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Title: Peak Shaving Battery Energy Storage System: Sizing, Simulation, and Testing
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The residential sector represents 17% of the end-use energy demand in Canada, with approximately 39% being supplied by electricity. Electricity demand varies throughout the day according to occupancy driven uses such as appliances, lighting, and air-conditioning, and may be employed for space and water heating. Residential electricity consumption often occurs during peak electricity grid use periods. With the increasing integration of non-dispatchable, intermittent renewable electricity generation a short-term temporal decoupling of generation and demand must be addressed. Distributed residential sized battery energy storage systems (BESS) provide one technology option to reduce peak residential electricity demand by bi-directionally exchanging power with the electricity grid when signaled. The effectiveness of a BESS to provide peak shaving and renewable integration services is highly dependent on the specific demands experienced by the system, its size, and energy management methods used to control the power flows. Battery technologies are diverse and are unconstrained by topography or fuel consumption (e.g. pumped hydro storage or compressed air energy storage, respectively). Different battery technologies also perform at certain maximum rates of discharge (based on energy/power ratio) and can be matched with the demand duration requirements of a specific support function to maximize use characteristics of the battery.

Through the use of ESP-r and the CHREM database, simulation of residential electricity demand was conducted for 5 regions across Canada with various electricity demands. The variation and duration of electricity demand and generation data was employed to design appropriate BESS configurations and sizes to meet objectives of peak demand reduction, renewable energy integration, and long-life BESS operation. The results suggest BESS sizes ranging from 5 to 22 kWh are capable of meeting peak shaving demands in different regions. For reduction of residential peak demand lithium batteries have been identified as an excellent option due to their long life and high power capabilities.

Based on these results a 6 kWh lithium iron phosphate battery pack and experimental cycling setup was constructed. Cycling operation was conducted on these commercially available large format lithium cells to establish basic operating and cycling characteristics and to verify expected performance. An advanced battery model was developed in MatLab for the lithium iron phosphate battery pack and parameters gained from the experimental system will be used to calibrate the model. Peak shaving operation will then be conducted using the previously generated residential demand profiles and the developed control methodology used in the simulations to obtain experimentally measured voltage, current, and efficiency values of the battery under realistic peak shaving demand profiles.