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ESS Sizing

Aspects to take into account

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Requirements of the application

- Energy/power, type of profiles
- Conditions such as temperature
- Objective of the application: cycle life, cost, autonomy, etc.

Procedure

1. Required energy
2. Life expectancy (number of cycles)
3. Power requirement
4. Capacity of the battery for the application C-rate (Be careful with lead acid)
5. Choose a cell
6. Determine the battery configuration (e.g. 4S1P)
7. Estimate self discharge (dependant on the application)
8. Consider temperature dependency
9. Estimate cost

Sizing example

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1. Energy requirement
   - Size the battery to be able to give you the energy required by the application
   - EXAMPLE: 18 kWh in the morning and 36 kWh in the afternoon. So we need to charge at least 54 kWh with PV panels. Imagine that we have 6 hours to charge the battery, then 54 kWh / 6 hours = 9 kW of PV panels are required
2. Life expectancy due to DoD (Depth of discharge)
   - Depending on the DoD applied during the life to the battery the aging is different. HIGHER DoD, FASTER DEGRADATION
   - EXAMPLE: 20 years x 365 days x 1 cycle per day = 7300 cycles requirement. From the data of the manufacturer it is concluded 60% of DOD is the maximum to reach the 7300 cycles. So the battery has to be oversized. Battery Energy x 0.6 = 54 kWh, then Battery Energy = 90 kWh

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3. Power requirement
   - The battery has to be able to give the peak power of the application. The maximum discharge and charge current have to be taken into account
   - EXAMPLE: 40 kW is the requirement; 40 kW / 48 V = 833.33 A. Our battery is 90 kW for 1C; 90 kW / 48 V = 1875 A. 833.33 / 1875 = 0.44 C-rate, lower than 1C, energy application, not power application
4. Capacity of the battery
   - Is the capacity of the battery, not the capacity of the single cell
   - EXAMPLE: 90 kWh / 48 V = 1875 Ah
5. Choose the type of cell
   - Depending on the application requirements some lithium technologies are more suitable. LiFePO4 for cycling and low power applications; NMC and NCA are more suitable for power requirements
   - EXAMPLE: LiFePO4; 3.2 V per cell

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6. Determine battery configuration
   - The number of series and parallel connected cells has to be defined
   - EXAMPLE: 48 V / 3.2 V = 15 cells in series. 1875 Ah / 15 Ah = 125 in parallel. 15S125P configuration
7. Estimate self discharge
   - In applications where the battery is not used for long times, months, it has to be taken into account
   - EXAMPLE: Neglected because it is used every day
8. Temperature dependence
   - The number of cycles at high temperatures is reduced so the battery should be again oversized if necessary. Normally data is given at 25 ºC
   - EXAMPLE: Not taken into account

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9. Cost
   - The cost of the system depends on the cost of the cell. However, you can imagine that there are other costs like cooling system for the battery, electronics associated to measure variables (BMS), maintenance of the battery if it has to be changed, etc.
   - EXAMPLE: with 60 euros per cell, the cost of the battery is 15 x 125 x 60 euros = 112.500 euros. The comparison should be done with the diesel engine taking into account the cost of the diesel, the cost of the engine, maintenance of the engine, probably more expensive than the battery

