

POWER ENERGY MANAGEMENT AND
CONTROL FOR ISOLATED HYBRID
PV/ENERGY STORAGES MICROGRID
SYSTEM

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DOCTOR OF PHILOSOPHY

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I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Doctor of Philosophy

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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Microgrid System

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ABSTRAK

Pada masa kini, penggunaan sumber tenaga boleh diperbaharui (RES) dalam kelas mikrogrid telah mendapat perhatian dalam membekalkan tenaga kepada pengguna. Pelaburan yang melibatkan tenaga boleh diperbarui dilihat sebagai satu pelaburan jangka panjang yang mendatangkan keuntungan dengan kadar pelepasan CO₂ yang rendah. Penyediaan tenaga elektrik ke kawasan yang jauh dan terpencil melalui grid utama menelan kos yang tinggi. Pada masa yang sama, permintaan kepada penggunaan tenaga elektrik bertambah saban tahun disebabkan perkembangan populasi setempat. Tesis ini mencadangkan topologi mikrogrid PV baharu di kawasan terpencil dengan menggunakan tenaga solar PV, simpanan tenaga bateri beserta penjana diesel sebagai sumber tenaga sandaran. Strategi pengurusan tenaga kuasa (PEM) digunakan untuk mengurus sumber tenaga dan mengawal aliran kuasa kepada permintaan beban. Objektif mikrogrid PV adalah untuk menyediakan tenaga elektrik di kawasan terpencil tanpa gagal yang dapat meminimumkan impak ketidak tentuan tenaga yang dihasilkan oleh tenaga solar, kesan kepada alam sekitar dan ianya beroperasi dalam penilaian ekonomi yang mampan sepanjang tahun operasi. Dua PV sistem yang berlainan kapasiti beserta dengan dua bateri tenaga simpanan dicadangkan penggunaannya dalam kajian ini. Langkah pertama, saiz kapasiti bagi sumber input (PV dan simpanan tenaga bateri) di formulasi berdasarkan saiz mikrogrid yang dicadangkan. Rujukan kawalan arus dicadangkan untuk menguruskan nilai arus pengecasan dan nyahcas bateri dengan cekap. Algoritma pengurusan kuasa kuasa PEM kemudiannya dicadangkan untuk mengoptimumkan penggunaan sumber tenaga (PV dan bateri). PEM juga boleh memastikan operasi mikrogrid berfungsi dengan cekap. Tambahan pula, parameter bateri seperti peratusan kadar mengecas dan nyah cas tenaga (SoC% dan DoD%) di pertimbangkan untuk memanjangkan tempoh hayat bateri. Perbezaan hasil dapatan microgrid PV yang dicadangkan dengan topologi microgrid PV tradisional dibentangkan. Prestasi seperti pengendalian bateri, penjanaan solar (PV, bateri dan penjana diesel) diplot dan dibandingkan untuk analisis secara terperinci di perisian Matlab/Simulink. Penilaian ekonomi bagi mikrogrid PV yang dicadangkan dan PEM dianalisis dan dibandingkan dengan mikrogrid PV tradisional. Keputusan menunjukkan peningkatan yang ketara dari segi prestasi penjanaan tenaga solar mikrogrid dan kadar kecepatan ciri pengecasan dan nyahcas bateri walaupun terdedah dengan sisi kelemahan solar . Penilaian ekonomi dijalankan melalui operasi jangka panjang (berdasarkan jangka hayat kemerosotan PV). Ia telah menunjukkan pulangan pelaburan (ROI) yang munasabah dua kali lebih cepat daripada mikrogrid tradisional.

ABSTRACT

Nowadays, renewable energy sources (RES) use in the microgrid environment has gained attention for supplying energy to the end-users and cost-effective investment for a long period with zero CO₂ emission. Providing electricity requires voltage transmission from the primary grid to the remote areas, which is sometimes not cost-effective based on the areas' location and give impact towards environment. Simultaneously, since the population keeps growing, it also has a continuous demand for the electricity supply year by year in the rural or remote areas. Therefore, the introduction of an isolated microgrid in remote areas is appropriated. This thesis proposes a new isolated PV microgrid topology at remote areas using PV and battery energy storage with the diesel generator as a backup energy source. The power energy management (PEM) strategy is employed to manage energy sources and control the power flow to the load demands. The objective of isolated PV microgrid is to provide reliable electricity at isolated areas that can minimize the impact of PV solar intermittent factor, environment and work in economic assessment through long-term operation years. Two small PV power plants with different capacities are proposed with two batteries bank of energy storage. First, the approach comes with the analytical formulation sizing of the input sources (PVs and batteries energy storages) based on the proposed isolated microgrid size. The reference current control is proposed for efficiently manage the charging and discharging batteries. The PEM control algorithm is then proposed to optimize the usage of energy sources (PVs and batteries). The PEM also could ensure the operation of the isolated microgrid working efficiently. Furthermore, the battery energy storage characteristics (SoC% and DoD%) are considering to maintaining the life span of the battery. To verify the proposed isolated PV microgrid, a comparison with the traditional isolated PV microgrid topology is presented. The performance such as battery operation, input voltage usage (PVs, batteries, and diesel generator) plotted and compared for detailed analysis in Matlab Simulink environment. The economic assessment of the proposed isolated PV microgrid and employment PEM are analysed and compared with the traditional isolated microgrid. The results show a significant improvement in terms of isolated microgrid performances that reflected from the intermittent PV power production, management of battery charging/ discharging characteristic and time recovery of speed for the energy storage. The economic assessment is carried out through a long-term operation (based on the life span of the PV degradation). It has shown a reasonable return of investment (ROI) two times faster than the traditional isolated microgrid.

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