CO_2 and Cost Impacts of a Transportation-microgrid with Electric Vehicle Charging Infrastructure: a case study in Southern California

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Purpose

- The goal is to see the accuracy of simulated microgrid models when applied to a real system
- This validation's main contribution is documenting the difficulties and challenges involved in transitioning from a simulated model to real-life implementation
- This paper focuses on the problems and outcomes of the microgrid's full-size components and describes how software is implemented in a full-scale microgrid
- The validation results are compared to the simulated model to analyze the differences and similarities between simulated and real-life data

Abstract

As an important part of Intelligent Transportation Systems (ITS), this paper presents a case study at the University of California, Riverside (UCR) that evaluates the effectiveness of different transportation-based microgrid configurations in reducing both carbon dioxide (CO_2) emissions and electricity costs. CO_2 emissions are calculated using high-resolution California Independent System Operator (CAISO) CO_2 emissions data to accurately assess the environmental impact of each setup. Electric costs were also compared to determine the financial savings potential for the consumer. The results demonstrate that a peak-shaving transportation-microgrid strategy can effectively reduce CO_2 emissions in the range of 24% to 38% and costs from \$27,000 to \$29,000 per year, even when considering the additional demand from 12 vehicles charging daily at the building. However, careful consideration should be given to battery sizing, as peak-shaving has diminishing returns. Doubling the battery size may only provide an additional savings of \$2,000 per year with a negligible reduction in emissions. This highlights the importance of optimizing battery capacity to maximize cost-effectiveness and environmental impact.

Microgrid Architecture

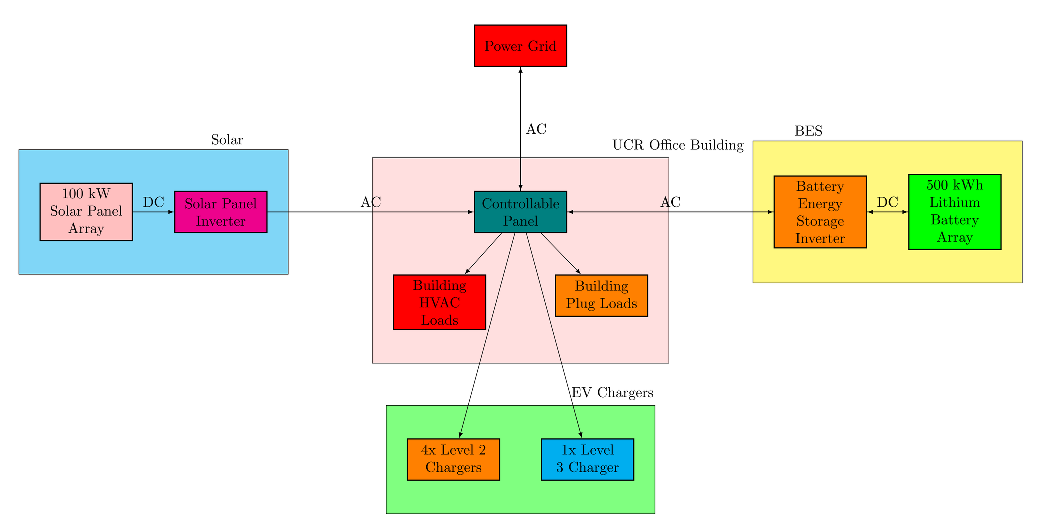

Figure: Microgrid Architecture of our Case Study Example BESS: Battery Energy Storage System

