Designing an Engineering System for Resource-Cost Optimization of Hybrid Energy Systems

By

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Abstract

This work describes the mathematical development of a resource cost optimization system for hybrid energy systems that have varying load and energy supply characteristics. The objective is to mathematically link both resource costs and future energy availabilities to the optimization process . A non-linear quadratic cost term, *'K'*, whose value is dependent on energy availability and probable future harvests is the controlling factor in the optimization process. Energy is made costlier as its availability drops for any generator within the hybrid system. This makes *'K'*, assume the position of a dynamic factor that is time dependent in two ways; that is on the present time, and on a period of 'user' defined operational interest.

The optimization algorithm is programmable over any period of energy allocations. Generators with storage provisions and different operating characteristics are linked in parallel to the load center. Energy allocations at the point of optimization would be a function of three determinants: the fuel resource cost, its current availability and the probability of its near-future availability. The resulting dynamic allocation problem is solved using a simple search technique.

Apart from the development of a quadratic cost control factor for the optimization process, there are two more novel features of this work. One relates to the development of a mathematical method to estimate non-renewability of exhaustible fuels. This relates to the opportunity losses borne by future generations by the current use of exhaustible fuel sources. The other feature developed through this work is a limiting factor on discount rates that are used on natural resources such non-renewable fuels. It is recognized in this study that the current rates of discounting will marginalize real costs of resources. Hence the development of a constraint condition to limit excessive discounting.

Extrapolated wind speeds are determined for a given site using available wind speed data. A Geographic Information System (GIS) based interface is used to provide spatial data

for a wind resource assessment. Thereby any site-specific characteristics can be linked to this program and an optimized energy allocation be carried out.

Results from the work is divided into three sections: the first is a validation section that checks the validity of the developed system in terms of mathematical accuracies and the allocation patterns of energy. The second is a cost section that reviews the energy costs that are computed. The third is a usability section that has results related to simulations of six different location from Sri Lanka and the United Kingdom that involve near-life conditions inclusive of variable loads and supply characteristics.

The results indicate that it may be cheaper to rationalize using a mix of conventional and renewable energy and by doing so, peak time energy and energy at times of resource scarcity can be made cheaper by conserving more abundant forms of energy earlier on; rather than relying on the reactive practice of using thermal energy sources such as diesel, in situations of resource scarcity. The method for computing damage and opportunity-loss costs, for non-renewable resources, reflects what present energy users may have to pay for the welfare of unborn generations.

This work is expected to be most useful in future scenario's, where renewable energy sources will become increasingly important as both a replacement and conservation measure for our limited stocks of fossil energy.