Hawaiʻi Natural Energy Institute Research Highlights

Grid Integration

Holistic Optimization of Microgrids

<u>Objective and Significance</u>: The primary goal of this project is to develop an adaptable and precise model for sizing microgrid systems (Figure 1), integrating various energy resources and storage technologies, such as photovoltaic (PV) systems, battery energy storage systems (BESS), hydrogen storage tanks, fuel cells, and electrolyzers. This model employs a combination of Mixed-Integer Linear Programming (MILP) and Particle Swarm Optimization (PSO) to determine optimal configurations, considering various factors, including fixed and operational costs, load demands, and PV generation profiles. The project's comprehensive approach aims to evaluate the model's efficacy against established industry tools, to minimize grid energy purchases and maximize renewable resources penetration.

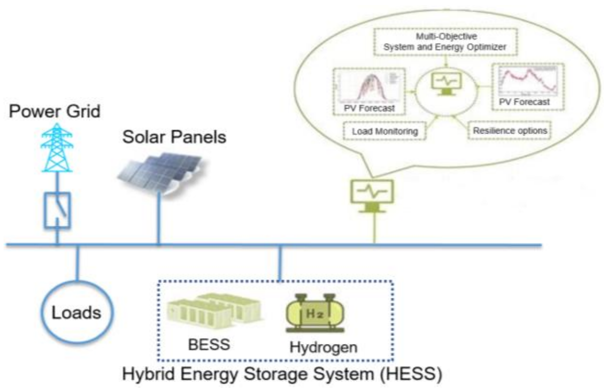

Figure 1. Microgrid with Hybrid Energy Storage (HESS).

<u>Background</u>: As microgrids become increasingly crucial in modern energy strategies, our research identified a significant gap in current optimization models. This gap is particularly evident in the integration of hybrid energy storage systems with hydrogen. Traditional systems have primarily focused on both large-scale and distributed PV and storage solutions, leaving room for improvement in more complex scenarios. Our extensive review of academic literature and industry-standard tools like XENDEE and HOMER revealed a need for more advanced modeling techniques to address these challenges.

<u>Project Status/Results</u>: To address these limitations, we are developing an innovative model that combines two powerful optimization techniques: MILP and PSO. MILP was selected for its robust ability to define optimal solutions under complex constraints, making it suitable for diverse real-world scenarios. Its effectiveness is demonstrated in Laurence Berkeley National Laboratory's Distributed Energy Resources Customer Adoption Model (DER-CAM), and it is considered the gold standard for a variety of optimization problems. In conjunction with MILP, we are implementing PSO to enhance the model's capabilities. PSO refines the search process, guiding the system toward global optima while ensuring comprehensive exploration of potential solutions (Figure 2).

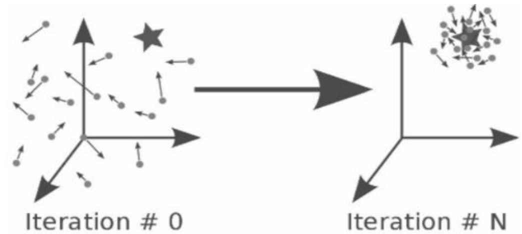

Figure 2. Particle Swarm Optimization Visual.

In our hybrid optimization model, PSO complements MILP by leveraging efficient search capabilities alongside MILP's precision. Each iteration of MILP informs PSO's heuristic function, guiding the search toward the global minimum and ensuring thorough exploration of the solution space. This integration helps avoid local minima traps and enhances the model's ability to optimize microgrid operations effectively.

Our project is currently progressing through several key stages. We are focusing on completing the development of the PSO model and will evaluate its performance using standardized PV and load profiles under normal conditions, without disruptions. Once we confirm the base model's accuracy in optimization and sizing, we will modify it to address resiliency scenarios, including critical load management, outage response, and diverse energy storage configurations. To ensure our model's effectiveness, we will conduct thorough data collection and analysis to align its performance with industry benchmarks. Finally, we plan to synthesize our findings and submit them for publication in a peer-reviewed journal that specializes in microgrid design and operation.

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Contact: Saeed Sepasi, sepasi@hawaii.edu

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