EV Charging Simulations

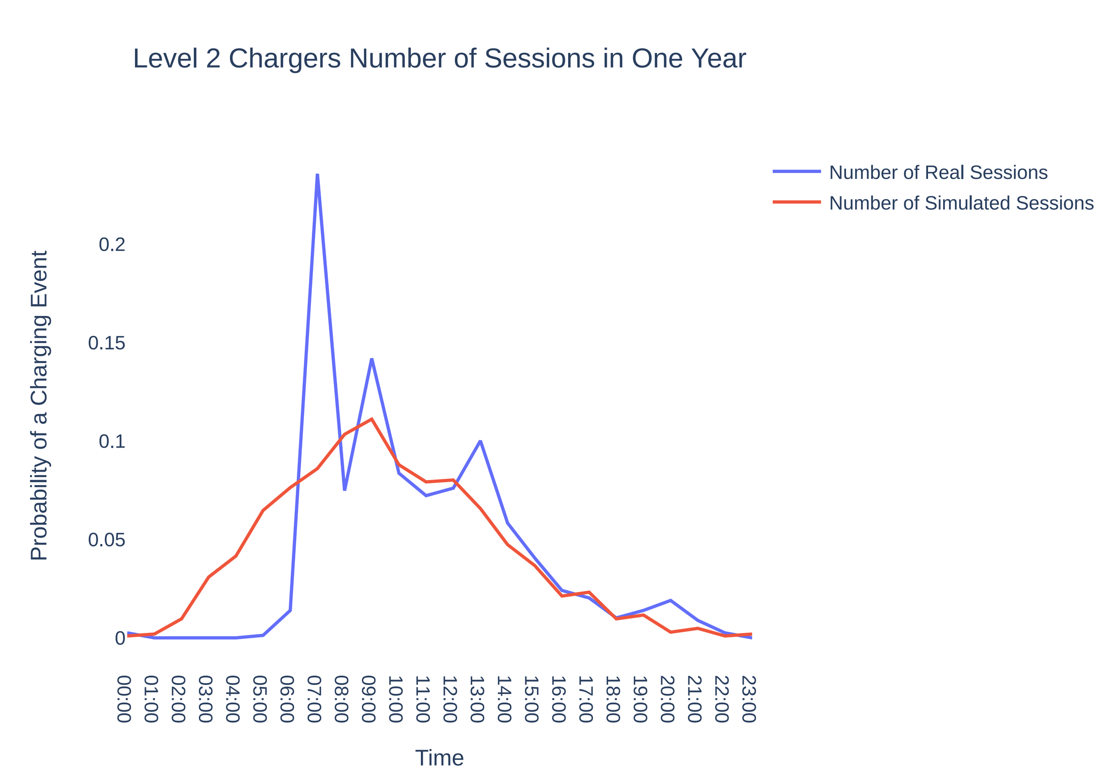

Figure: Validation of the Level 2 EV Charger Stochastic Process that Compares the Probability Density Function of Actual Charging Data to the Poisson Process

Control Software

Algorithm 1: Microgrid Control Software

```
df ← dataset
output ← []
count ← 0
delay ← 15 minutes
new_interval ← current_time
while data_length > count do
    inverter_power ← df.power[count]
    while new_interval > current_time do
        output ← inverter_get_data
    end
    count += 1
    new_interval += delay
end
```

