National Institute of Technology Rourkela

Progress Seminar

Seminar Title	: Power Management and Hierarchical Control of PV Fuel-cell DC Nano-grid
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Venue	: EE401, 4th Floor Electrical Engineering Department, Electrical Science Building
Date and Time	: 02 Apr 2025 (05:00 PM)
Abstract	: In recent years, solar photovoltaic-based DC nanogrids have become increasingly popular for applications such as EV charging, residential and commercial power supply, particularly in remote and off-grid locations. However, the intermittency of solar energy requires the use of energy storage systems to ensure reliable operation. Conventional battery energy storage systems are bulky, have limited capacity, and exhibit slow dynamic response. In contrast, fuel cells offer higher energy density, lower emissions, and a more compact design but suffer from slow response time. This study explores the integration of PV, BESS, and proton-exchange membrane fuel cells in a standalone DC nanogrid, resulting in a more sustainable and efficient energy solution. Moreover, a dynamic power management scheme for efficient power sharing and seamless operation of a standalone DC nanogrid feeding isolated DC load is simulated. The PMS compares generated power to reference power for seamless mode transition and the dual loop controller produces current reference for the DC-DC converter current controllers of the FC, battery, and supercapacitor. A low-pass filter is employed to distinguish between average and fluctuating power components for the battery and SC respectively. The PEMFC operates only for a limited duration, preventing excessive sizing and reducing overall system operational costs. Moreover, supercapacitors are beneficial in hybrid energy systems for stabilizing the DC bus voltage, especially in applications with rapid and frequent load variations. They effectively manage transients, reducing stress on the battery by minimizing transient currents. However, incorporating supercapacitors increases the system's cost, size, and complexity. In DC Nano-grid applications, where load changes are not rapid and frequent, the system can be optimized by excluding the supercapacitor as well. Instead, the battery alone will regulate the DC bus voltage, reducing both cost and complexity. Furthermore, a techno-economic analysis is carried out by utilizing the load following dispatch strategy of Homer Pro software, reveals that incorporating fuel cells reduces the levelized cost of energy by 5.1%, lowering it to 0.3510/kWh from 0.3659/kWh. Additionally, the total net present cost decreases by 4.29% compared to a system without a fuel cell. The inclusion of fuel cells also reduces capital and maintenance costs by significantly lowering battery autonomy from 36 hours to 4 hours, thereby enhancing system cost-effectiveness and reliability. The proposed work focuses on the development of PMS during different operating situations such as sunny days, rainy days and night time for optimum utilization of PV, fuel cell and HESS.