BATTERY ENERGY STORAGE SYSTEM
SIZING METHODOLOGY AND OPTIMAL OPERATING STRATEGY FOR PEAK LOAD SHAVING APPLICATION

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Travail pratique de Master (2006)

This project is about finding and assessing methodologies for optimizing the sizes and operation of a BESS (Battery Energy Storage System), in the context of power peak-shaving. Power peak-shaving helps industries in reducing their annual demand bill, and postpones the construction of additional transmission lines. This optimization problem is split into two issues: a size optimization and an operation optimization. For both of them, existing methods are adapted and tested on real cases.

The size problem looks for BESS capacity (kWh) and power (kW) that leads to the maximum value of the objective function which measures the economical benefits of the BESS over a desired working life. It takes the investments costs, replacements costs and savings into account. The battery operation mode, mainly the number of cycle per day, must be set before the computation of the objective function.
A literal analysis for simple peak models brings properties that can be used to roughly evaluate the feasibility of a load curve, for a peak shaving application, in function of its peaks' width, in hours.

A numerical resolution, implemented in a Matlab code, allows the user to assess any load profiles of any length.
The operation problem is handled with the dynamic programming algorithm. The optimal battery schedule for a given load curve and battery sizes can be found, according to an evaluation function, mainly measuring the energy costs. Savings realized on the energy bill are usually negligible in front of the demand bill reduction (peak-shaving). The dynamic programming can also be used to find the smaller capacity required for a given amount of power to shave, according to physical constraints included in the algorithm. The size reduction can significantly lower the investment costs of a BESS.

Two leading types of batteries, lead-acid batteries and Vanadium Redox Flow batteries, are studied to implement their Kirchhoff models and physical constraints in the dynamic programming algorithm.
The objective function and dynamic programming are tools to build a general BESS sizing methodology. For instance it is recommended to use them separately. Simultaneous optimization of sizes and operation is not possible but there is an option for alternatively optimizing them to reach, step to step, a global optimal solution. This issue is an opened question for a future work.