CO_2 and Cost Impacts of a Microgrid with Electric Vehicle Charging Infrastructure: a Case Study in Southern California

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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.

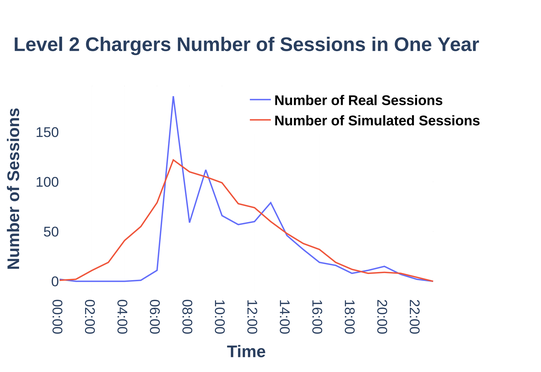

Figure 1: **Validation of the Level 2 EV Charger Stochastic Process that Compares the Probability Density Function of Actual Charging Data to the Poisson Process**

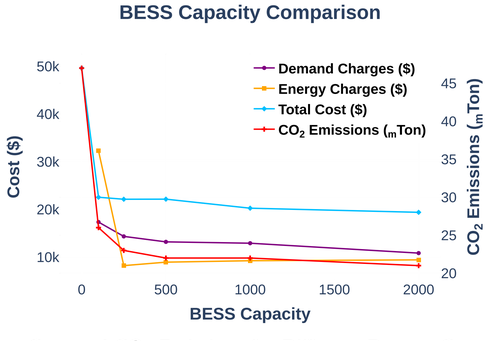

Figure 2: **Cost and CO_2 Emissions for Different Battery Capacities: A BESS capacity of 250 -500 kWh is ideal for lowering costs and CO_2 emissions with less diminishing returns in savings.**

Microgrid Architecture

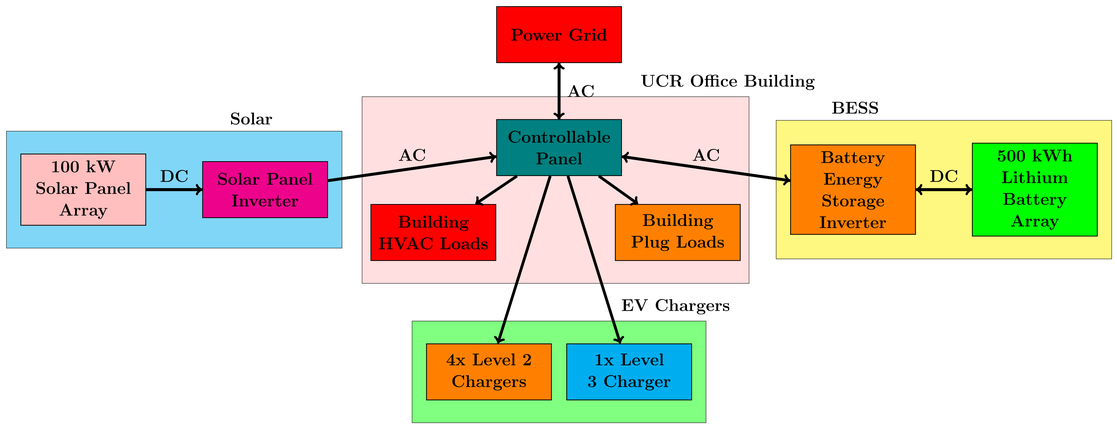

Figure 3: **Microgrid Architecture of our Case Study Example BESS: Battery Energy Storage System**

Simulated Scenarios of the UCR Microgrid using Different Layouts

Table 1

Scenario	
1	Standard Building with no EV Chargers
2	Standard Building with Level 2 and Level 3 Charging
3	Microgrid Building with 100 kW Solar, 500 kWh BESS, No EV Charging
4	Microgrid Building with 100 kW Solar, 100 kWh BESS, Level 2, and Level 3 Charging
5	Microgrid Building with 100 kW Solar, 250 kWh BESS, Level 2, and Level 3 Charging
6	Microgrid Building with 100 kW Solar, 500 kWh BESS, Level 2, and Level 3 Charging
7	Microgrid Building with 100 kW Solar, 1 MWh BESS, Level 2, and Level 3 Charging
8	Microgrid Building with 100 kW Solar, 1 MWh BESS, Level 2, and Level 3 Charging

Microgrid Utility Electricity Prices and Associated CO_2 Emissions Output under Different Scenarios

Table 2

Scenario	Demand Charges ($)	Energy Charges ($)	Total Cost ($)	CO_2 Emissions ($_m$Tons)
1	7695	22736	30431	34
2	17343	32289	49632	47
3	3904	0	3904	18
4	14341	8209	22550	26
5	13193	8937	22130	23
6	12909	9239	22148	22
7	10835	9418	20253	22
8	9811	9577	19388	21

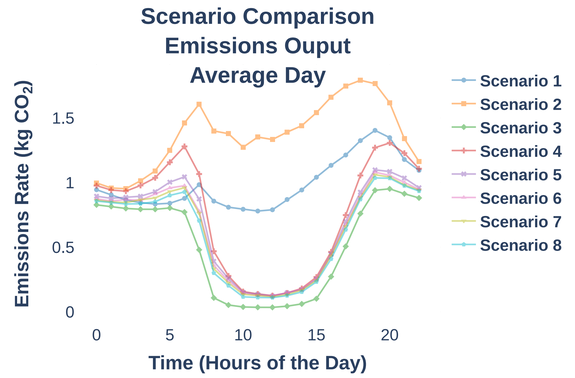

Figure 4: **Microgrid CO_2 Emissions Outputs Averages During Times of Day: Adding a microgrid significantly reduces CO_2 Emissions compared to the non-microgrid scenarios (1 and 2).**

Conclusions and Future Work

- Transportation-microgrids offer significant economic and environmental benefits
  - Estimated annual savings of $8,000-$10,000 compared to conventional systems
  - Annual savings of $27,000-$29,000 compared to buildings with EV chargers but no microgrid
  - 24% - 38% reduction in CO_2 emissions compared to conventional buildings
  - 45% - 55% reduction in CO_2 emissions compared to buildings with EV chargers and no microgrid
- Increased battery capacity does not guarantee improved performance
  - Increased capacity improves performance but not proportionally to the cost
  - Large capacity needed for challenging situations may not be cost-effective
- 15 kW demand price floor discourages zero net load
  - Discourages zero net load in peak shaving setups, increasing CO_2 emissions
- Future Work
  - Optimizing electric costs and CO_2 emissions through throttling charging, maximizing solar energy use, and minimizing grid draw during peak CO_2 emissions times
  - Assessing the impact of California's new net energy metering policy

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