

EV Efficiency Enhancement Calculation with Gearbox and DC Generator

Understanding the Gearbox Effect

Since the system includes a 5:1 gearbox between the EV motor and DC generator, the following effects are observed:

- For every 1 rotation of the EV motor, the generator rotates 5 times.
- Torque increases by 5×, but speed (RPM) also increases by 5×.
- Power input to the generator remains nearly the same (excluding efficiency losses).
- The gearbox has a 92% efficiency, meaning 8% of the power is lost during conversion.

Thus, the power transferred to the generator after gearbox losses is:

$$P_{\text{input,new}} = P_{\text{input,old}} \times 0.92$$

Power Input to Generator (After Gearbox)

Before using the gearbox, the power sent to the generator was:

- 30 kWh battery: 10 kW
- 40 kWh battery: 13.33 kW

After gearbox efficiency (92%), the new input power to the generator is:

$$30 \text{ kWh battery: } 10 \times 0.92 = 9.2 \text{ kW}$$

$$40 \text{ kWh battery: } 13.33 \times 0.92 = 12.26 \text{ kW}$$

Power Output from DC Generator

The DC generator has an 85% efficiency, meaning it converts only 85% of the input power into electricity:

$$P_{\text{output,new}} = P_{\text{input,new}} \times 0.85$$

$$\text{For a 30 kWh battery: } 9.2 \times 0.85 = 7.82 \text{ kW}$$

For a 40 kWh battery:

$$12.26 \times 0.85 = 10.42 \text{ kW}$$

Now, if two generators are used, the total energy recovered is:

$$30 \text{ kWh battery: } 7.82 \times 2 = 15.64 \text{ kW}$$

$$40 \text{ kWh battery: } 10.42 \times 2 = 20.84 \text{ kW}$$

Battery Power Distribution After Gearbox

Since we only have 30-40 kWh total, power allocation remains the same:

- EV Motor takes 67% of battery power.
- Generators take 33% for energy recovery.

For 30 kWh battery:

- **20 kW to EV Motor**
- **10 kW to Generators**
- **15.64 kW recovered**

For 40 kWh battery:

- **26.67 kW to EV Motor**
- **13.33 kW to Generators**
- **20.84 kW recovered**

Key Benefit:

- Without the gearbox: Total recovery was 11.42 kW (30 kWh) and 15.26 kW (40 kWh).
- With the gearbox: Recovery increases to 15.64 kW (30 kWh) and 20.84 kW (40 kWh).

This is an additional 30% energy recovery!

Range Calculation

Assuming 6 km per kWh as the EV's consumption rate:

Range = Total Usable Energy / Consumption Rate

For 30 kWh battery:

- Before generator: 180 km
- After generator + gearbox boost:

$$(30 + 15.64) / 0.167 = 273.84 \text{ km}$$

For 40 kWh battery:

- Before generator: 240 km
- After generator + gearbox boost:

$$(40 + 20.84) / 0.167 = 374.64 \text{ km}$$

With the gearbox, range increases by ~52%