TRANSFORM
Energy Systems through Game-changing Technology

BUILDINGS | CARBON CAPTURE AND STORAGE | FUEL CELLS | NUCLEAR | POLICY | PLANNING
RENEWABLES | SMART GRID | STORAGE | **SUSTAINABLE MOBILITY** | SUSTAINABILITY ANALYSES

MODELING THE POWER SYSTEM DYNAMICS OF FUEL CELL ELECTRIC VEHICLES

Prof. Xianguo Li

When you combine battery electric vehicle technology with fuel cells, you get an emissions-free vehicle that runs on electricity but doesn't need to be plugged in. Instead, you just fill up the tank with hydrogen — a process that takes minutes, rather than hours.

But modelling the complex behaviour of these hybrid systems is challenging, making it difficult to run diagnostics or advance the technology. With more hydrogen fuel cell electric vehicles (FCEVs) hitting the market, WISE researcher Xianguo Li and his colleagues set out to create a new approach.

They started by equipping a 2021 Toyota Mirai FCEV with sensors to measure various operating parameters, including voltage, current, power, pressure, flow and temperature. Next, they collected data in real-time during a chassis dynamometer test that simulated everything from highway cruising to stop-and-go traffic. They also subjected the vehicle to high loads and speeds to understand how the powertrain system behaves under extreme conditions.

Ultimately, the researchers collected more than 21,000 data points. They used 15,000 of them to train a neural network to predict the Mirai's hybrid power system dynamics. Then they tested the accuracy of the model with the remaining 6,000.

The results proved both highly accurate and computationally fast at predicting the critical outputs of the fuel cell and battery dynamics — including fuel cell voltage, battery temperatures and more — under various driving scenarios.

As FCEVs continue to evolve, this machine-learning model gives automotive companies a powerful new tool to accelerate emissions-free transportation.

***Researchers**: Xianguo Li, Adithya Legala, Matthew Kubesh, Venkata Rajesh Chundru, Graham Conway*

***Partners**: Natural Sciences and Engineering Research Council of Canada, Southwest Research Institute*

Source: *Legala, A., Kubesh, M., Chundru, V., Conway, G., Li, X. (2024). Machine learning modeling for fuel cell-battery hybrid power system dynamics in a Toyota Mirai 2 vehicle under various drive cycles. Energy and AI, 17, 100415.*

.

READ ARTICLE

wise.uwaterloo.ca

WISE
WATERLOO INSTITUTE
FOR SUSTAINABLE ENERGY

UNIVERSITY OF
WATERLOO