볼트EV 전기차에 탑재한 초기 및 개선판 배터리의 실생활 열화 추이 비교 분석

정우덕*
전력거래소*

Comparative Analysis of Real Life Degradation Trends Between Original and Improved Batteries on Bolt EV

Woo-Duk Chung*
Korea Power Exchange*

Abstract – Two types of lithium-ion battery packs on board a Chevrolet Bolt EV, the original 60 kWh version and the improved 66 kWh version, were tracked under real life conditions for roughly four years each in order to observe the differences in degradation trends. The usage conditions such as monthly driving distance and the depth of discharge were largely kept consistent to reduce additional variables in the comparison.

1. Introduction

A nickel-manganese-cobalt (MNC) lithium-ion battery pack with 60 kWh nominal capacity that provides 383 km of driving range was originally used on the first generation Chevrolet Bolt EV from 2017 to 2019[1]. This was changed to an improved 66 kWh version with 417 km (259 miles) of range for 2020 and later model years[2].

Because a number of vehicles with the original battery pack caught fire due to battery defect, GM recalled the affected model years starting in late 2021[3]. As a result, the 2018 model year Bolt EV used in tracking real life use had the original battery pack for its first four years, and then the improved battery pack for the next four years after getting recalled. This provided an opportunity to compare the degradation trends of the two under similar conditions.

2. Collecting Data

2.1 Method of Collection

Both the data from the on-board diagnostics (OBD) port and the infotainment display were used to gather the necessary data pertaining to battery usage and health.

<Table 1> Data Collected from the Vehicle

Source	Name	PID	Unit	Multiply
Infotainment Display	Energy Used	N/A	kWh	1
	Distance Traveled	N/A	km	1
	Ambient Temperature	22801F	°C	1
OBD Port	Displayed State of Charge	228334	%	1
	Battery Capacity	2241A3	0.1Ah	0.31968
	Charged Amount	22437D	10Wh	100

The multiplication factor for obtaining the battery capacity in kWh units has been determined in the previous three-year analysis of the original battery pack[4] and is reused here. The vehicle-specific PID numbers for battery-related data has been changed since the 2019 model year[5], but the battery replacement itself did not introduce changes to the existing vehicle. Consequently, the data collection was made under the same conditions for the entirety of the scope of interest.

2.2 Scope of Data

The following table outlines the duration and the distance that each battery packs were active for in the vehicle.

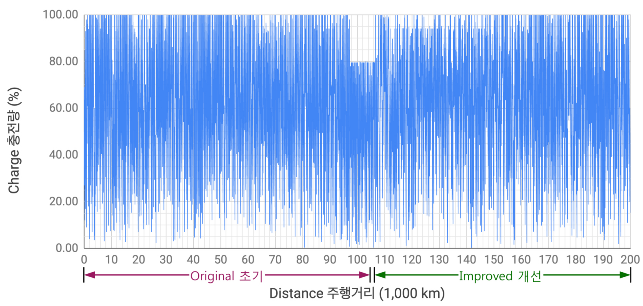
<Table 2> Battery Pack Usage

Battery Type	Time Span (Y-M-D)	Duration (months)	Odometer (km)	Distance (km)	Data Points
Original (60 kWh)	2018-06-01 2022-06-17	48.5	0.0 104,525.5	104,525.5	3,246
Improved (66 kWh)	2022-07-12 2026-05-25	46.4	106,626.0 200,007.7	93,381.7	2,984

The original 60 kWh battery pack on the target vehicle received a software update that limited its maximum state of charge (SOC) to 80% as a safety precaution during the initial recall on February 17, 2022. It was then replaced with the improved 66 kWh version four months later as the final recall procedure. The internal battery capacity estimate data became unreliable a month before the replacement, possibly due to the prolonged charging limitation causing errors in capacity calculation. Thus, this period was excluded from the analysis.

2.3 DOD and EFC

The vehicle's depth of discharge (DOD) was maintained largely between 10% and 100% of displayed SOC over its entire scope except during the aforementioned 80% limitation imposed by the recall between February and July of 2022.



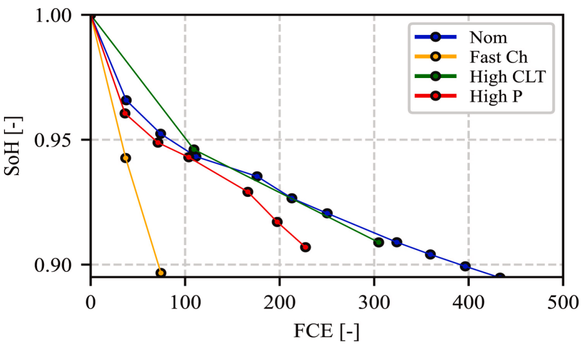
<Fig. 1> Charge-Discharge Pattern of the Vehicle

The original battery pack spent a total of 13,482.5 kWh, which resulted in 244.70 equivalent full cycles (EFC) with the changing capacity considered. This means that the lifetime average capacity is 55.10 kWh. The improved battery pack that it replaced has so far logged 12,591.6 kWh of usage and 210.86 EFC, which gives us 59.71 kWh lifetime average.

