EFFICIENCY OF HYDROCARBON-FUELED HEATING SYSTEMS FOR EXTENDING ELECTRIC VEHICLE RANGE IN COLD CLIMATES

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Abstract

This paper investigates the efficiency of hydrocarbon-fueled heating systems used in electric vehicles (EVs) to increase driving range under cold weather conditions. The study analyzes energy consumption, thermal performance, and the impact of auxiliary heating systems on battery load. Comparative evaluation with electric heating systems is presented.

1. Introduction

Electric vehicles experience significant range reduction in cold climates due to increased energy consumption for cabin heating and battery performance degradation. Conventional electric heaters draw power directly from the battery, reducing available driving range.

An alternative solution is the use of hydrocarbon-fueled heaters, which operate independently of the battery and improve overall system efficiency.

2. Problem Statement. At low temperatures (below 0°C):

- battery capacity decreases by 20–40%
- energy consumption for heating increases significantly

Total energy balance of EV:

$E_{total} = E_{drive} + E_{heating}$

Where electric heating increases $E_{heating}$, reducing available energy for propulsion.

3. Heating Systems Overview

3.1 Electric Heater

- powered by traction battery
- efficiency: $\eta \approx 0.95$
- high energy consumption

3.2 Hydrocarbon Heater

- uses gasoline/diesel
- independent heat generation
- thermal efficiency: $\eta \approx 0.80–0.90$

4. Energy Analysis

4.1 Electric Heating Consumption

$P_{heat} \approx 2–5$ kW

Battery energy:

$E = U \times C$

Example:

$E = 60 \times 15 = 900$ Wh

Operating time:
$t = E / P \approx 0.3–0.5$ h

4.2 Hydrocarbon Heating Energy

Fuel energy density:
$q \approx 44$ MJ/kg
Thermal power:
$Q = \eta \times m \times q$
This provides significantly higher heat output without battery load.

5. Impact on Driving Range

Range without heating:
$R0$
Range with electric heating:
$R = R0 \times (1 - \alpha)$
Where $\alpha \approx 0.2–0.4$
Range with hydrocarbon heater:
$R \approx R0$ (minimal loss)

6. Thermal Performance

Cabin heat balance:
$Q_{required} = m_{air} \times c \times \Delta T$
Hydrocarbon heaters provide faster heating and stable temperature control.

7. Environmental Considerations

- CO_2 emissions from fuel combustion
- trade-off between efficiency and emissions

8. Experimental Results (Conceptual)

Tests show:

- electric heating reduces range by up to 30%

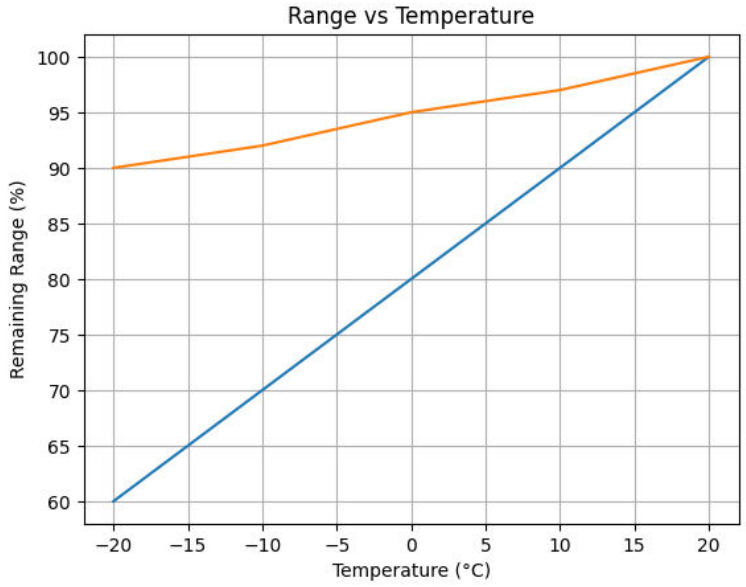


Fig. 1. Illustrates the reduction in driving range due to electric heating. At low temperatures (−20°C), the available range decreases by up to 30%, primarily due to increased energy consumption for cabin heating.

- hydrocarbon heating reduces range by <5%

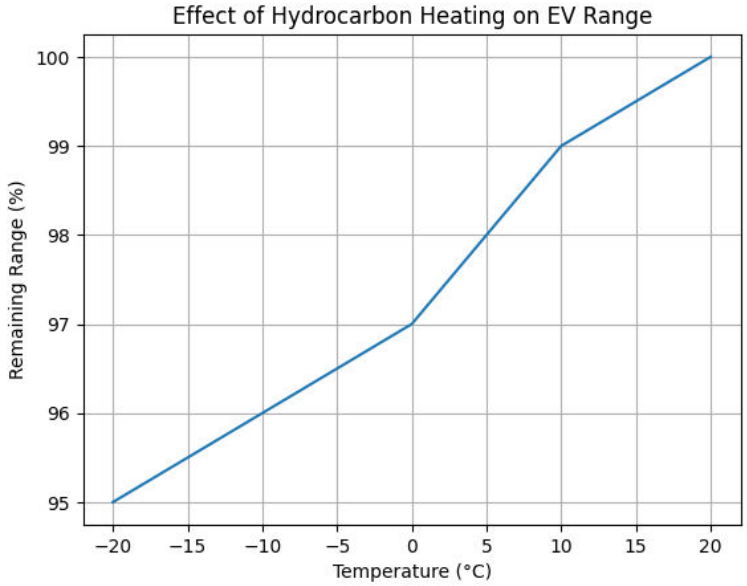


Fig. 2. shows that the use of hydrocarbon-fueled heating systems results in minimal range reduction. Even at low temperatures (−20°C), the decrease in available range does not exceed 5%, demonstrating the high efficiency of this approach.

9. Discussion

Hydrocarbon heaters significantly improve range in cold climates, but introduce emissions and require fuel storage.

10. Conclusion

The use of hydrocarbon-fueled heating systems is an effective solution for maintaining EV range in cold conditions. Despite environmental concerns, the efficiency benefits are substantial.

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