Design of an Energy Management Algorithm for a Hybrid PV, Battery, EDL and Diesel System

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Content

Initial situation:

Situation

Context

- Corruption and lack of investments have prevented the national company, EDL, from continuously providing power to its inhabitants.
- In 2021, EDL has only been able to secure 2 to 4 hours of power a day
- Rise in Prices of Crude Oil made electric generators more expensive.

Design requirements

- Satisfy demand at all time
- Must be affordable
- Minimize losses
- Sustainable

Literature Review

Energy Sources and Storage

Energy sources used in the models studied:

- PVPs
- Wind
- Diesel
- Lead-acid batteries
- Lithium Ion batteries
- Grid

Algorithms and Priorities

Role and priorities of the algorithms studied:

- Prioritize carbon footprint
- Prioritize Price
- Surplus :
  - Can sell to the grid
  - Can’t sell to the grid

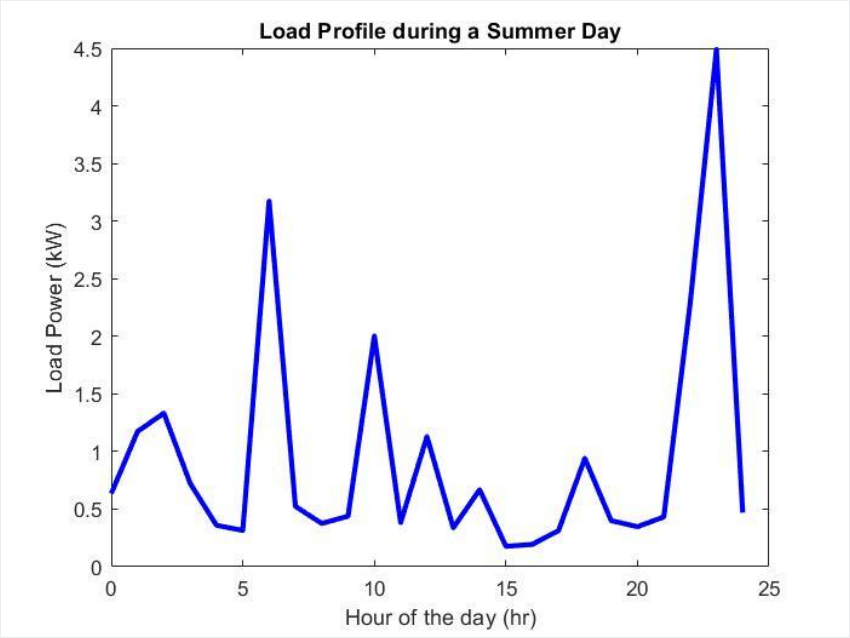
Load Data:

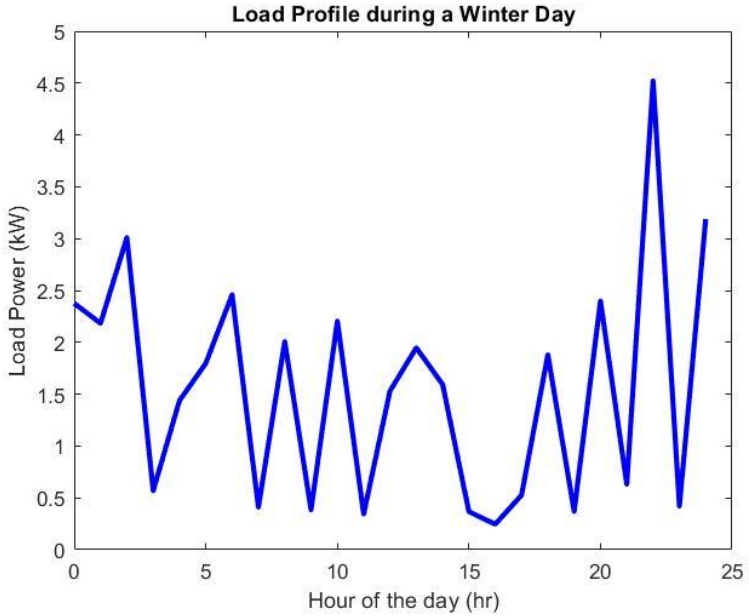
Data

Load Characteristics:

Load Characteristic	Energy (KWh)
Total	11,300
Average	1.3
Maximum	7.9
Minimum	0.2

