A Stand-Alone Hybrid Power System with Energy Storage

Abu Mohammad Osman Haruni
B.Sc. (BUET), M.ScEng. (University of Tasmania)

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Centre of Renewable Energy and Power Systems (CREPS)
School of Engineering
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Abstract

Small-scale hybrid stand-alone power systems are becoming popular alternatives in remote and island areas where grid connection is not economically or technically viable. Harnessing the abundant supply of wind and solar energy can play an important role in ensuring an environmentally friendly and clean energy generation for remote and isolated communities. However, renewable energy sources are intermittent in nature, and as a result, power generation from renewable energy sources often may not necessarily match the load demand. Therefore, energy storage is required to ensure reliable power supply.

Hybrid power systems with renewable sources can provide efficiency, reliability and security, while reducing operational costs. However, the main challenge of hybrid power system applications is satisfying the load demand under constraints. Therefore, proper control and coordination of each energy generation unit is vital. It is also important to ensure robustness of the energy management system to avoid system black-outs when power from the renewable energy sources is not adequate to support all loads.

This thesis proposes a novel operation and control strategy for a hybrid power system for a stand-alone operation. The proposed hybrid system consists of a wind turbine, a fuel cell, an electrolyzer, a battery storage unit and a set of loads. The overall control strategy is based on a two-level structure. The top level is the energy management and power regulation system. The main objective of this system is to ensure a proper control and coordination of the system. It also controls load scheduling during wind variability under inadequate energy storage to avoid system black-outs. Depending on wind and load conditions, this system generates reference dynamic operating points to low level individual sub-systems. Based on these operating points, the local controllers manage the wind turbine, fuel cell, electrolyzer and battery storage units. The local controller of wind turbine extracts the reference power from the varying wind by regulating the rotor speed. The fuel cell is controlled by using a hydrogen regulator and boost converter, and the electrolyzer via a buck-converter. A bi-directional dc-dc converter is employed to control charging and discharging of the
battery storage system. The proposed control system is implemented with MATLAB Simpower software and tested for various wind and load conditions. Results are presented and discussed.
Authorship

The work continued in this thesis has not been published or previously submitted for a degree at this or any other educational institution. To the best of my knowledge, this thesis contains no material previously published or written by another person except where due reference is made.

Signed………………..
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List of publications

Refereed journal publications

- Gargoom, AMM and Haruni, AMO and Haque, ME and Negnevitsky, M, ‘Smooth synchronisation and power sharing schemes for high penetration wind diesel hybrid remote area power systems’, *Australian Journal of Electrical & Electronics Engineering*, 8 (1) pp. 75-84.

Refereed conferences publication

- Haruni, AMO and Gargoom, AMM and Haque, ME and Negnevitsky, M, ‘Dynamic Operation and Control of a Hybrid Wind-Diesel Stand Alone Power

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