**High-rate lithium ion energy storage to facilitate increased penetration of photovoltaic systems in electricity grids**

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**Supporting Information**

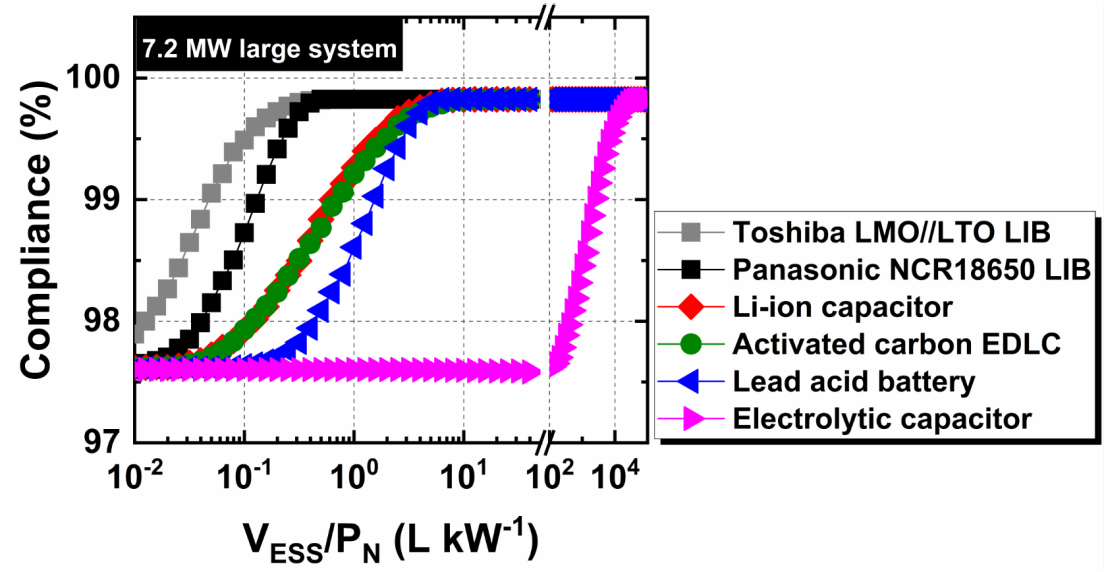


Figure S1. Ramp rate compliance of a PV array for different energy storage technologies. Compliance (%) of an energy storage system (ESS) of volume, *VESS*, to limit the ramp rate of the generated power to ≤ 10% per min from a 7.2 MW PV array (*PN* = 7.2 MW) for a period of 46 summer days (using 1 s irradiance data) in Sydney, Australia (adapted from Jiang et al.1). Note the compliance (%) was calculated as the percentage of power ramps over the total time (including day and night) where the power ramping was limited to within the 10% min-1 target.

Table S1. Theoretical gravimetric and volumetric capacity of different anode materials.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Anode Material | Densitya  (g cm–3) | *n*b | Theoretical Capacity | |
| Gravimetric (mAh g–1) | Volumetric (mAh cm–3) |
| Graphite (C6) | 2.27 | 1 | 372 | 843 |
| Li4Ti5O12 | 3.42 | 3 | 175 | 611 |
| TiO2 (Rutile) | 4.13 | 1 | 335 | 1384 |
| TiO2 (Brookite) | 3.99 | 1 | 335 | 1337 |
| TiO2 (Anatase) | 3.79 | 1 | 335 | 1270 |
| TiO2 (Bronze) | 3.64 | 1 | 335 | 1219 |
| TiNb2O7 | 4.29 | 3/5 | 233/388b | 998/1663 b |
| Ti2Nb10O29 | 4.43 | 12/22 | 216/396 b | 957/1755b |
| TiNb24O62 | 4.54 | 25/49 | 205/402b | 930/1824b |

aSingle crystal densities are listed for each material. Practical electrode densities are a function of particle size/morphology and electrode preparation.

bWhere two values are given, the value on the left is calculated for the one electron reduction of Ti4+/Ti3+ and Nb5+/Nb4+; the value on the right corresponds to the one electron reduction of Ti4+ to Ti3+ and the two electron reduction of Nb5+ to Nb3+ as is increasingly common in the literature.

**References**

1. Jiang, Y., Fletcher, J., Burr, P., Hall, C., Zheng, B., Wang, D.-W., Ouyang, Z. and Lennon, A.: Suitability of representative electrochemical energy storage technologies for ramp-rate control of photovoltaic power. *J. Power Sources*  **384**, 396-407 (2018).