Prelim Title

Southern California microgrid emission and price optimization under different pricing structures and control algorithms

Abstract

Intro

Background

California it's going through a major transition of its energy production which involves a higher share of renewable energy in the mix. This is to meet California's climate goals of x by 20xx. However, achieving that goal will be a major feat involving utility companies, government agencies, and increasingly the consumers. Many industrial and commercial sites are adopting not only solar but battery energy storage systems as well. California law requires large facilities to install solar and batteries: find citation. This has major potential in addressing current issues with solar power as a large percentage of the energy mix. The infamous duck curve has only been getting steeper in recent years which leads to a huge stress onto the grid leading to concerns and reliability. Equally as important, while California has a fairly clean grid during solar peak production hours, the electrical demand does not align with this and relies on the grid during more polluting times. Battery energy storage systems are being proposed as one solution to mitigate duck curve problems. This paper will review flat until you rates of various utility companies that are optimized for our microgrid in order to see if customers using BESS for economic benefit coincide with reducing emissions.

Pricing (Flat vs TOU)

One of the main outcomes for this paper is to see how flat rate versus time of use pricing affects user behavior and the emissions associated with adapting different rate schedules. A flat with demand charge for the purposes of this paper means that the customer is charged for the maximum power consumed within a 15 minute rolling average regardless of when this maximum occurs. A time of use(TOU) rate means the customer will have A charge for the maximum amount of power used if any 15 minute rolling average within each of the predefined blocks, Usually off peak, mid peak, on-peak and any depending on the season super off-peak. In this building's case the official rate schedule is RPU’s flat demand charge, however, to control algorithm will be program for various scenarios including if our microgrid were on the RPUS TOU rate, and if it were using investor owner utilities in California. He microgrid currently uses

Peak Shaving

Peak shaving is a standard method for reducing high demand charges. Since demand charges are based on only the maximum value over the entire month. In this simple algorithm we assume the consumer we want to minimize that the demand charges as much as possible. The algorithm is based on cost savings only since the expectation is that the consumer will Use the algorithm of the most cost savings. During flat rate pig shaving the algorithm will simply look at the amount of power being imported and if there is enough energy and the batteries mitigate that amount. With TOU get my charges a heavier priority will be given during on peak times, evaluates to higher demand chargers during off peak hours.

Emissions

The microgrids solar production very much overlaps with the local energy production within the larger grid. This leads to to the problem within our microgrid that while it is zero emissions during solar peak hours we still rely on the 30 main electrical grid during off pixel or hours which is when the grids even more polluting. However, with a BESS we can utilize solar power during peak times and at night. In this experiment the control algorithm is economic based since we want to see how TOU rates align with actual emissions output. The simulation will use emission output calculations from CAISO for each time interval and the amount of power pulled from the grid is multiplied by this average. This gives us an estimate the amount of CO2 emissions from the microgrid when it's consuming power from the grid rather than using 0 output emissions from solar and battery storage.

Optimization

Simulation in Modelica

The microgrid scenarios are simulated in open modelica using the modelica buildings library. The power circuits are three phase balanced circuits. The simulation of microgrid as the grid connected to the building net load. The net load is the model is broken down solar power, HVAC loads, regular building loads, electric vehicle chargers, and the BESS. The solar power is represented as power output from a generator with its power output being controlled by the load forecasting algorithm that was trained on historical solar data from the building. The HVAC loads and the regular billing loads are represented separately in this model but utilize the same method; they both use load forecasting models trained on historical real power data to be represented as a resistive load to the system. The EV chargers are represented as two models the level 2 EV chargers and the Level 3 EV chargers. While the rest of the loads tend to follow a daily and yearly pattern and the load is somewhat continuous, EV loads are different since they switch on and off so the load is x in nature. The microgrid has 4 Level 2 chargers, so it can have 4 “steps” of 5 kW each while there is only one “step” of 50 kW with the Level 3 chargers. Both use a gaussian random generator to generate the number of charge sessions in a day, the arrival times, and charging durations. However, the number of sessions and duration is reduced to X and Y respectively for the Level 3 charger. The BESS is represented as a battery connected to a bidirectional inverter. Unlike the other components the BESS output is controlled by generated data, the BESS output is computed real time by using a peak shaving algorithm that decision is based on the output of the BESS SOC and the grid meter. The algorithm charges the battery when there is excess solar power being exported to the grid and the battery needs to be charged, and discharge to the microgrids when the microgrid imports more than 15 kW of power, and the SOC of the battery is above the minimum threshold. A python module reads the net load and determines the amount of of CO2 being produced by the microgrid during that time interval.

Experiment

Emissions and pricing under flat rate peak shaving

Emissions and pricing under TOU peak shaving

Emissions and pricing under flat rate optimization

Emissions and pricing under TOU optimization

\*If possible vary pricing structure with RPU, SCE, SDGE, LADWP, and PG&E

Results/Conclusion

Pricing table under 4 methods

Emissions table under 4 different methods

Discuss ideal scenarios under different methods

Discuss future control methods