3. Comparing the Degradation

3.1 Experimental Expectations

According to a study on lithium-ion cell degradation[6] that used a close analogue of the target vehicle's battery - EV grade cells from the same manufacturer (LG) that uses the same chemistry (NMC 622) - remaining capacity, or state of health (SOH), is expected to be about 92 to 93% after 200 to 250 FCE under normal 1C charge / 1.5C discharge cycles at 100% DOD. This is labeled as "Nom" in Fig. 2.



<Fig. 2> SOH as a Function of FCE for LG E61V Cell

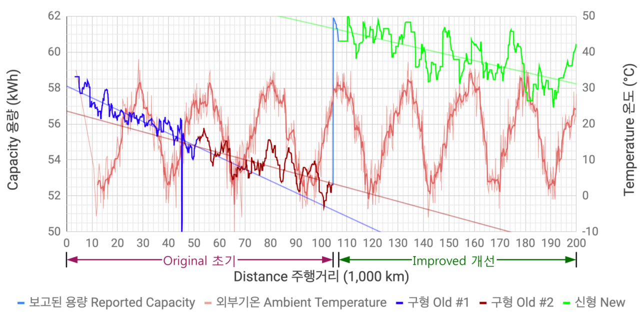
3.2 Real Life Results

The original battery initially showed a relatively steep fade (degradation) rate,, falling to 94% SOH after two years of use and at 120 cycles. The next two years had the rate slow down by nearly half, and ended up losing approximately 3% more after 124 additional cycles. This is largely in line with the above experiement, but the final SOH is somewhat lower.

<Table 3> SOH Changes Observed by Battery Type

Battery Type	Initial (kWh)	Final (kWh)	Fade Rate ($kWh/10^5 km$)	SoH (%)	Cycles
Original (60 kWh) #1	58.10	54.70	6.60	94.1	120.39
Original (60 kWh) #2	54,70	52.67	3.86	90.7	244.70
Improved (66 kWh)	61.26	58.24	3.23	95.1	210.86

On the other hand, the improved battery had a consistently more gentle rate of degradation - less than even that of the third and fourth year of the original pack. This led to just 5% decrease in SOH over the span of 211 cycles, which is markedly better than both the experiment and the original.

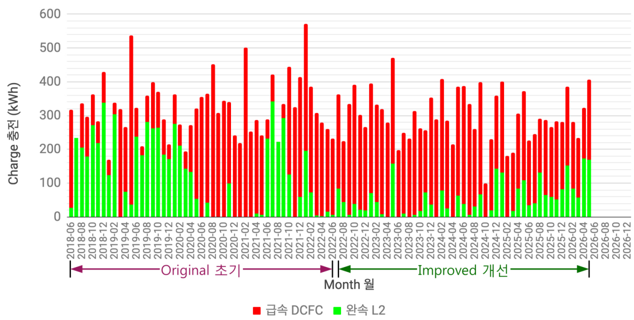


<Fig. 3> Capacity Fade over Distance & Temperature

The newer pack also had a more pronounced correlation with ambient temperature in addition to having a wider overall fluctuation of reported capacity. One possible cause can be attributed to the updated management software being more sensitive in making capacity assessments.

3.3. Effects of Fast Charging

The vehicle's battery was charged via either fast charging ("DCFC", 55 kW max.) or slow charging ("L2", 7 kW max.). And the amount used for each type was tracked separately.



<Fig. 4> Monthly Charge Amount by Charging Speed

After the first two years, fast charging was preferred over slow charging by 4-to-1 ratio. And yet the fade rate was the slowest during this period. Thus a faster charging speed was apparently not detrimental to the battery degradation. The fact that the peak charging speed is less than 1C has likely contributed to this result. Had it been faster, e.g. 1.5C used for "Fast Ch" in Fig. 2, outcome may have been different.

<Table 4> Amount & Proportion of Fast Charging

Battery Type	Slow Charging (kWh)	Fast Charging (kWh)	Fast Use (%)
Original (60 kWh) #1	4,411.99	3,417.39	43.6
Original (60 kWh) #2	1,719.72	6,080.45	78.0
Improved (66 kWh)	2,544.53	11,537.52	81.9

4. Conclusions

It is evident that the improved 66 kWh battery pack for Bolt EV is more resilient overall to the battery degradation than the original 60 kWh version when compared at 210 EFC and about 93,000 km of driving. Predominant use of fast charging has also not negatively impacted this trend, although effects of ambient temperature has become more noticeable.

[References]

[1] Richard Schmuch et al., "Performance and cost of materials for lithium-based rechargeable automotive batteries", Nature Energy, Vol.3, pp.267-278, 2018.

[2] Forrest Jehlik et al., "Vehicle Technology Assessment, Model Development, and Validation of a 2020 Chevrolet Bolt", National Highway Traffic Safety Administration, Report No. DOT HS 813 351, p.4, 2023.

[3] Jin A Choi et al, "A Study on the Fire in Charging Facilities of Electric Vehicles", Journal of Information System Engineering and Management, Vol.10 No.20s, pp.496-509, 2025

[4] Woo-Duk Chung, "Analysis of Real Life Battery Degradation Trends of Bolt EV", The 52nd KIEE Summer Conference, pp.38-39, 2021.

[5] Sean Graham, "Chevy Bolt OBD2 PIDs Project", allev.info/boltpids, 2020.

[6] Johannes Rohwer et al., "Impact of battery ageing history on future degradation rates and capacity recovery effects in NMC 622 pouch cells", Journal of Energy Storage, Vol132 Part B, id.117690, pp.1-9, 2025.