Technical and Financial Evaluation of Battery Energy Storage for Distribution Capacity Upgrades Deferral

Laura García García

Aleksi Paaso, Chong Huh, Cori Johnson

Outline

- Context
- Introduction to the Methodology Proposed
- Technical Analysis of the BESS solution
- Cost Benefit Analysis
- System-Wide Extrapolation
- Proposed Step-by-Step Approach for Utility Application of the Method
- Case Study
- Conclusions

Context

- The utility industry is experiencing a significant transformation, motivated in part by recent technological and communications advancements

- **Battery Energy Storage Systems** (BESSs)
  - Technology used to be seen as excessively expensive
  - Significant cost decrease projected

- BESS grid applications previously determined ineffective are now feasible
  - Grid congestion relief
  - Reliable and safe integration of distributed energy resources (DERs)
  - Improved reliability
  - Alternatives to traditional distribution system upgrades

Introduction to the Methodology Proposed

- **Objective:** To evaluate the technical and economic feasibility of utilizing BESSs as a non-wire alternative to defer or avoid significant traditional distribution system upgrades

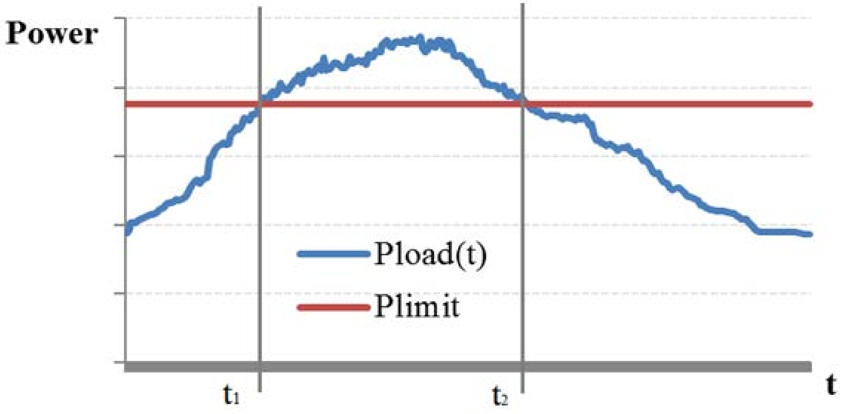
- **Methodology proposed:** Detailed engineering analysis and financial modelling framework
  - Time-series analysis to evaluate the performance and size requirements of the BESS for given system conditions
  - Based on storage sizing and technology cost projection models, the battery storage systems were compared to the cost deferral opportunity of traditional capacity upgrade projects forming

Technical Analysis of the BESS solution

Detailed time-series modelling, using distribution planning software automated through the use of high-level scripting language.

- Control strategy and algorithms of BESS monitor and keep within desired range:
  - Current
  - State of charge (SOC)
  - Power Factor

- Optimal battery size calculation, BESS should be sized so that:
  - Power to support load that exceeds rating during worst condition (1)
  - Energy to sustain load for total duration of peak (2)



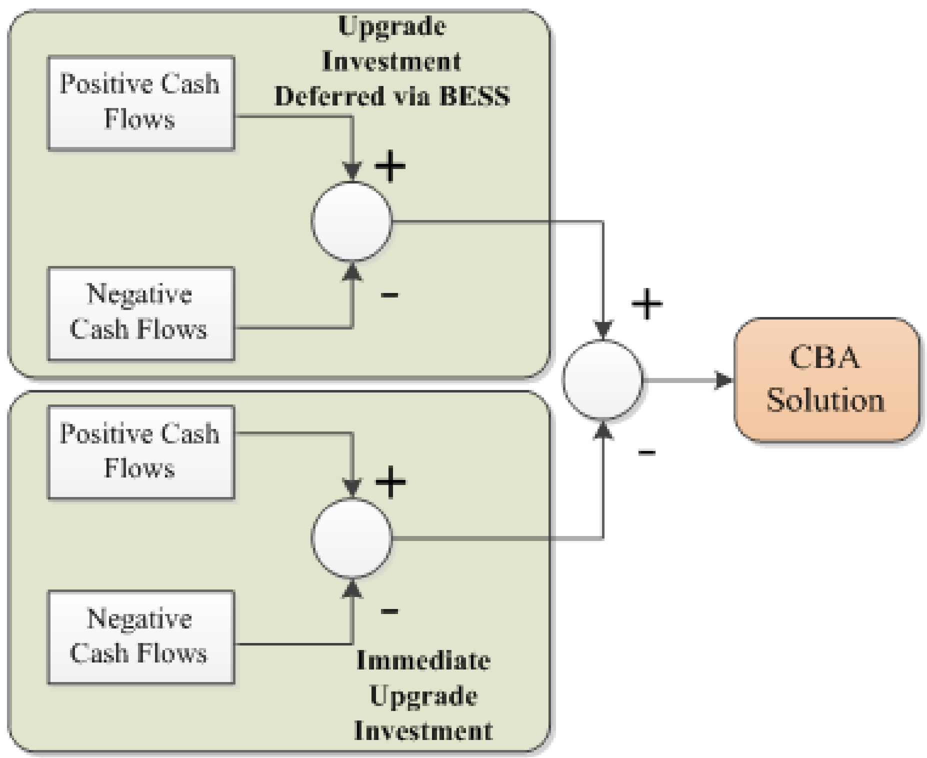
$$P_{BES}(t) = \max(P_{load}(t) - P_{limit}) \quad (2)$$

