THE ANDREW & ERNA VITERBI FACULTY OF ELECTRICAL ENGINEERING

CRML

Control Robotics and Machine Learning Laboratory

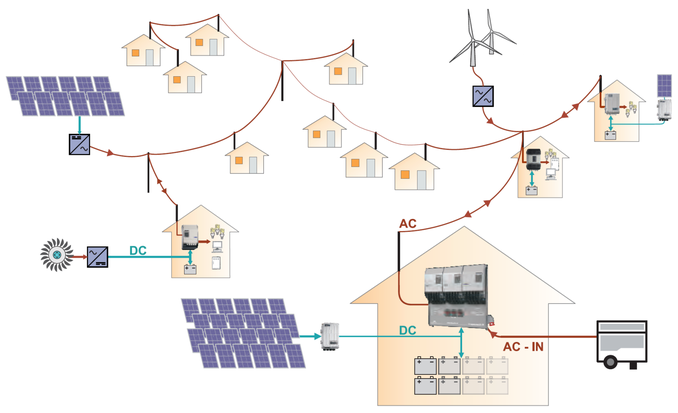
TECHNION Israel Institute of Technology

Continuous Energy for a Crucial Facility Which is lacking of Resources

Elad Itzhak and Guy Dauber, Supervised by Michael Perl

Introduction

- Renewable energy systems are a crucial step against climate change and global warming
- Renewable energy sources are getting cheaper and are more available
- Renewable energy systems allow fully autonomous and local control of the power supply, using mini-grids
- Renewable energy mini-grids allow economic efficiency under variety of constraints



Renewable energy mini-grid example

Goals

- Minimize the total cost required for a complete renewable energy mini-grid
  - Consists of 100% renewable energy, including generation and storage
  - Continuous operation under various weather and power demand conditions

Challenges

- Severe weather conditions
- Area needed for power plants (solar panels and wind turbines)
- Electrical characteristic and integration treatment
- Economic dispatch model for the generation and storage sources

Data Analysis

Database analysis

Naive analysis (without weather data)

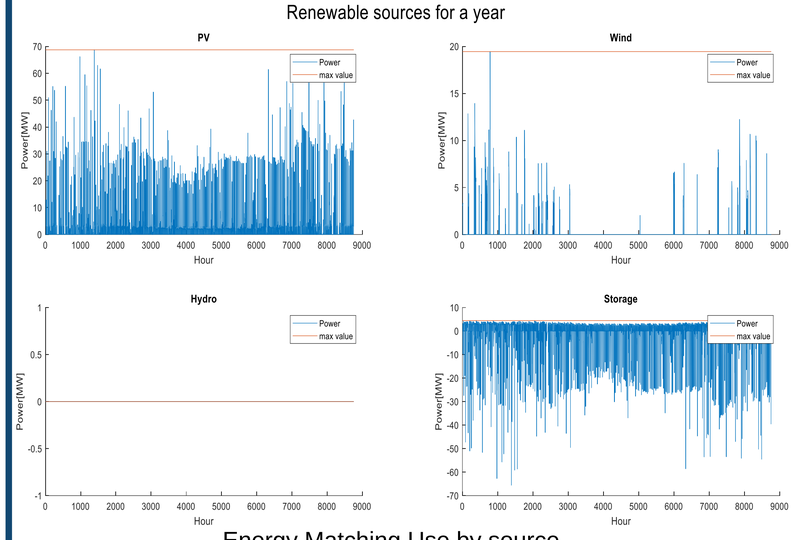
Analysis of the user's database and Naive analysis of user's database

Extended analysis of the database (including weather data)

Optimization by Energy Matching

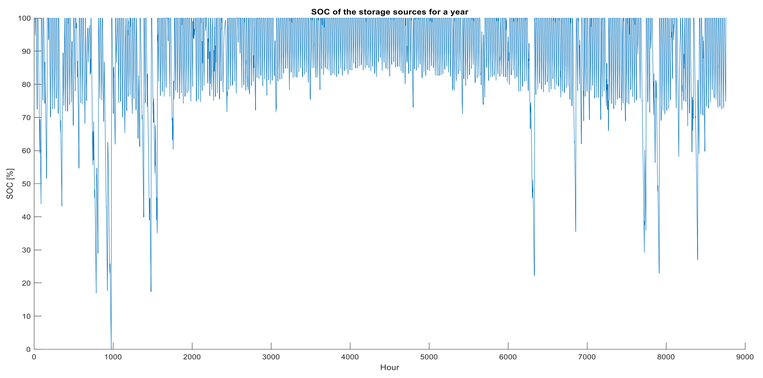
- The data analysis was implemented using MATLAB, with user friendly interface
- Naïve approach was used at first, without consideration the whole available data
- The analysis includes a simple model for the storage sources' state of charge

