I. Introduction/Motivation

Research is presented that investigates the potential for solar power generation with battery energy storage for reducing the effective cost of energy if real time pricing is present. A linear optimization approach is developed based upon a two-step process. This analysis considers an expected lifespan of the solar panel. The capital costs for the solar arrays and batteries are considered. The results illuminate the most cost effective means to provide power to customers.

Observation:

Demand vs. Wholesale Market Price vs. Solar Irradiance in Dayton, OH (Source: Duck Energy and Nrel)

System without storage: No control on the flow of the power

System with storage: With control on the flow of power (Very expensive)

II. System Model

- With storage system and direct connection of PV to loads

III. Formulation

Objective Function:

\[
\min C = \sum_{i=1}^{t} (G_t + C_t)
\]

Equality Constraints:

- Demand: \(D_t = G_t + P_t + B_t\)
- Stored Energy: \(S_t + PV_{size} = P_t + PC_t + L_t\)
- Battery Height: \(E_t = \sum_{i=1}^{t} (B_{c discharged} * PC_i - B_i)\)

Inequality Constraints:

- On the grid: \(G_t \geq 0\)
- Stored Energy: \(\sum_{i=1}^{t} (PC_i - B_i) + E_0 \geq 0\)
- Battery Bank Size: \(E_t \leq E_{max}\)
- Battery Discharge: \(B_i \leq E_t\)

IV. Simulation Results:

1) Electricity Bill Minimization:

![Graph showing electricity bill minimization](image)

- For 8 kWh of Battery and 17 square meter of PV and average price of 11 cents per KWh

- Initial electricity bill for a year was $1335, Optimized cost $835

2) Investment Return:

Storage:
- $400 per kWh, 13 years life span

PV:
- $750 per square meter
- 25 years life span

Average electricity price: 20 cents per KWh

Maximum Investment return considering different life span and cost of storage system