Hybrid PV–Wind–Battery–Diesel System Optimization

Using Grey Wolf Optimizer (GWO) and Particle Swarm Optimization (PSO)

Author: Dr. Davoud Moazami
Date: 2025-12-30
Email: dmoazami@yahoo.com

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1 Project Overview

This project optimizes the design of a hybrid renewable energy system consisting of:

- Photovoltaic (PV) panels
- Wind turbines
- Battery storage
- Diesel generators

Objective:

- Minimize Levelized Cost of Energy (LCOE)
- Ensure high system reliability ($\geq 95\%$)

Algorithms Implemented:

1. **Grey Wolf Optimizer (GWO)**
   - Mimics grey wolf hunting behavior (alpha, beta, delta, omega)
   - Efficiently explores and exploits solution space
   - Outputs optimal capacities, LCOE, reliability, convergence, and hourly supply plots
2. **Particle Swarm Optimization (PSO)**
   - Inspired by swarm intelligence
   - Updates particle positions based on personal and global bests
   - Outputs optimal capacities, LCOE, reliability, convergence, and hourly supply plots

2 Requirements

- **Software:** Maple (tested on Maple 2023+)
- **Libraries:** RandomTools, plots

3 How to Run

Simply run the code from the top by executing `restart;` and Maple will process the entire script automatically. All outputs, including results and plots, will be generated.

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4 Code Structure

4.1 Common Sections (Both Algorithms)

Section	Description
1. Restart and Libraries	Clears session and loads Maple packages
2. General Settings	Simulation horizon, project life, discount rate, algorithm-specific parameters
3. Design Variables	Min/max bounds for PV, Wind, Battery, Diesel; PSO includes velocity limits
4. Economic Data	CAPEX, OPEX, and diesel fuel cost
5. Technical Parameters	Unit capacities, battery efficiency, DoD, max battery power
6. Load and Resource Profiles	Hourly load, PV, and wind generation profiles
7. Auxiliary Functions	`CheckBounds` for variable limits, `CRF` for capital recovery factor
8. Fitness Function	Computes LCOE including penalties for reliability violations
9. Reliability Function	Computes system reliability using Energy Not Supplied (ENS)

4.2 GWO-Specific Sections

Section	Description
10. Initialize Wolves	Creates initial population of wolves
11. GWO Main Loop	Updates positions using Alpha, Beta, Delta influence
12. Results	Prints optimal design, best fitness, and reliability
13. Plots	Fitness convergence, reliability convergence, and 24-hour energy supply

4.3 PSO-Specific Sections

Section	Description
10. PSO Initialization	Creates particles, velocities, personal and global bests
11. PSO Main Loop	Updates particle positions and velocities using inertia, cognitive, and social components
12. Results	Prints optimal design, best fitness, and reliability
13. PSO Convergence Plot	Fitness vs iteration
14. Hourly Outputs	Calculates hourly PV, Wind, Battery, Diesel, and total supply
15. Hourly Plots	24-hour energy dispatch by source and total load

5 Key Features

- Accurate Energy Modeling: PV, Wind, Battery SOC, Diesel dispatch fully modeled
- Reliability-Constrained Optimization: Ensures ENS is minimized and reliability $\geq 95\%$

- Flexible Algorithm Selection: Run either GWO or PSO with the same model
- Visualization: Convergence plots and 24-hour energy supply plots
- Customizable: Algorithm parameters, bounds, and profiles can be adjusted

6 Notes

- PSO parameters (`numParticles`, `maxIter`, `c1`, `c2`, `w_max`, `w_min`) can be tuned for faster convergence or better exploration.
- GWO parameters (`numWolves`, `maxIter`) can also be adjusted similarly.
- Codes are designed to run fully in Maple and produce both numerical and visual outputs.

7 Contact / Support

For any questions or support:
Dr. Davoud Moazami
Email: dmoazami@yahoo.com