# Naypyidaw home energy storage

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Field capacity tests can be found for grid storage23,24,25, photovoltaic (PV) integration19,26,27, telecommunication28 and electric vehicles (EVs)29,30. While most of these use on-site capacity tests to monitor battery ageing19,23,24,25,26,28, others remove the battery for laboratory measurements24,27,29. Such capacity tests require a certain system downtime, leading to increasing work time and decreasing revenue.

a, Voltage and C-rate over one exemplary day. b, Data availability. c, Data gap analysis. d, Voltage distribution. e, Current distribution. f, Battery housing temperature. g, EFCs per year. h, DOD distribution with a bin width of 5 pp and depicted at the midpoint DOD, so DODs close to 0% and 100% are not shown, although they occur. i, Mean voltage seasonality.

The different cathode materials are lithium nickel manganese cobalt oxide (NMC), a blend of lithium manganese oxide (LMO) and NMC (simply referred to as "LMO" in this paper), and lithium iron phosphate (LFP). Within the NMC systems, there are differences in cell chemistry. Two of the NMC systems have a high nickel share.

To account for system design and cell chemistry, the system nomenclature gives information on both parameters to interpret the results. Therefore, this paper refers to "SmallLMO" (or "SLMO"), "MediumNMC" (or "MNMC") and "MediumLFP" (or "MLFP") HSSs. As there are already HSSs in the energy range above 15 kWh on the market, none of the systems are classified as large. SLMO and MNMC systems share similar battery chemistries, but their system design is not comparable. While the MLFP and the MNMC systems show a similar system design, their battery chemistries are not comparable.

The large dataset allows the information extraction on actual home storage operation (Supplementary Notes 3-5). In the following, the most important findings for method development are presented.

It is important to note that the parameter distributions of identical systems vary between households as the HSS operation is highly dependent on the PV generation and the electrical house consumption. In addition, the systems show different operational strategies (Supplementary Fig. 1) and different temperature distributions in dependence on the room and the system (Fig. 1f and Supplementary Fig. 2).

When analysing field data, operational strategies and software updates need to be taken into account. Some of these changes are shown in Supplementary Fig. 5, where the derating behaviour is changed, and the EOD voltage is decreased to counteract battery ageing.

a, SOHC over system age. b, SOHC over EFCs. c, SOHC according to age and EFCs. d, Different discharge behaviour of HSSs. SOHC normalized to the nominal capacity stated on the modules.

Supplementary Note 6 provides all the necessary information to understand the conducted capacity tests and warranty conditions. Supplementary Fig. 6 explains the capacity reserves that manufacturers apply to meet warranty conditions. The reserves are implemented by stating less capacity on the datasheet than the HSSs have. Supplementary Fig. 7 shows the capacity test scheme, and Supplementary Fig. 8 shows the influence of the ageing reserve and the normalization quantity on the warranty condition.

HSSs regularly reach EOC and EOD voltage, and full cycles occur. The developed method uses this behaviour to estimate the capacity (Methods and Supplementary Methods). First, it identifies relaxation phases around the EOC and EOD voltages. Second, it estimates the relaxation OCV using a second-order equivalent circuit model with a two-step fitting procedure. Third, it estimates the capacity using an offset-current-corrected coulomb counting between a fully charged (EOC voltage) and a fully discharged (EOD voltage) state.

Figure 3 shows the storage operation of two exemplary days. During this period, the HSS shows a full cycle: It is empty at the beginning of day 1, gets fully charged until noon, stays at a high SOC during the day and is fully discharged overnight. The next day, it gets fully charged again. On the basis of this storage operation, four integration possibilities exist to estimate the capacity while integrating the current from empty-to-empty (E2E), full-to-full (F2F), empty-to-full (E2F) and full-to-empty (F2E).