Fe-Ni Battery Testing for Peak Shaving And Frequency Regulation Applications

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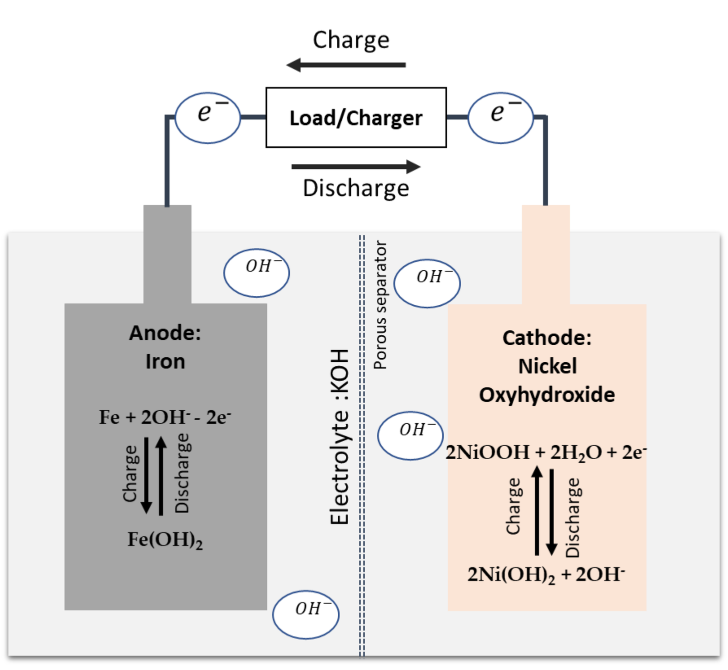
Introduction: Grid energy storage is a critical component of modern energy systems, facilitating the integration of renewable energy sources and ensuring a stable and reliable power supply. Among the various battery technologies available, the Fe-Ni battery has emerged as a promising candidate for grid energy storage due to its unique properties. This poster presentation presents a comprehensive investigation of the performance of Fe-Ni batteries in the context of two vital grid applications: peak-shaving (PS) and frequency regulation (FR) duty cycle.

Fe-Ni Battery Specification



Nominal Voltage, V	12 V (1.2 V/cell)
Energy, kWh	1.2 kWh, 5-h rate
Cell Capacity, Ah	100 Ah, 5-h rate
Weight (filled), lb	14/cell
Electrolyte Vol. gallons	0.4/cell
Dimension, inches	{3.2 (w) × 5.6(d) × 14.5 (h)}/cell
Operating Temperature,	-30º C To +60º C (-22º F To +140º F)

Procedure, Results and Discussion

Peak Shaving Cycling

Operation cond.: Discharge at **1000 Wh** (three durations 6 hours, 4 hours, 2 hours) about 80% Depth of discharge/ Constant current charge until the voltage reaches 1.65V then constant voltage charge until 30% overcharge is achieved.