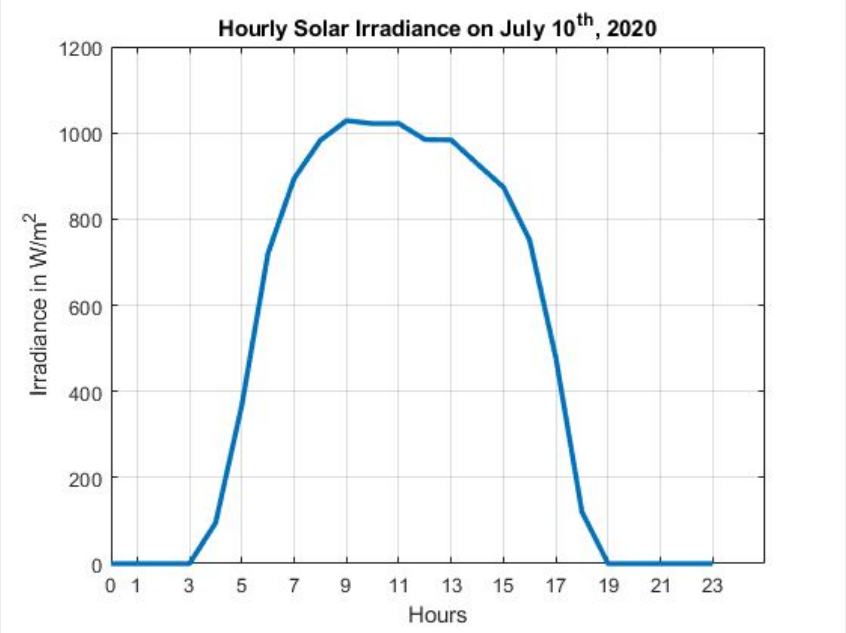
Load Profiles





System components:

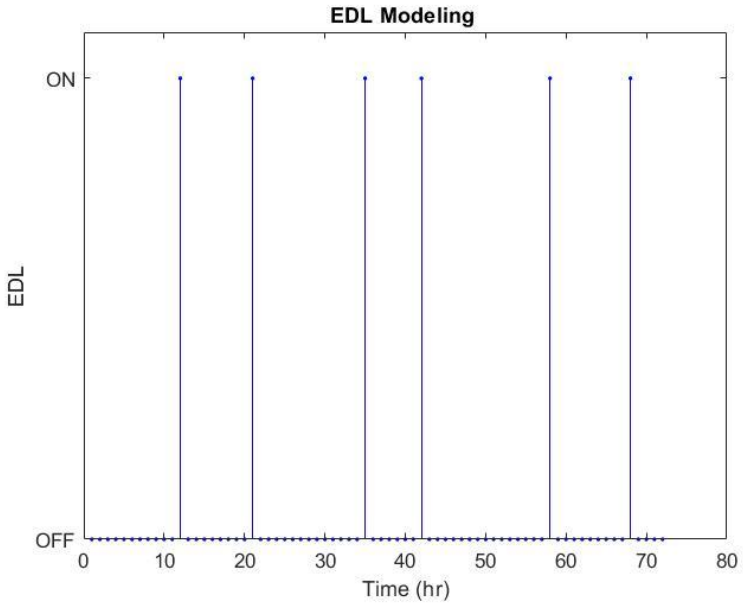
Photovoltaic Panels (PVPs)



Key considerations

+ Data: hourly insolation on horizontal plane (Wh/m^2)
+ Use of Anisotropic model to find energy available on tilted panels
+ Temperature data to calculate power losses (NOCT concept)
+ Area is 24m^2, efficiency of panels is 22% and PV inverter efficiency is 97%

Electricité du Liban (EDL)



Battery System Storage

Minimum dis/charge time	10 hours
Maximum power	2.4 kW
Maximum SOC	90%
Minimum SOC	30%
Dis/charging efficiency	90%
Battery inverter efficiency	94%

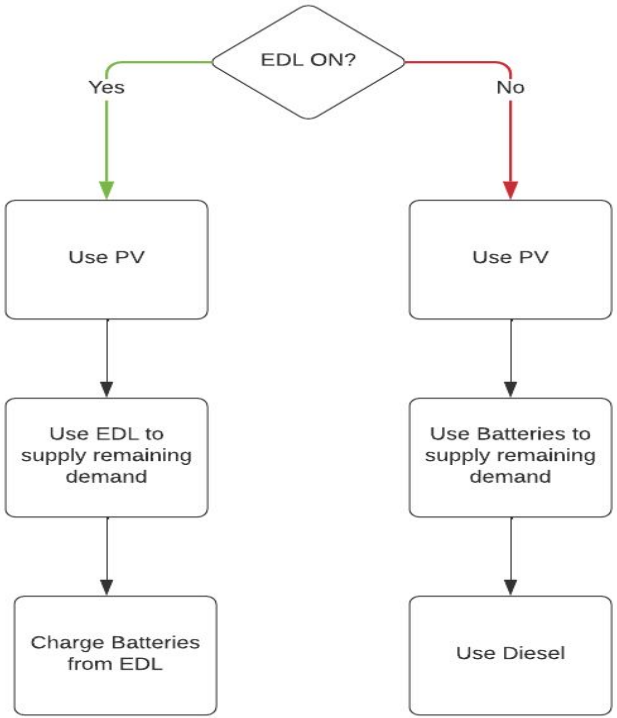
+ Storage capacity is 2000Ah, terminal voltage 12V (so 24 kWh)
+ Maximum dis/charge energy per time step is 2.4 kWh (+efficiency)
+ Min and Max SOC extend battery life
+ More advanced models account for self discharge and battery ageing (capacity loss)