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Aditional information

Life expectancy graph

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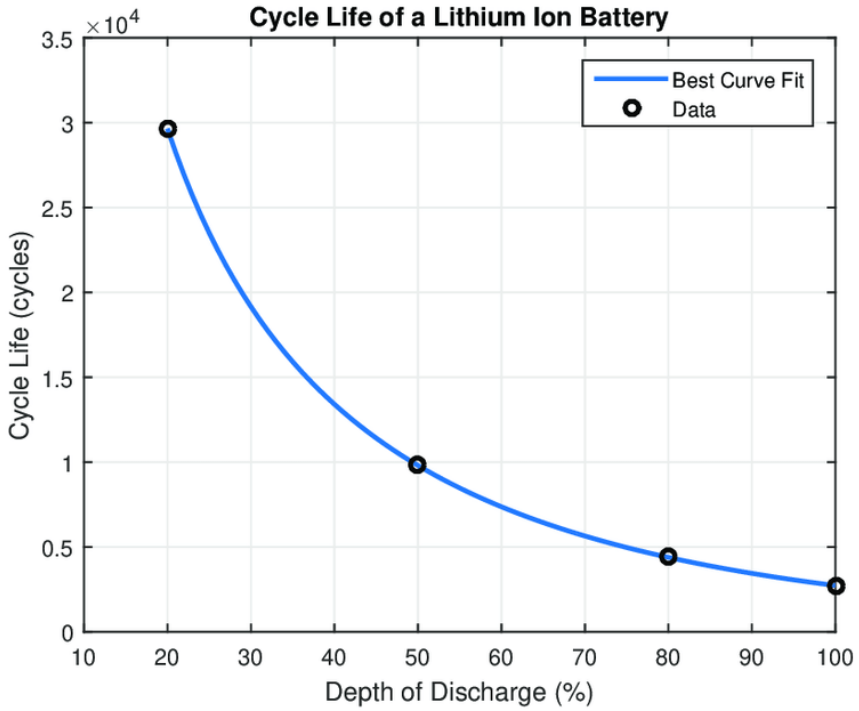
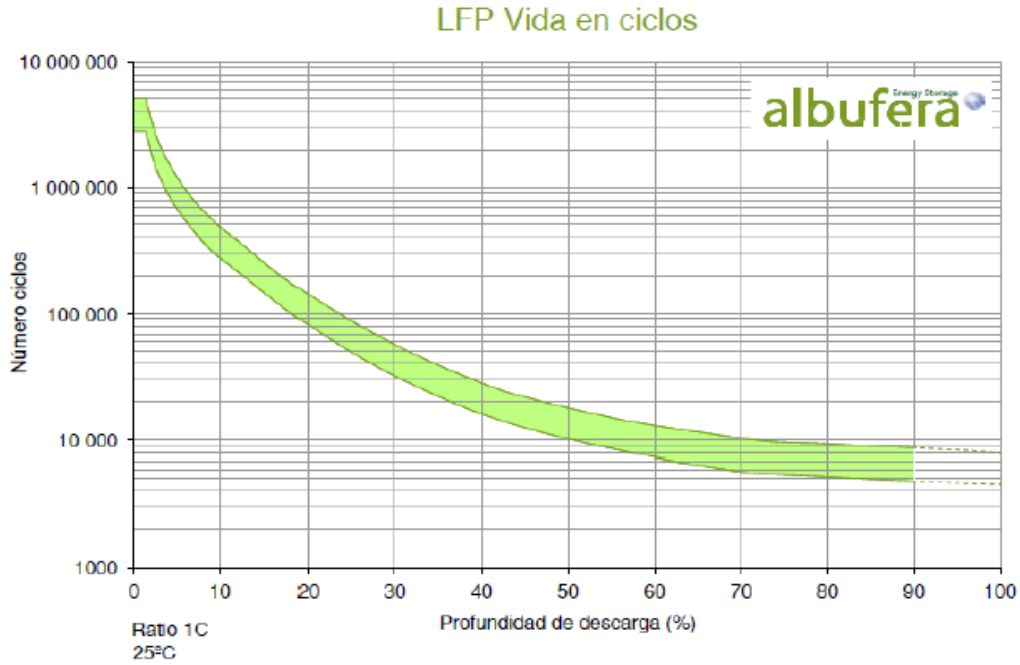
- It is necessary to know how the cell selected is going to be aged to size the battery for a concrete application.
- In the case of the exercises done in class, the exercise has to give you this information.
- In the case you will face in the future you have to obtain this curve by yourself, normally the manufacturer will not give you this information.





