# Design of a Hybrid Power Supply using a Genetic Algorithm


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# Overview

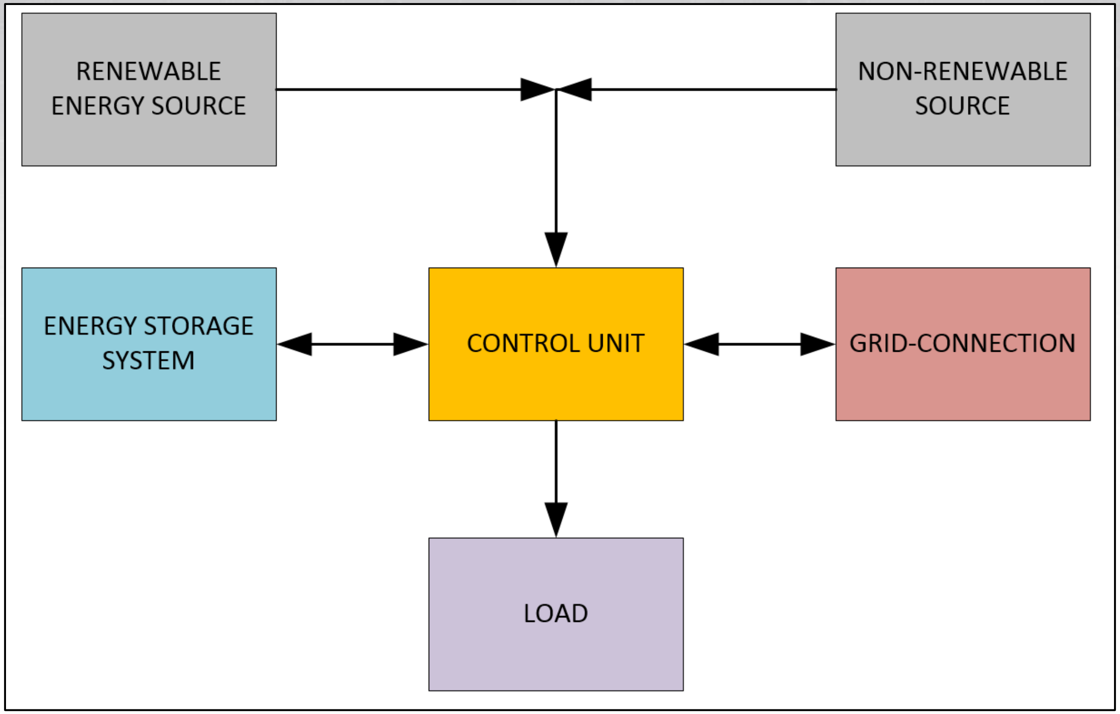
1. Introduction
2. Design Objectives
3. Sizing Methodologies
4. Genetic Algorithm
5. Results
6. HOMER software
7. Conclusion

# 1. Introduction

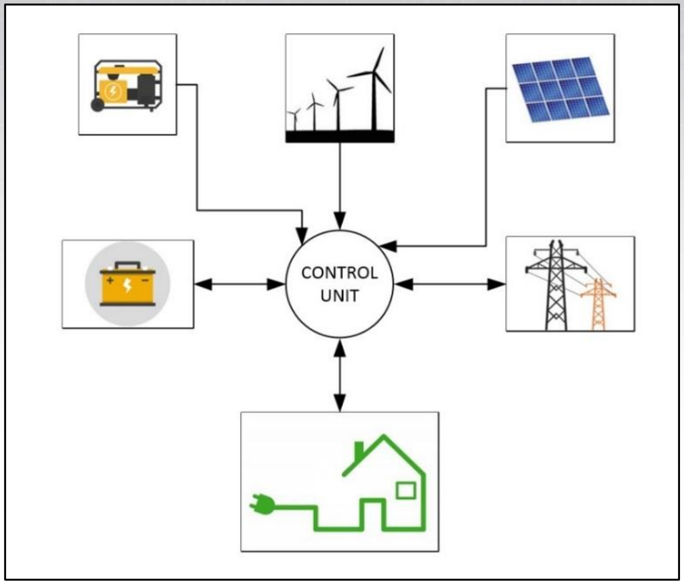
- Dispatchable
- Emissions
- Limited supply: eventually become unavailable

- Intermittent: weather dependent
- Cannot be depleted
- Generates without emissions

