Range Extended Electric Vehicle (REEV) Computational Model

- REEV ➔ an electric vehicle + an alternative power unit (range extender, RE) ➔ on board battery charging to extend driving range.
- This research investigates the impact of battery pack capacity, RE power and driving conditions on REEV driving range using drive cycle analysis.
- Malaysian Urban Drive Cycle (MUDC), Worldwide Harmonized Test Cycle (WLTP), Highway Fuel Economy Test cycle (HWFET) and New European Drive Cycle (NEDC) are used in the analysis to cater for urban, highway, and urban + highway driving conditions.

**Vehicle power requirement:**
- Aerodynamic drag
- Wheel & axle
- Transmission
- Electrical motor
- Auxiliaries

**Power Bus & Controller:**
- Calculate power balance equation
- Define charging strategy
- Switches on/off range extender
- Switches on/off braking regeneration

**Battery:**
- Charging/discharging
- Range extender: On / Off

**Battery control strategy**
In CD mode, REEV has zero tailpipe emission (similar to EV) whereas in CS mode, RE is activated to sustain the battery state of charge (SOC).

**Vehicle Model Specifications**
- Curb weight without battery: 1323 kg
- Cargo mass: 80 kg (weight of an adult)
- Drug coefficient: 0.28
- Frontal area: 2.27 m²
- Wheel radius: 0.305 m
- Electric motor: 80 kW AC synchronous electric motor
- Battery maximum capacity: 38 kWh
- Battery type: Laminated Lithium ion (LiMn2O4 with LiNiO2)
- Battery energy density: 157 Wh/kg

**Electric motor efficiency:** 0.95
Inverter efficiency: 0.97
Transmission efficiency: 0.96
Cohesive efficiency: 0.96
Fraction of regeneration: 0.3
Moment of inertia: 3.84 kg m²
Rolling resistance coefficient: 0.007
Auxiliary power consumption: 6 kW

**Inputs:**
- Drive cycle
- Vehicle specifications

**Computational vehicle model block diagram**

**Drive cycles speed traces**

**Minimum RE Power Requirement to Sustaining Battery Charge**
- MUDC: 10 kW
- WLTC: 12.5 kW
- HWFET: 14.5 kW
- NEDC: 10 kW

Highway driving condition requires the highest RE power to sustain the battery charge, in contrast to urban driving which requires the lowest RE power.

**Impact of RE power & battery capacity on extended driving range on different drive cycles**
- Extended range increases exponentially with the increase of RE power in all driving conditions.
- Thus the RE should be designed to have power close to, equal or higher than the self-sustaining power to maximize its impact on the extended driving range.
- Higher battery capacity allows longer battery charging time by RE, therefore has higher extended range.
- Battery capacity has larger impact on the extended range in highway driving condition as compared to urban driving condition.

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