Be careful with the C-rate dependent capacity

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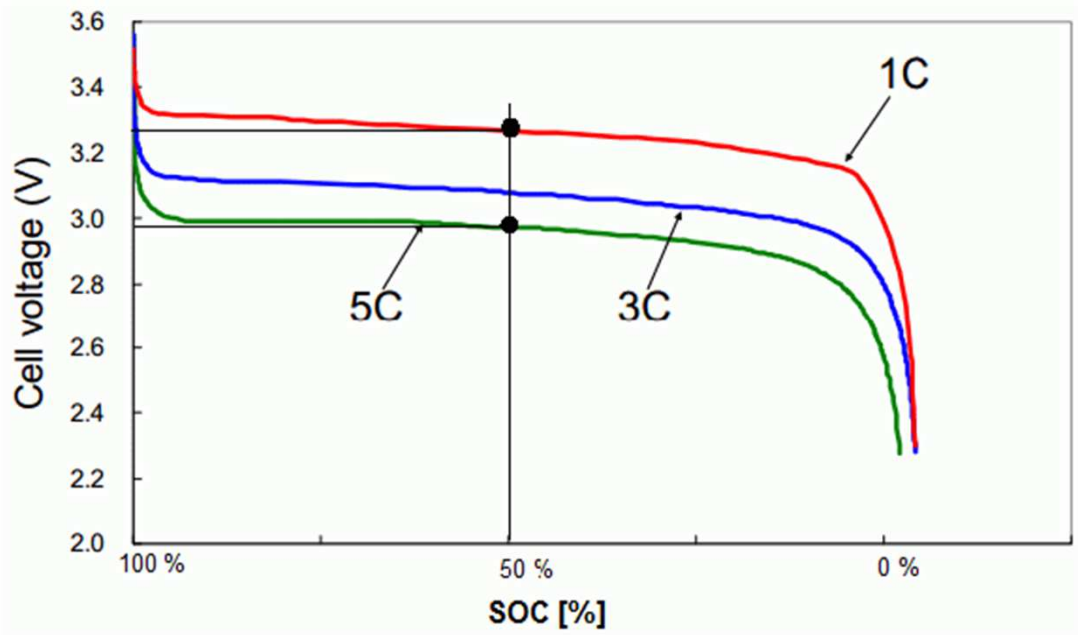
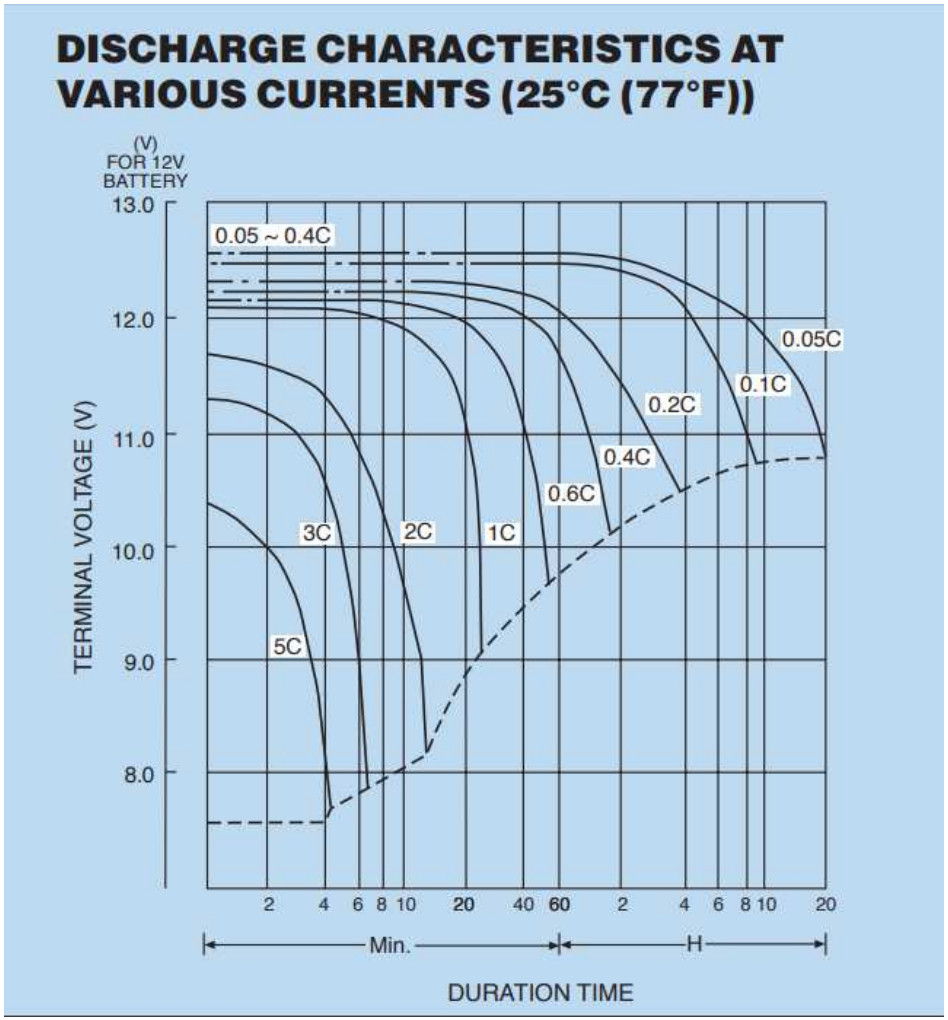
- Lithium Ion cells can give almost the same capacity for any current C-rate.
- However, lead acid cells or batteries can give you only their nominal capacity if the working current is very low. (This will affect to your sizing)

Lithium ion cell discharge characteristic



Lead acid battery discharge characteristic



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Muchas gracias

Thank you

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