$$E_{BES}(t) = \int_{t_1}^{t_2} (P_{load}(t) - P_{limit})\, dt \quad (3)$$

Cost Benefit Analysis

A Cost Benefit Analysis (CBA) to evaluate customer benefits is key to assessing feasibility of this solution

- Automated evaluation model:
  - Cash flow of the upgrade investment deferral through the BESS solution
  - Cash flow of the immediate capacity upgrade investment



Considerations for Cash Flow Calculation

- Necessary considerations for each specific project :
  - Projected Overload
  - Location
  - Cost of the solution (BESS vs traditional capacity upgrade solution)
    - ✓ Capital and operational expenditures
    - ✓ Depreciation
    - ✓ Gains from the deferral of the traditional capacity upgrade investment

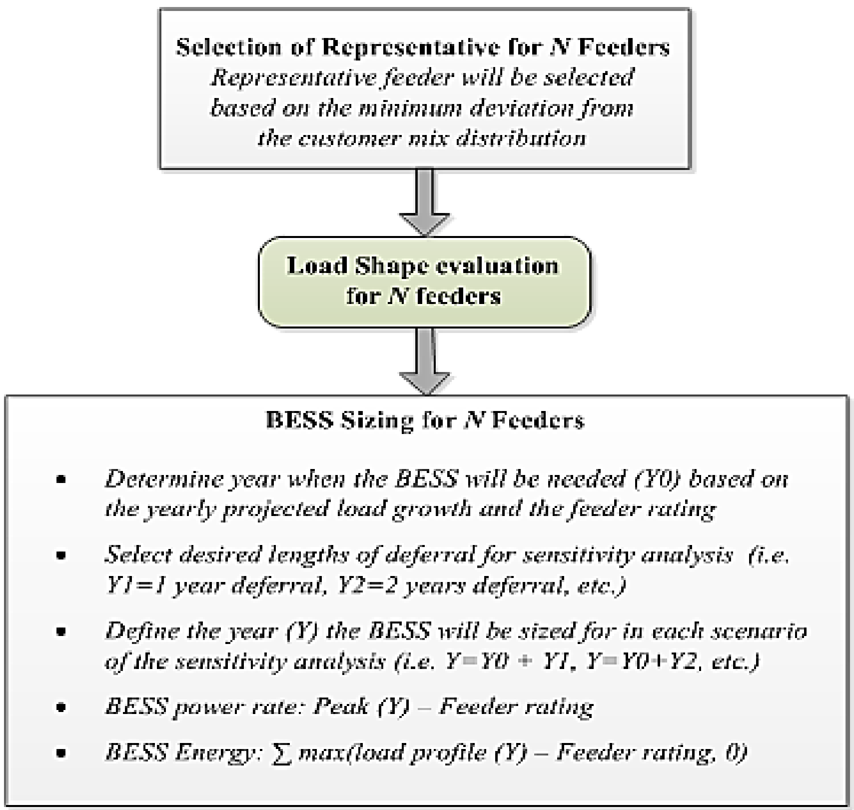
- BESS solution costs based on:
  - Size of the system determined through simulation
  - BESS cost models developed through stochastic forecasting
    - ✓ applied to Lithium-Ion batteries

- Difference between the two cash flow solutions can be declared as customer benefits

System-Wide Extrapolation

Technical evaluation described is a sophisticated and time intensive process, an estimation of the real size of BESS needed for each feeder could be approximated

- **Methodology :** Characterization of the broader set of N feeders by their distribution of customer mix
  - o Based on percentage of residential (R), commercial (C) and industrial (I) customers



