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Homework 5

8 years of operation at 24,000 km per year.
average battery out put of 204 Wh/km
rated cell of 3.6V) a capacity of 3.4 Ah, L=1, N(100%)=1,000

i) BOL kWh storage and BOL range $24{,}000(8) = 192{,}000$ km

$\frac{192{,}000 \text{ km}}{1{,}000} = 192$ km per cycle

BoL Rang = 192 km per cycle

BoL storage = 192 (204) = 39.16 kWh

ii) Cells required?
$E_{cell} = V \times Ah = 3.6V \times 3.4 Ah = 12.24$ Wh

Number of cells = $\frac{39.16 \text{ kWh}}{12.24 \text{ Wh/cell}}$ = 3200 cells

iii) Cells Required if BoL Range is 425 km
storage = 425 (204) = 86.7 kWh
Number of cells = $\frac{86.7 \text{ kWh}}{12.24 \text{ Wh/cell}}$ = 7083 cells

iv) how many parallel strings are required if the pack has 96 cells in series

$V_{pack} = 96 \times 3.6 = 345.6$ V
Parallel strings = $\frac{7083}{96}$ = 74

v) battery pack mass, assuming pack density of 150
Total energy = 86.7 kWh

Battery mass = $\frac{86.7 \text{ kWh}}{150 \text{ Wh/kg}}$ = 578 kg

2. PHEV Pack: 10 years at an average of 50 km per day average battery output of 5 km/kWh, and a 14.6 Ah cell with 3.65 V. $L = 3$ $N(100\%) = 1{,}000$

i) BoL battery pack energy storage

$$\text{Daily energy required} = \frac{50\ \text{km}}{5\ \text{km/kWh}} = 10\ \text{kWh/day}$$

10 years = 3650 days

$$3650 = N_{100\%}(100\%/DoD)^{L} \rightarrow \sqrt[3]{3.65} = \frac{100\%}{DoD} \rightarrow DoD = 65\%$$

$$\text{Energy Storage} = \frac{10\ \text{kWh}}{0.65} = \boxed{15.4\ \text{kWh}}$$

ii) Total number of cells

$$E_{cell} = 14.6(3.65) = 53.29\ \text{Wh}$$

$$\text{Number of Cell} = \frac{15{,}400\ \text{Wh}}{53.29\ \text{Wh}} = 288.98\ \text{cells}$$

$\boxed{288 \rightarrow \text{nearest multiple of 3}}$

iii) Pack voltage in 3 Parallel cells

$$n_S = \frac{288}{3} = 96 \qquad V_{Pack} = 96(3.65) = \boxed{350\ \text{V}}$$

iv) battery pack's mass, assuming 150 Wh/kg

$$\frac{15{,}400\ \text{Wh}}{150\ \text{Wh/kg}} = \boxed{102.67\ \text{kg}}$$

3. NiMH HeV battery Pack: 10,000 cycles Per year for ten years, 60 wh Per cycle usage, a 6.5 Ah cell with a rated voltage of 1.2V $L=1.5$ $N(100\%)=1000$

$N = 10{,}000(10) = 100{,}000$

$DoD = \left(\frac{100{,}000}{1000}\right)^{1/1.5}(100) = 4.641\%$

i) BoL battery Pack storage

$$\text{BoL energy storage} = \frac{60}{0.04691} = 1{,}292.8 \approx \boxed{1.292\ \text{kWh}}$$

ii) Total number of cells

$E_{cell} = 6.5(1.2) = 7.8$

$$\text{Total Cell} = \frac{1292}{7.8} = \boxed{165.6\ \text{cells}}$$

iii) battery Pack's rated voltage if cells are in series

$V_{Pack} = 165.6(1.2) = \boxed{198.72\ \text{V}}$