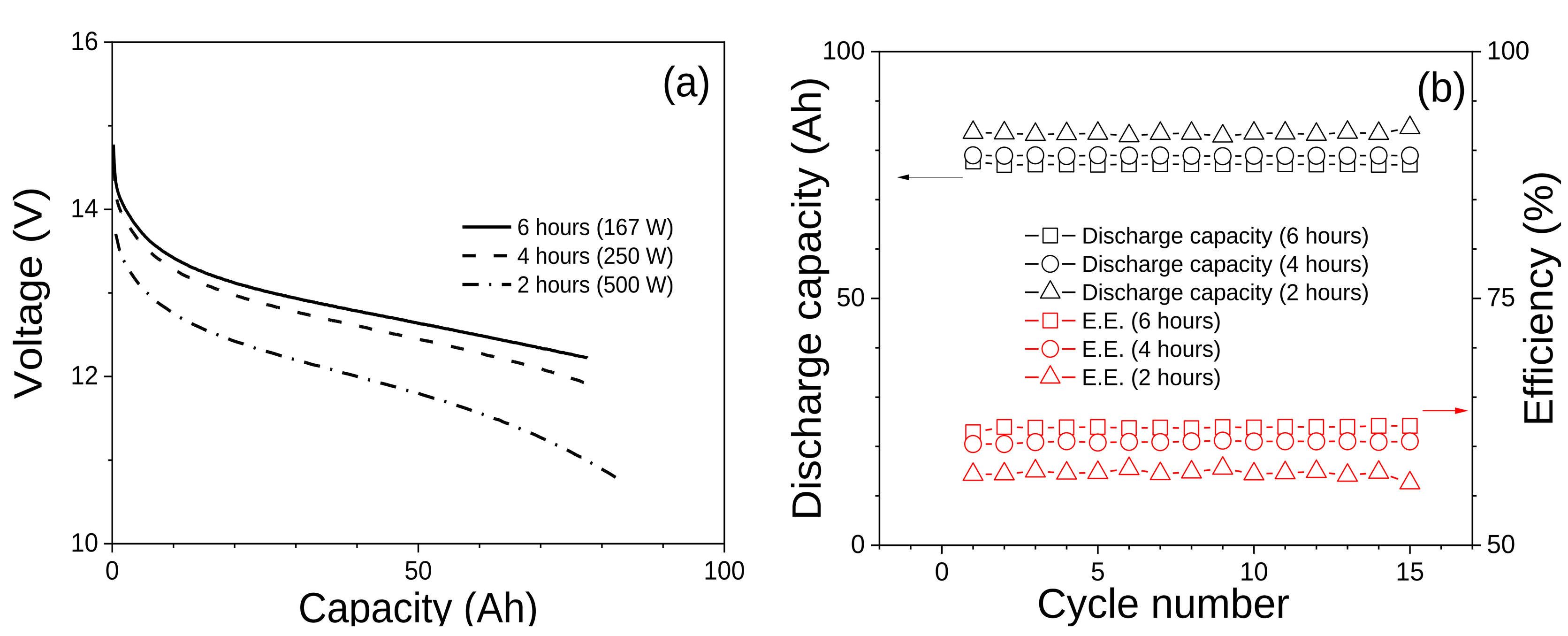


Fig. Discharge voltage profiles for PS at 2, 4, and 6hours duration with a total discharge energy of (1000Wh, respectively. (b) Discharge capacities for PS with 2-, 4-, and 6-hours duration.

