

Case Study 3- Optimal Retrofitting of an Existing Energy System for Min LCE

An existing PV-Diesel system ($A_{PV} = 40m^2$, $P_{D,nom} = 1k W$) is considered to be retrofitted to a Wind-PV-Battery-Diesel system with existing PV and Diesel generator but with CO_2 emission limited to 1000 kg/year.

Background Theory:

- Integrated Configuration-Size Optimisation
- Deterministic Design
- Dispatch Strategy as Design Variable
- Single Objective Optimisation
- Genetic Algorithm

The screenshot displays the MOHRES software interface with several key windows and parameters:

- Inputs Sample:**
 - InputsSample.xlsx
 - Standalone
 - Fixed
- Design Objectives/User Requirements:**

NaN	System Cost (\$)
-1	Levelised Cost of Energy (cent/kWh)
NaN	Total Blackout Duration (h)
NaN	Average Blackout Duration (h)
NaN	Maximum Blackout Duration (h)
0	Unmet Load (VWh)
NaN	MTBF (h)
NaN	Penetration (%)
100	CO2 Emission (kg)
NaN	Excess Power (VWh)
- Optimisation Parameters:**

50	GA/N\$GA IIPS: max generation/iteration
50	GA/N\$GA IIPS: population size
0.3	GA/N\$GA II: Pc
0.9	GA/N\$GA II: Pm
0.2	Margin of safety (-) (storage sizing)
1	Autonomy period (day) (battery sizing)
0.5	Autonomy period (day) (H2 tank sizing)
- GA search parameters:**

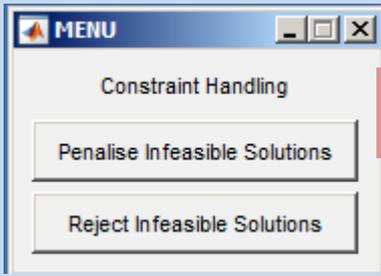
$$\min\{LCE\}$$

$$s. t.$$

$$U_t \leq 0$$

$$CO_2 \leq 100 \text{ kg/yr}$$
- Design Method:**
 - Deterministic: Storage Sizin...
 - Optimisation Method: GA Single Obj Constrained
- Set Limits/Inclusion of Design Variables:**

WT Rotor Radius (m)	0 0.1 22
PV Panel Area (m^2)	40
No of Batteries	0 2 400
Nominal Diesel Generator Size (Watt)	1000
Nominal Fuel Cell Size (Watt)	0
Nominal Electrolyser Capacity (Watt)	0
- Dispatch Strategy:**
 - Storage/auxiliary usage and charge order...
 - Include in optimisation
 - Select manually



- Reject Infeasible Solutions (this optimisation problem is not too constrained/ design space is not too rigid)

Multi-objective Optimisation of Standalone Hybrid Renewable Energy Systems under Uncertainties

Pareto Frontier **System Performance**

System Cost (\$) Versus Total Blackout Duration (h)

Power Balance Perf. @ Desired LoC PDF and PoF Distributions

System Cost (\$) = @ LoC (%) =

Levelised Cost of Energy (cent/kWh) = @ LoC (%) =

Total Blackout Duration (h) = @ LoC (%) =

Average Blackout Duration (h) = @ LoC (%) =

Maximum Blackout Duration (h) = @ LoC (%) =

Unmet Load (Wh) = @ LoC (%) =

MTBF (h) = @ LoC (%) =

Penetration (%) = @ LoC (%) =

CO2 Emission (kg) = @ LoC (%) =

Excess Power (Wh) = @ LoC (%) =

Click LCE (the objective) to sort all solutions based on their LCE → The top solution (Sol #1) has the lowest LCE(optimum solution)

The entire population of the last generation of the GA search are shown here; all satisfy the constraints

Sort/Filter Design Candidates

System Cost (\$)	414000
Levelised Cost of Energy (cent/kWh)	54
Total Blackout Duration (h)	
Average Blackout Duration (h)	
Maximum Blackout Duration (h)	
Unmet Load (Wh)	
MTBF (h)	
Penetration (%)	
CO2 Emission (kg)	
Excess Power (Wh)	7.8142e+07

Results

1	9.3	40	128	1000	0	0	1	3	0	1	0	411000	53.6
2	9.3	40	128	1000	0	0	1	3	0	1	0	411000	53.6
3	9.5	40	66	1000	0	0	1	3	0	1	0	412000	53.7

- $\vec{X}_{opt} = \{R_{WT}, A_{PV}, n_B, P_{D,nom}, P_{FC,nom}, P_{EL,nom}, U_1 \text{ to } U_3, C_1 \text{ to } C_2\} = \{9.3, 40, 128, 1000, 0, 0, 1, 3, 0, 1, 0\}$;
- The only storage/auxiliary unit in the system is battery: $U_1 = 1$ (Battery), $U_2 = 3$ (Diesel), $U_3 = 0$ (no FC), $C_1 = 1$ (Battery), $C_2 = 0$ (no Electrolyser)
- $\vec{Y}_{opt} = \{TLSC, LCE, BO_t, BO_{av}, BO_{max}, U_t, MTBF, penet, CO_2, P_{excess}\} = \{411000, 53.6, 0, 0, 0, 0, 8760, 241, 80, 78 \times 10^6\}$

Reset All Designs Nondominated Solut... Save Solution Save Optimisation Results Save Listed Results

