Multi-objective Design of Standalone Renewables-based Hybrid Energy Systems for Off-grid Mining

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Mining operations are often located in remote regions of the planet where grid electricity is usually unavailable, leading to heavy dependence on fossil fuels (typically diesel) for power generation. There is a desire within the mining industry to reduce this dependence due to the challenges associated with diesel generation: fluctuating operating costs, transport safety and greenhouse emissions among others. Local generation from renewables, integrated with energy storage to balance power generation and load demand, is considered to be the most promising solution to the mining industry energy problem. Deciding on the configuration and size of renewables-dependent energy systems is a balance between two contrasting objectives: cost minimisation and reliability maximisation. This work addresses the challenge of the design of a standalone integrated energy system incorporating both electrical and thermal generation and storage for heat and electricity supply to an off-grid mining operation located in remote Canada.

We consider an integrated energy system with two generation and three storage alternatives as described in Amusat et al. [1]. Models are developed for the different components of the energy system, with dynamic models incorporated for the material and energy balances of the storage alternatives, leading to a system of nonlinear differential algebraic equations (DAEs). We account for the temporal nature of the solar resource by generating probability distribution functions (PDFs) for each hour of the year from historical data, based on which random yearly solar profiles are generated to act as solar inputs for the model. System reliability, represented by the loss of power supply probability (LPSP), is evaluated based on the performance of the individual designs under the stochastically generated input scenarios. The system cost is defined as a function of the capacities of the generation and storage units. The bi-criteria problem is implemented in MATLAB and solved with an evolutionary algorithm (NSGA-II) to obtain an approximation to the Pareto-optimal front.

The methodology presented for reliability evaluation ensures that hourly, seasonal and inter-year variations in renewables are accounted for in the design of renewables-based energy systems. The system model presented is generic, applicable to any location and easily modifiable to incorporate any combination of generation and storage alternatives.

References

[1] Oluwamayowa O. Amusat, Paul R. Shearing, and Eric S. Fraga. System design of renewable energy generation and storage alternatives for large scale continuous processes. In Krist V. Gernaey, Jakob K. Huusom, and Rafiqul Gani, editors, *Computer Aided Chemical Engineering*, volume 37, pages 2279–2284. Elsevier, 2015.