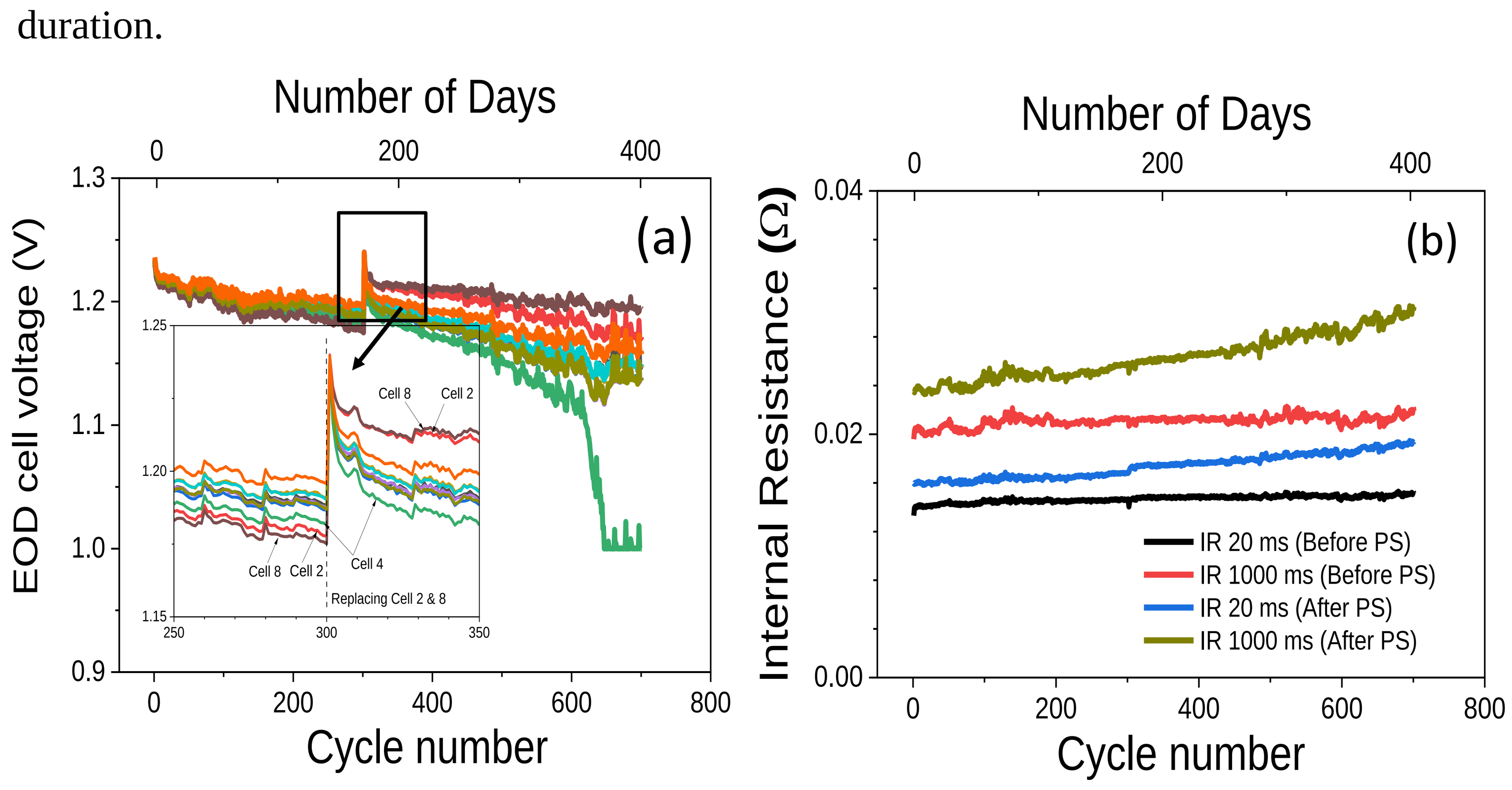


Fig. (a) End of discharge voltage for each individual cell of 10-cell string of PS at 6-hours duration (b) Internal resistance including ohmic (20 ms) and over polarization (1000 ms) for 10-cell sting over 700 PS cycles.

Frequency Regulation Cycling

Operation cond.: FR tests are done at three different initial state of charge (SOC) levels (100%, 50%, and 25%) to observe the stability, performance, and degradation effect on the battery cells. After each FR cycle, the cell or multi-cell string is recharged back to its original SOC before continuing the next FR cycle.