Proposed Step-by-Step Approach for Utility Application of the Method

- **Step 1:** Establish estimated benefit potential through the performance of an estimated system-wide analysis
- **Step 2:** Specific characteristics that would make each one of the system feeders a good candidate for this solution. Screening criterion proposed:
  - Feeders projected to be overloaded in the near future
  - Capacity expansion is in a specific range (i.e. 1-5MW)
  - Small projected load growth
  - Traditional capacity upgrade requires a large capital investment
- **Step 3:** Perform a complete assessment of the solution for candidate feeders selected

Case Study (I/II)

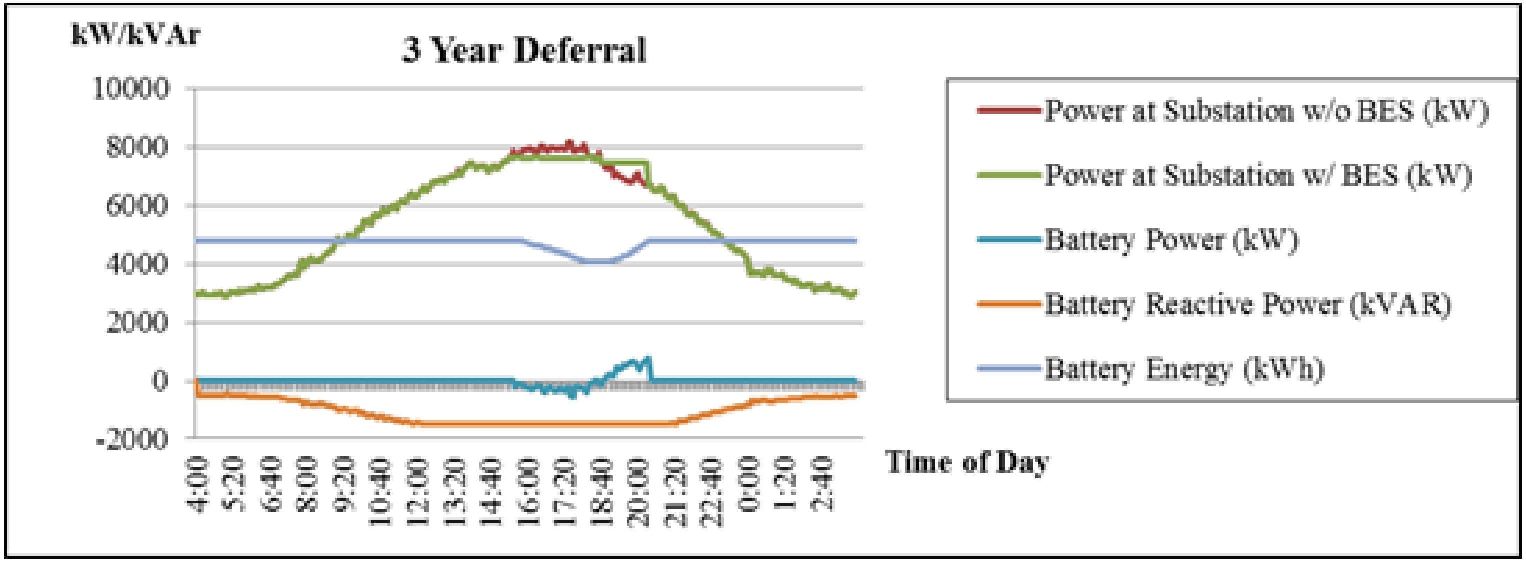
Use case involves a sample distribution feeder with the following conditions:

- Current year peak load: 7700 KW
- Current allowable rating: 7800 KW
- Expected load growth: 2%
- Estimated BESS cost: $1000/kW
- Estimated traditional investment cost: $700,000

	Minimum BESS Size Required		Commercially Available BESS		Cost of BESS
Length of Deferral	Capacity (kWh)	Power (kW)	Capacity (kWh)	Power (kW)	Approximated Total Cost ($)
3 years	750	500	750	500	600,000
4 years	1300	720	1500	750	1,100,000
5 years	1950	900	2000	1000	1,500,000

Case Study (II/II)

Results from the Time-Series Load Flow Simulation for the **3 year deferral case:**



- Maximum energy discharge from BESS shows necessary BESS capacity is 750 kWh
- Maximum power injection from the BESS shows necessary BESS power rating is 500kW

The results from the CBA under established assumptions reveal that benefits from the deferral of the traditional capacity upgrade investment would be positive.

Conclusions

- The paper presents a practical methodology to evaluate the technical and economic feasibility of BESSs utilized to defer or avoid traditional distribution system upgrades

- The extrapolation methodology proposed simplifies the complexity of the system-wide analysis.

- The case study illustrates the application of the described methodology
  - Shows positive impact on customer economics that this type of solution could have if it is deployed under suitable conditions

- The methodology could be advanced in order to include other factors and account for more complex revenue streams that could be leveraged through this application