Energy Matching



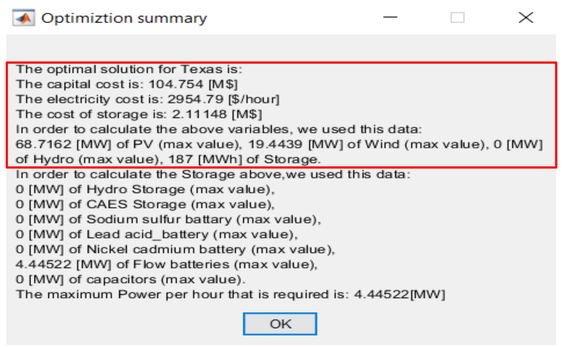
Energy Matching Use by source

- Most of the use of renewable energy is with the help of solar energy
- The use of storage sources is lower in the summer months as we might expect.



Energy Matching – State of Charge

- There is less use of storage sources in the summer.
- The critical days are in the winter days.



Energy Matching Summary

- Energy charging occurs when possible.
- The peaks for wind energy and solar energy are significantly higher and therefore the costs are higher.

Comparison between optimizations

ENERGY MATCHING	EXTENDED ANALYSIS	NAÏVE ANALYSIS			
104.754	17.4833	5.37871	Capital cost [M$]		RENEWABLE ENERGY SOURCES
2954.79	413.429	210.259	Electricity cost [$]		
68.7162	4.61859	4.88974	PV [MW]	Max values	
19.4439	8.26858	0	Wind [MW]		
0	0	0	Hydro [MW]		
2.11148	2.32263	2.11148	Storage cost [M$]		STORAGE SOURCES
4.44522	4.88974	4.44522	Flow batteries [MW]	Max values	

Optimizations Compairson

- Energy Matching: Capital and operating costs are very high but more realistic.
- The Naïve analysis gives a very far assessment from our final assessment

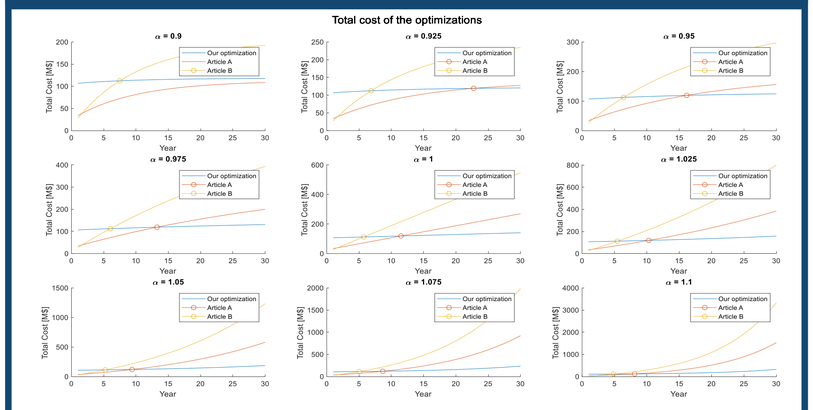
Systems Comparison

2^{nd} Article	1^{st} Article	ENERGY MATCHING	
27.7	33.827	106.86548	CAPITAL COST [M$]
17.32	7.856	1.1353	ANNUAL OPERATING COST [M$]

Energy Matching costs Vs. other articles costs

- We got better annual operating cost, but worse capital cost

Economic Benefit



Energy Matching costs Vs. other articles costs

- With different inflation rates our optimization is almost always below the articles
- For α = 0.9 this does not hold within the 30-year time frame
- It can be concluded that optimization by operating costs is more beneficial optimization.

Conclusions

- Energy matching method leads to more realistic costs
- With sufficient duration of time ($\sim 30\ years$), our solution is more beneficial for down to inflation value of 0.925
- Our optimization reached significantly cheaper operating cost, but the capital cost was more expensive
- It is more beneficial to optimize over operating cost, rather than capital cost
- It might be helpful to partially use our analysis, and add more green energy source if possible

Further Possible Projects

- Further analysis, using nuclear energy facilities
- Categorizing generating and storage sources, with different weight in the analysis
- More comprehensive modeling and accurate analysis:
  - Taking electrical characteristics under consideration
  - Real time analysis and response, using short-term weather forecast, dynamic control and adaptive signal processing

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