Abstract

Renewable energy sources, such as solar or wind, have a potential to overcome some of the issues associated with high dependence on fossil fuels. However, independent utilization of renewable sources for reliable power generation is difficult because: 1) Expensive power producing and storage components are needed; 2) Renewable sources are intermittent and unpredictable. Hybrid renewable energy systems (HRES) combine multiple renewable sources, different storage options, and/or conventional components. This allows complementarity among system components to improve reliability and capital and operational costs. Designing HRES (i.e. component sizing, operational strategies, etc.) depends highly on uncertain weather resources and power demand. Moreover, with multiple generation and storage components, operating such systems requires complex logical rules that determine when and how each component should be used in the system. These rules are called energy management policy (EMP). Due to the complexity of this problem, common approaches reported in literature for optimal sizing and operation of HRES use average data for weather resources, such as a typical meteorological year (TMY) and metaheuristic methods for optimization. This treatment leads to highly suboptimal or infeasible designs because a TMY ignores inherent weather variability which has a significant effect on the system performance during real operating conditions. Moreover metaheuristic algorithms tend to exhibit slow convergence and are not guaranteed to furnish local optimal solutions. In addition, these methods do not exploit important and valuable information such as the gradient of the cost function and this makes formal verification of the solution optimality impossible. For these reasons, we intend to develop a gradient optimization method and consider weather resources uncertainties for optimal sizing and operation of HRES. In order to apply a gradient method to this problem, differentiability of HRES cost function was studied with a simple system. In general EMP decisions introduce discontinuities in the cost function for fixed weather scenarios. In contrast, it has been observed that the discontinuities can be smoothed out by expectation of the cost function. In general non-discontinuity does not guarantee differentiability of a function; however we suspect that HRES expected value function will be differentiable and if that is the case, stochastic approximation, a gradient based method can be used to optimize the expected value function. This approach has the potential for significant efficiency gains as compared with metaheuristic approaches, and furthermore furnishes true local optimal solutions. The results obtained with a tested simple system confirm this assertion. Further research will look into a more mathematical understanding and determination of necessary conditions to ensure differentiability of the expected value cost function and will seek to improve stochastic approximation algorithm, its application to more complex systems, and further comparisons with metaheuristics will be investigated.