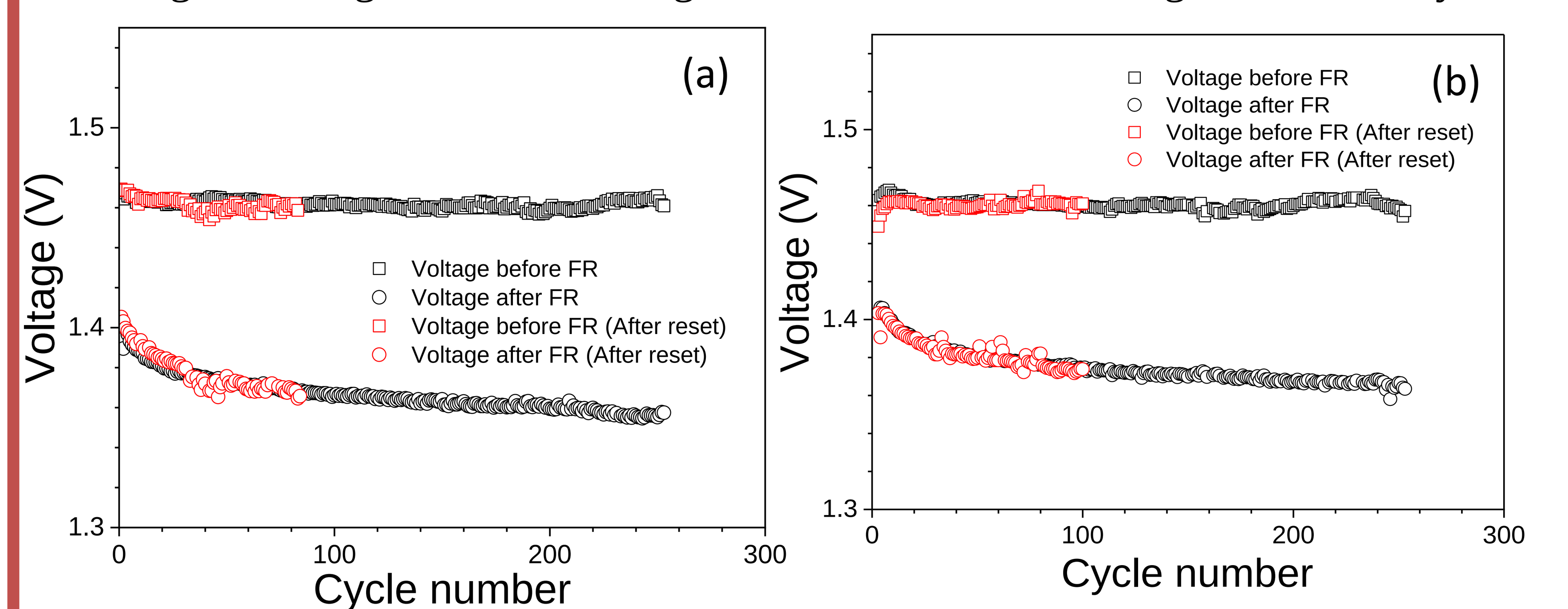


Fig. Voltage plots for before and after FR at **(a)** 100% SOC **(b)** 50% SOC . The red color indicates the voltage after reset, meaning after a full discharge and charge cycle FR cycling is started again.