# 1. Introduction



# 1. Introduction



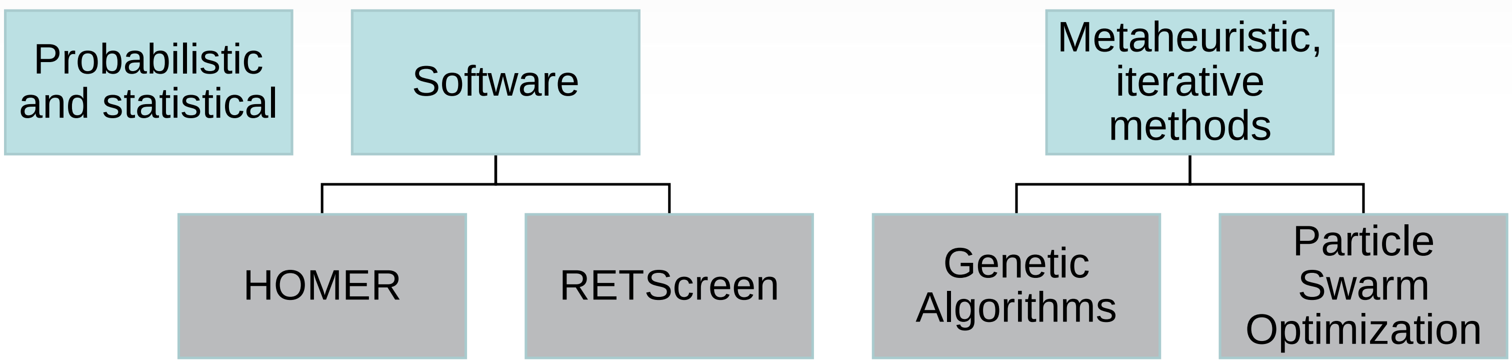

- Energy density increased
- Weakness of one power source replaced by strength of another
- Solar (daylight only) combined with generator reduces fuel consumption and increases capacity factor

# 2. Design Objectives

- **How do we choose between different HPS configurations? What we want to achieve in the design?**
  - Trade-off analysis
  - Multi-objective problem: Technical, economical and environmental
- **Technical: dispatchable**
  - Minimize loss of power supply probability (LPSP)
- **Economical: the investor’s money**
  - Minimize the capital and lifetime costs
  - Maximize the lifetime savings and return on investment
- **Environmental: reduce emissions**
  - Maximize renewable energy source usage

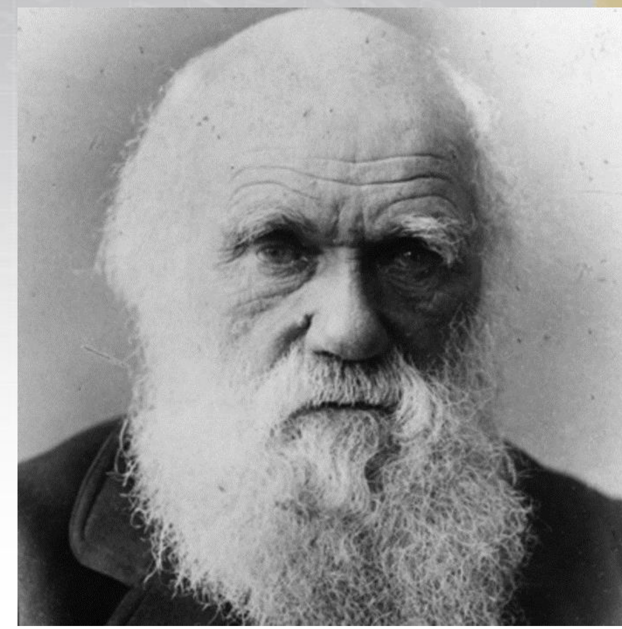
# 3. Sizing Methodologies

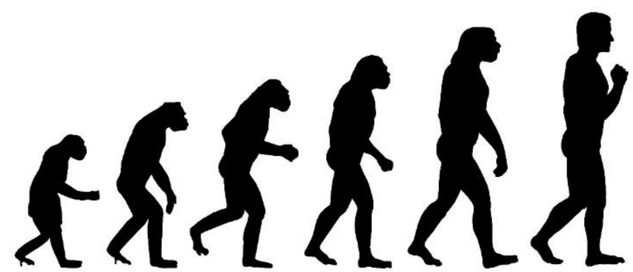
- Each HPS is unique
- Dependant on location and weather (assuming renewables are incorporated)
- Financial constraints of the investor
- Sizing problem