Results

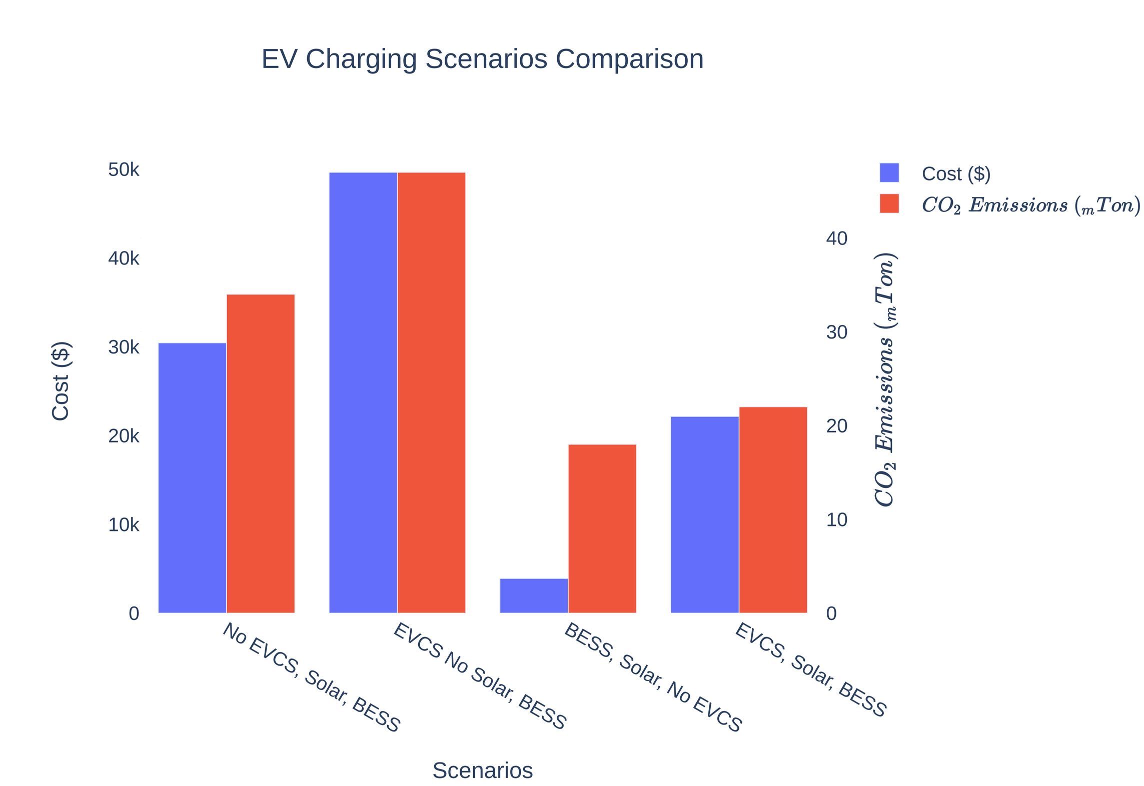

Figure: EV Charging Scenarios Comparison

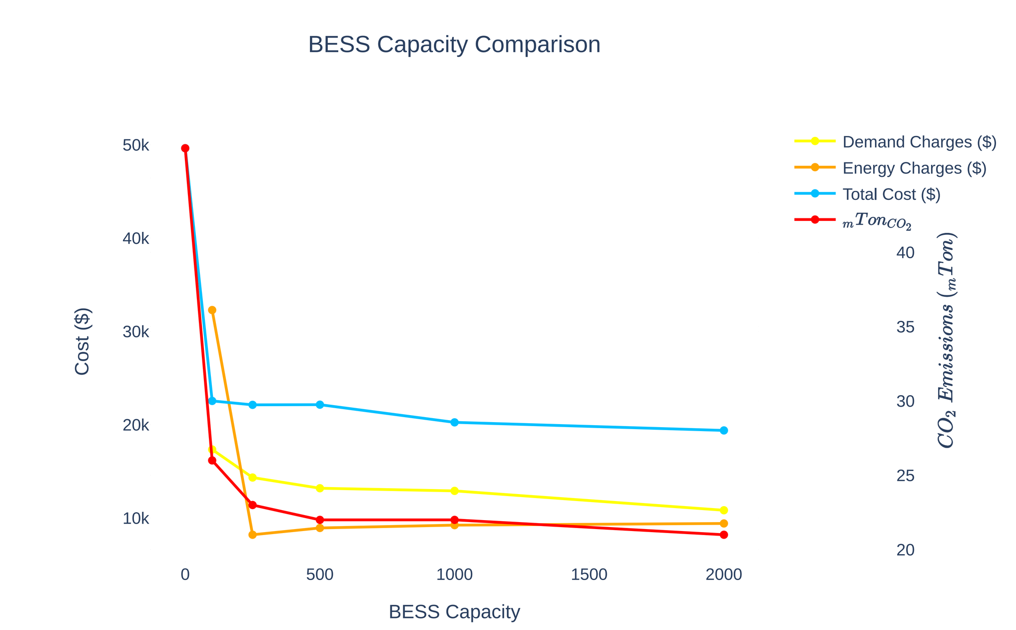

Figure: Cost and CO_2 Emissions for Different Battery Capacities

Conclusion

- The results from this short validation demonstrate the possibility lowering the max demand of the net load, thus reducing the facility's demand costs, by utilizing a BES system in combination with solar power
- The algorithm proposed and implemented achieved the goal of lowering the max demand, thereby reducing the stress on the grid
- Load prediction is needed to optimize data for the algorithm more accurately; optimization using shorter time intervals is also needed to reduce possible power surges
- This approach is unsuitable for islanding since the net load would exceed zero on multiple occasions
- Future improvements on this microgrid system will integrate load control, and a faster reaction time to the system that should enable full capability of automated islanding

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