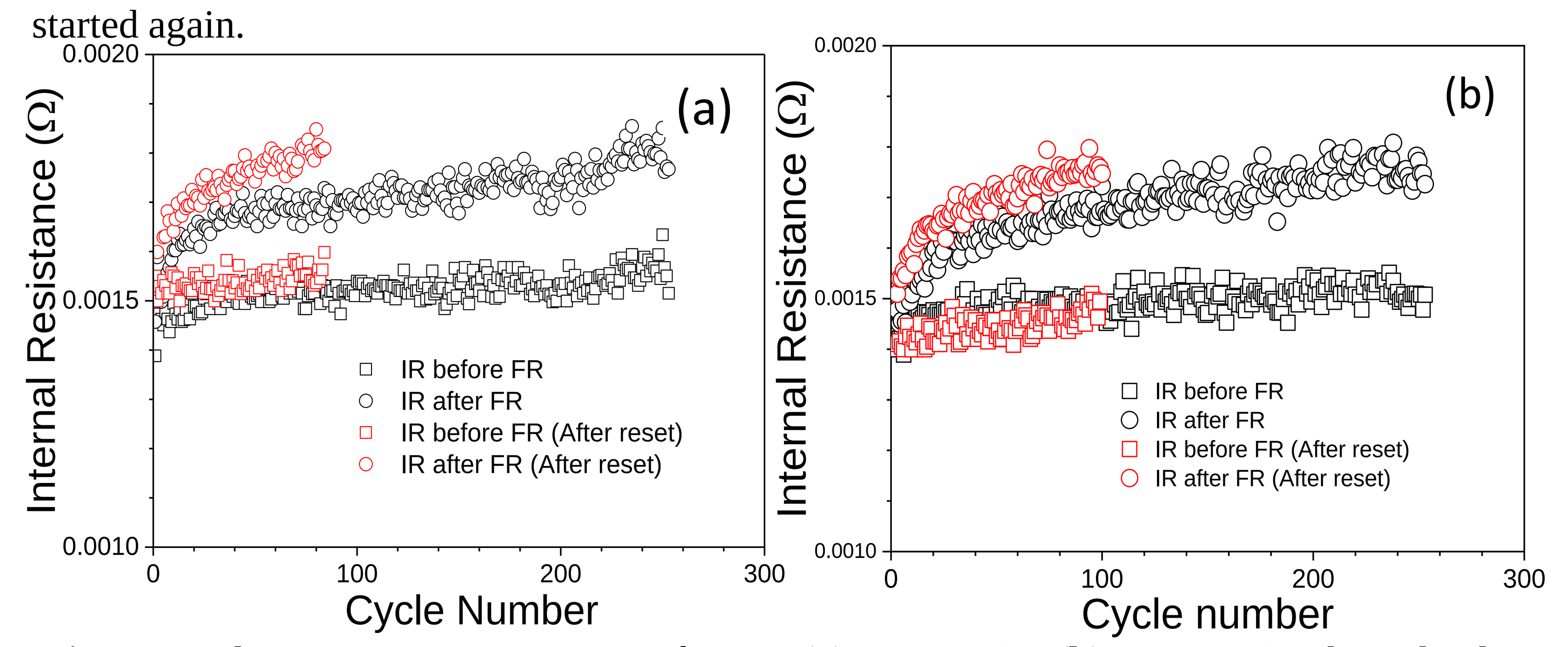


Fig. Internal resistance measurement of FR at **(a)** 100% SOC **(b)** 50% SOC. The red color indicates the internal resistance after reset.

- Internal resistance measurement is done with ARBIN cyclers DC pulse test method at 20 ms pulse width. For both starting SOCs, the internal resistance exhibits a gradual increase as cycling progresses, possibly due to cell degradation during cycling.

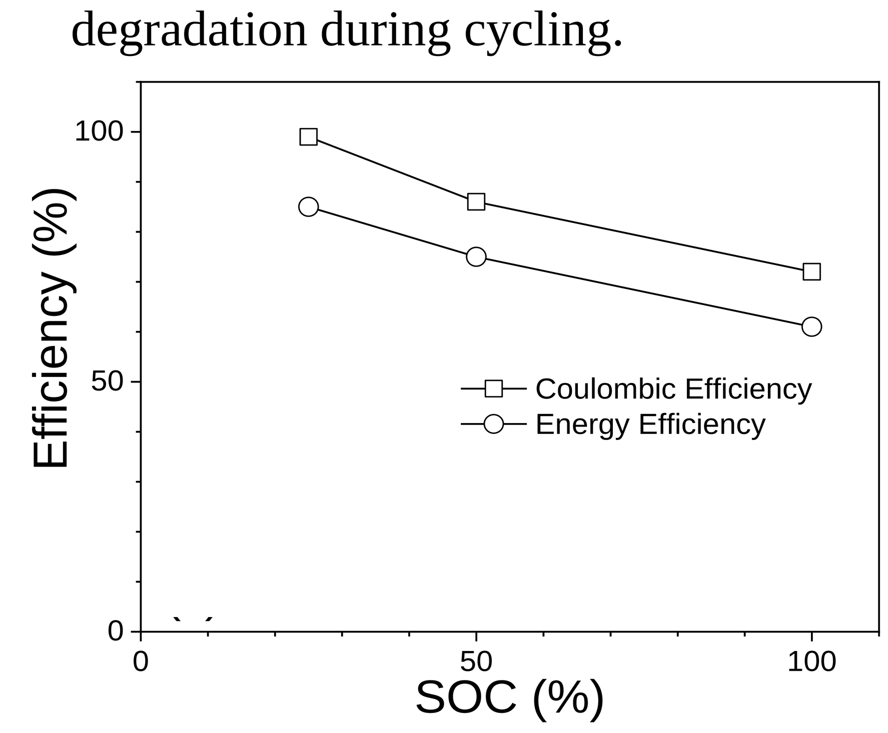


Fig. Comparison of Coulombic and energy efficiencies of FR duty cycles at 25, 50, and 100% SOCs.

- FR starting SOC is related to the coulombic and energy efficiency. Starting SOC of 50% has higher efficiency than starting SOC of 100% and testing at 25% SOC achieved higher efficiency than 50% SOC, but 25% SOC had limited performance and cyclability (approximately 20 cycles) due to reaching the discharge cut-off voltage during the FR duty cycle.

Conclusion and Future works

- Fe-Ni batteries exhibited stable and reliable performance during PS duty cycles and highlighted the battery's adaptability to various load conditions, discharging rates, and durations of discharge cycles.
- Optimal SOC selection is crucial for specific applications, and maintaining the battery properly and implementing appropriate charging strategies are essential for ensuring optimal performance, and efficiency in FR applications.
- Overall, Fe-Ni batteries show promise for both PS and FR applications due to their stability, reliability, excellent cycle life, and environmental benefits.
- For the future N-cell batteries are going to be tested for grid applications.

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