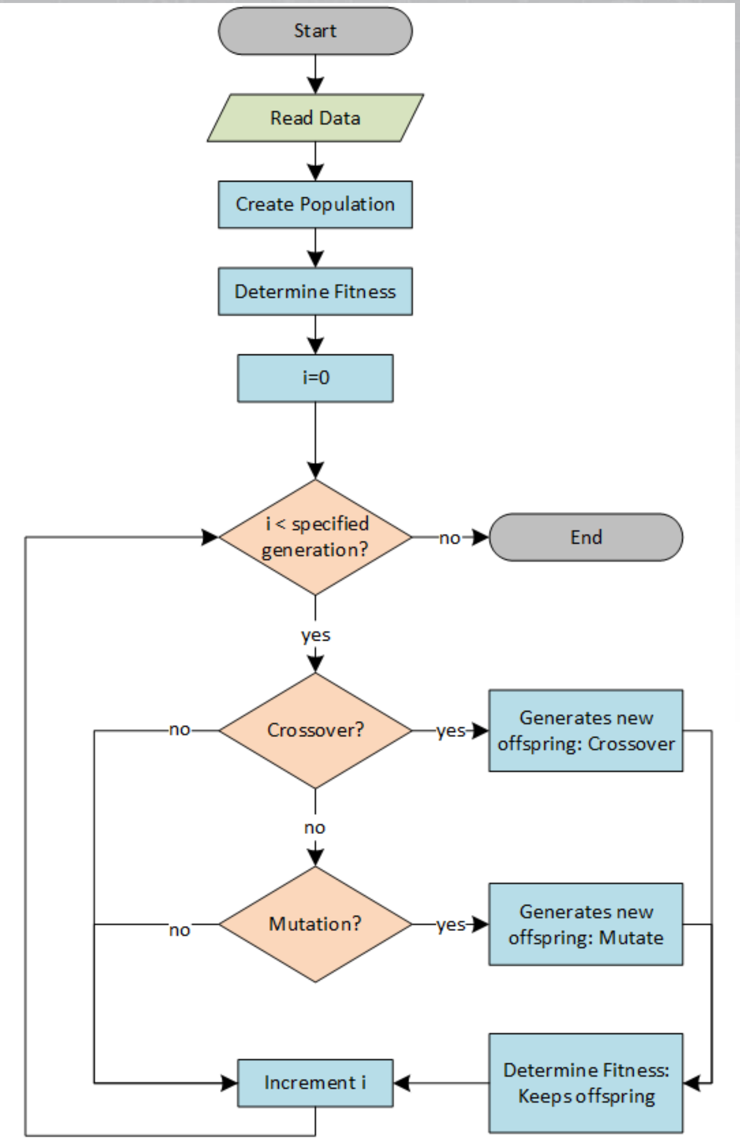
# 4. Genetic Algorithm

- **Stochastic global search and optimization technique**
- **Theory of evolution by Charles Darwin**
- **Elimination of inferior species gradually over time through natural selection**
- **After a defined amount of generations, a fitter population is achieved**
  - Thus a list of viable solutions of HPSs are obtained
  - Trade-off analysis based on investor’s objectives





