power quality (Fahmy, 1996; Celik, 2003).

Nowadays, PV and wind generators are widely use in many applications such as water pumping, illumination, electricity supply in outlying areas (Wu et al, 2000) and supplying communication systems. To include power shortage capability, diesel generators have been considered (Abdin et al, 1999). However, considering the importance of

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