Quick Facts

Conventional vehicles with internal combustion engines use mechanical power to drive their air conditioning compressors in the summer and draw on engine waste heat to warm their passenger compartments in the winter.

In contrast, electric vehicles rely mainly on their battery's energy for climate control, and this can reduce vehicle range by as much as 68% per charge.

NREL tests and analyses are demonstrating the potential for thermal management strategies to extend the driving range of electric vehicles.

Thermal management strategies include zone-based cabin temperature controls, advanced heating and air conditioning controls, seat-based climate controls, thermal pre-conditioning techniques, and thermal load reduction methods.

Research at NREL's Vehicle Testing and Integration Facility advances the understanding of vehicle climate control loads and supports the development of better thermal management technologies.

NREL Works to Increase Electric Vehicle Efficiency Through Enhanced Thermal Management

Researchers at the National Renewable Energy Laboratory (NREL) are providing new insight into how heating and cooling systems affect the distance that electric vehicles can travel on a single charge. Electric vehicle range can be reduced by as much as 68% per charge because of climate-control demands. NREL engineers are investigating opportunities to change this dynamic and increase driving range by improving vehicle thermal management.

NREL experts are collaborating with automotive industry partners to investigate promising thermal management technologies and strategies, including zone-based cabin temperature controls, advanced heating and air conditioning controls, seat-based climate controls, vehicle thermal preconditioning, and thermal load reduction technologies. The ultimate goal is reducing the amount of energy needed for climate control so that more of the battery's energy can be used to increase vehicle range—all while maintaining the comfortable cabin temperatures that drivers expect.

To carry out their investigations, researchers at NREL's Vehicle Testing and Integration Facility put vehicles through thermal soak and warm-up and cool-down cycles, while measuring temperatures at strategic interior and exterior locations. Temperature data and thermal analysis tools are used to evaluate the effectiveness of potential energy-saving and comfort-optimization strategies. After using baseline vehicle thermal test data to validate the models, configurations that cannot be tested are simulated to assess performance. Once NREL knows how the climate control load will be affected under a wide range of conditions, vehicle simulations are used to assess the potential impact on driving range.

This research has helped determine that preconditioning a vehicle—achieving a comfortable cabin temperature by preheating or precooling the passenger compartment while the vehicle is plugged in—can extend driving range and battery life. NREL researchers are also testing the benefits of combining cooling loops to enable preconditioning of not only the cabin, but also the power electronics, electric motor, and battery. They are also investigating the use of a heat pump for waste heat recovery from the motor and power electronics

A vehicle undergoes climate control testing at NREL's Vehicle Testing and Integration Facility.

Photo by Dennis Schroeder, NREL 19931

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