# 4. Genetic Algorithm

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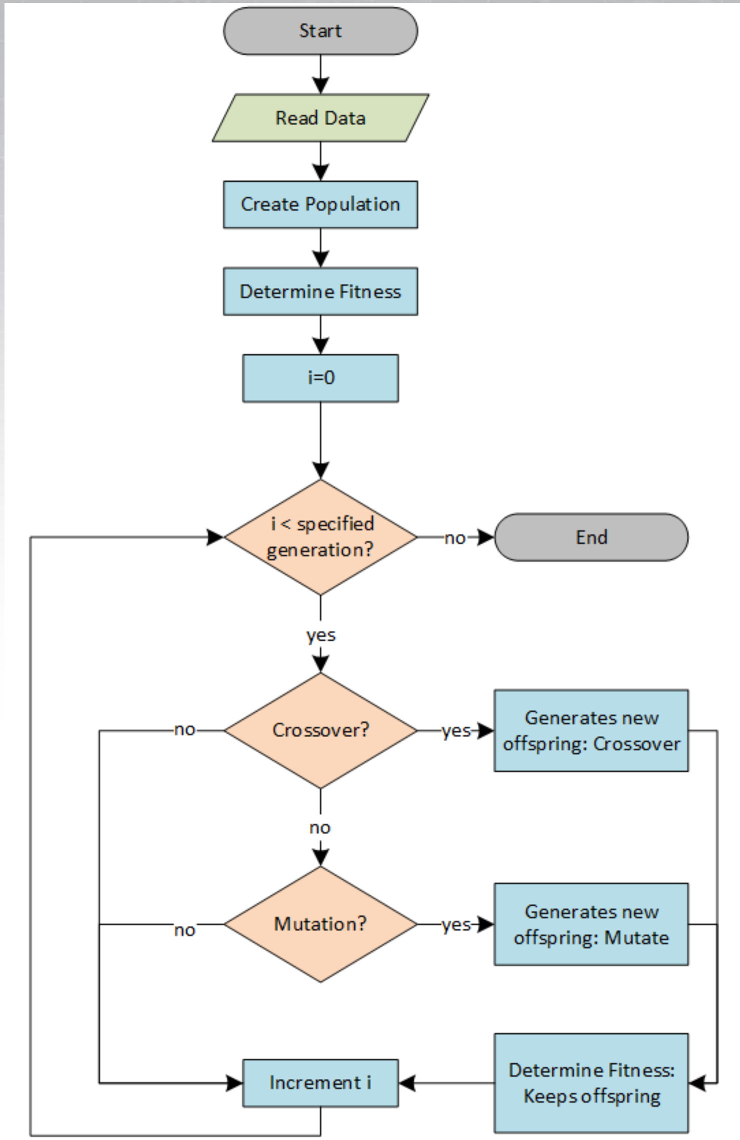
# 4. Genetic Algorithm

- **Structure with encoded solution: chromosome**
  - Similar to DNA strings
  - Each DNA has information regarding system
  - [$T_{PV}$ $N_{PV}$ $T_{GEN}$ $N_{GEN}$ $T_{BAT}$ $N_{BAT}$ $T_{INV}$ $N_{INV}$]
  - Types - integer represented
  - Number of system components
- **Chromosome has 4 configurations:**
  - Combinations of solar, grid, battery and generator
  - Internal local optimizer

# 4. Genetic Algorithm



# 4. Genetic Algorithm

- **Population: 80**
- **Generations: 40**
- **Crossover rate: 80%**
- **Mutation rate: 20%**
- **Selection:**
  - Rank-based roulette wheel
- **Dispatch strategies are incorporated for the battery and the generators**

- **Data input:**
  - Weather profile: Stellenbosch
  - Load profile: farm
  - Time series: hourly
- **Fitness function**
  - Weighted linear combination of different attributes
  - Short-term and long-term assessment with regards to objectives (as previously discussed)

# 5. Results

| | LPSP (%) | PV Penetration (%) | Capital cost (ZAR) | IRR (%) |
|---|---|---|---|---|
| Solar Grid (SG) | 58.8 | 22.8 | R1,313,985 | 15,5 |
| Solar Grid Battery (SGB) | 42.6 | 51.1 | R2,172,083 | 16,2 |
| Solar Grid Generator (SGG) | 10.8 | 76.4 | R1,373,100 | 23.6 |
| Solar Grid Battery Generator (SGBG) | 10.5 | 78.8 | R1,894,675 | 20.6 |

**SGB**

- High capital cost
- No emissions, lower O&M

**SGG**

- IRR, LPSP, PV Penetration, capital cost
- O&M, fuel prices, emissions

**SGBG**

- LPSP, IRR, PV Penetration
- Fuel prices and O&M, emissions

# 6. HOMER software

- Hybrid Optimization Model for Electric Renewables
- GA produces overall lower capital cost with a lower loss of power supply probability
- GA can compare more types for diverse results
- GA can fill in missing data, where HOMER cannot
- Both produce accurate results
- GA must be built and incorporated: time consuming
- HOMER commercially available

# 7. Conclusion

- **Genetic Algorithm**
  - Viable method to design a hybrid power supply
- **Compared to HOMER**
  - GA produces more diverse and robust configurations
  - GA is more accurate and faster design methodology
  - GA has lower capital cost and better loss of power supply probability
- **Future work**
  - Larger database of components
  - Additional power sources (wind, biomass, biogas, hydro…)
  - Selling excess generated power back to the grid

# Thank you