Diesel Generators (DGs) are commonly used in developing countries as backup power sources to overcome the problem of inadequate grid connectivity and frequent outages. However, power from DGs is highly expensive and environmentally harmful. Obviously, systems based on solar generation and batteries offer a good opportunity to offset this high DG cost.

A systematic layout design of a hybrid microgrid is investigated in this work aiming at simultaneously integrating the energy management and the capacity of each component of the system. This work proposes an optimization framework targeted to reduce the running costs associated with the grid and DG, in the presence of outages, and the overall costs of installing new resources such as PVs and batteries.

**Microgrid Model**
- The system is assumed supplying the essential/critical load of a facility, (i.e., the loads of high priority are ranked as critical).
- **Legacy (current) system**: Diesel generator and the utility grid.
- **New (additional) system**: PV Array, Battery Energy Storage System (BESS), bi-directional power inverter and the Energy Management System (EMS).

**Opportunities and Challenges**
- Green Energy Resources has almost no running cost beside its cleanliness.
- Offering an affordable power supply can assist weak utility systems (inadequate grid infrastructure or/and frequent interruption of the grid).
- Conventional backup systems depend mainly on diesel fuel (pollution).
- DGs are greedy consumer of fuel (high running cost but low investment).
- Sizing a system based on elementary statistics leads to oversizing > high cost.
- Hybrid generation compromises between cost and cleanliness (PV-BESS-Diesel).

**Optimization Framework**

**Cost Function**
\[ C = [C_D + C_{PV} + C_{BESS} + \frac{C_{FC}}{L} + C_F + C_{ER}] \]

**Fitness Function**
\[ \Pi = 1 - \frac{P_L}{P_{Total}} \]

**Applied technique**: Genetic Algorithms

**Search space**: All possible solutions (3 year simulation (PV, DG, BESS, EMS)) \((0.9 - 2.1)\)

**Simulation Results**

**Optimized Microgrid Components**
- Number of storage units: 174 units
- Number of PV panels: 602 panels
- Rated power of the diesel generator: 100 kW
- Maximum affordable state of charge: 40 %
- Stop charging threshold from GenSet: 40 %

**Net Savings and Conclusion**
- The annual payments of installation and replacement count \(75 \times 10^6\) US-$
- The long-term annual savings will be \(145 \times 10^6\) US-$
- Means that the net annual saving will be \(70 \times 10^6\) US-$, that is: approx. half the fuel cost in the old configuration.
- In old configuration, diesel operates 2.5 year = 5840 Hrs

**References**