Diesel Electricity Generator

- As a backup when no other energy source is available
- For our load, the maximum power needed is 9.480kW therefore 10kW generator is chosen for that purpose
- Advantages:
  - Size can be chosen according to the load
  - Quickly available when needed
- Disadvantages:
  - Diesel generators are expensive since the cost of operation is dependent on the prices of fuels,
  - Important source of pollution

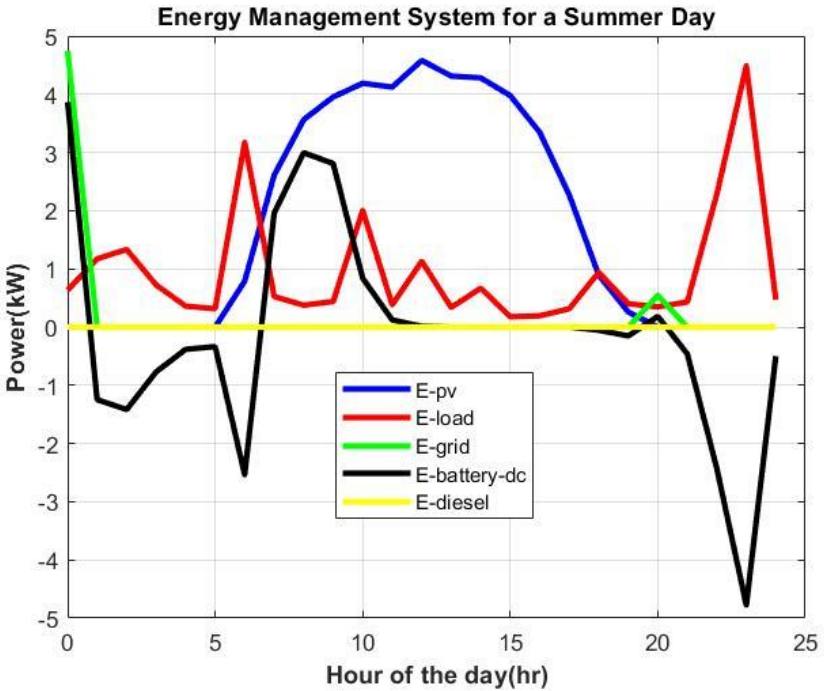
The Algorithm:

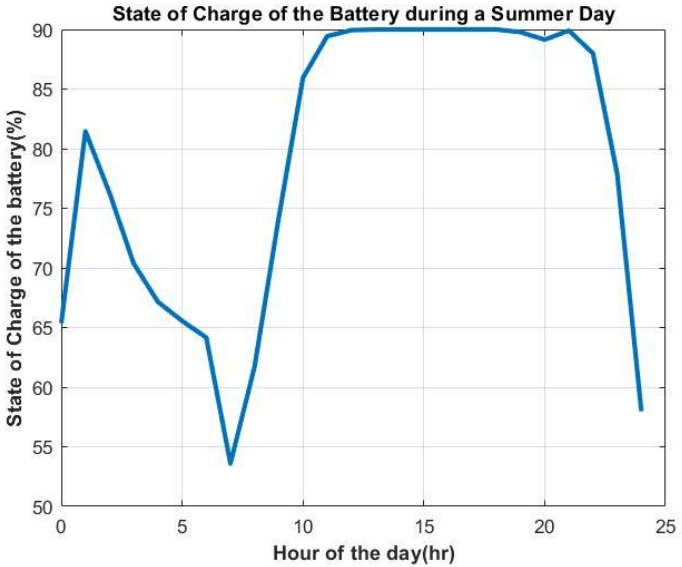
Power Flow Diagram



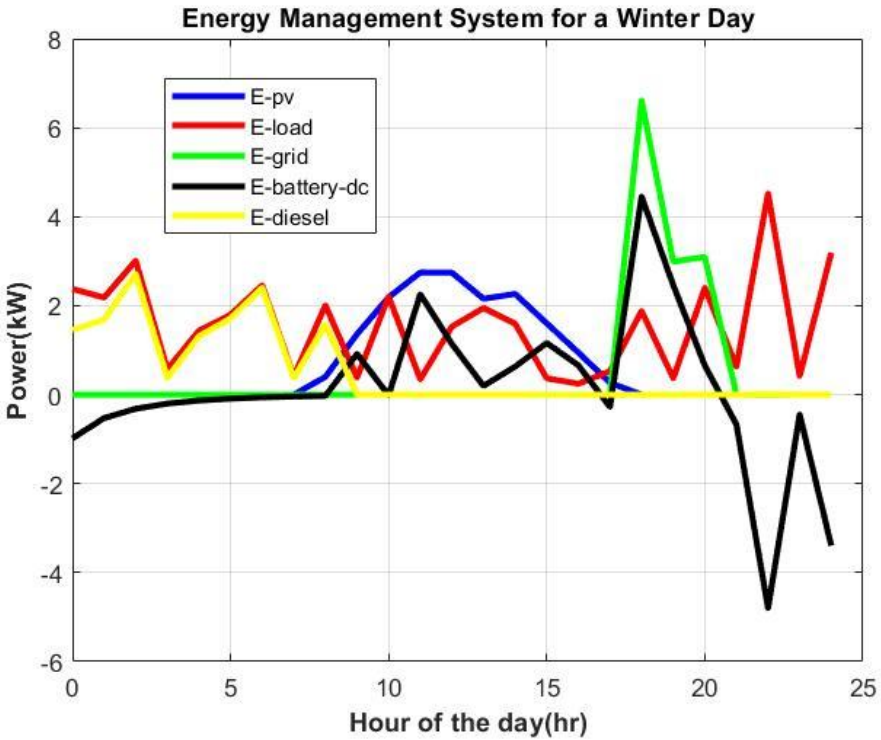
Results:

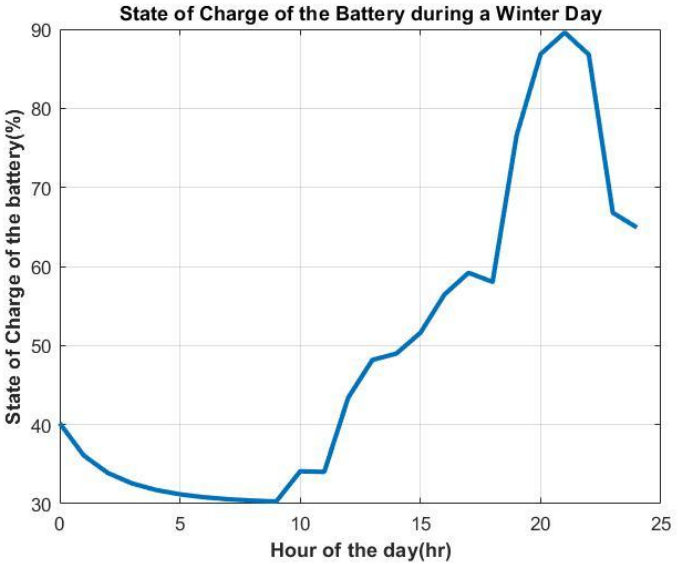
Simulation - Summer Day



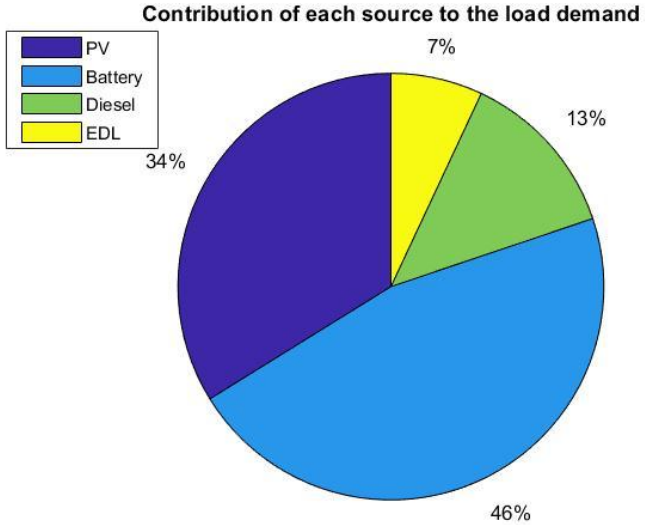


Simulation - Winter Day





Results - Total Load Demand



Conclusion:

In short, EMS are...

- Relevant when power systems have more than 1 resource
- Necessary with Hybrid Renewable energy systems
- Used for cost reduction and/or satisfying demand
- Different strategies for different systems

THANK YOU!