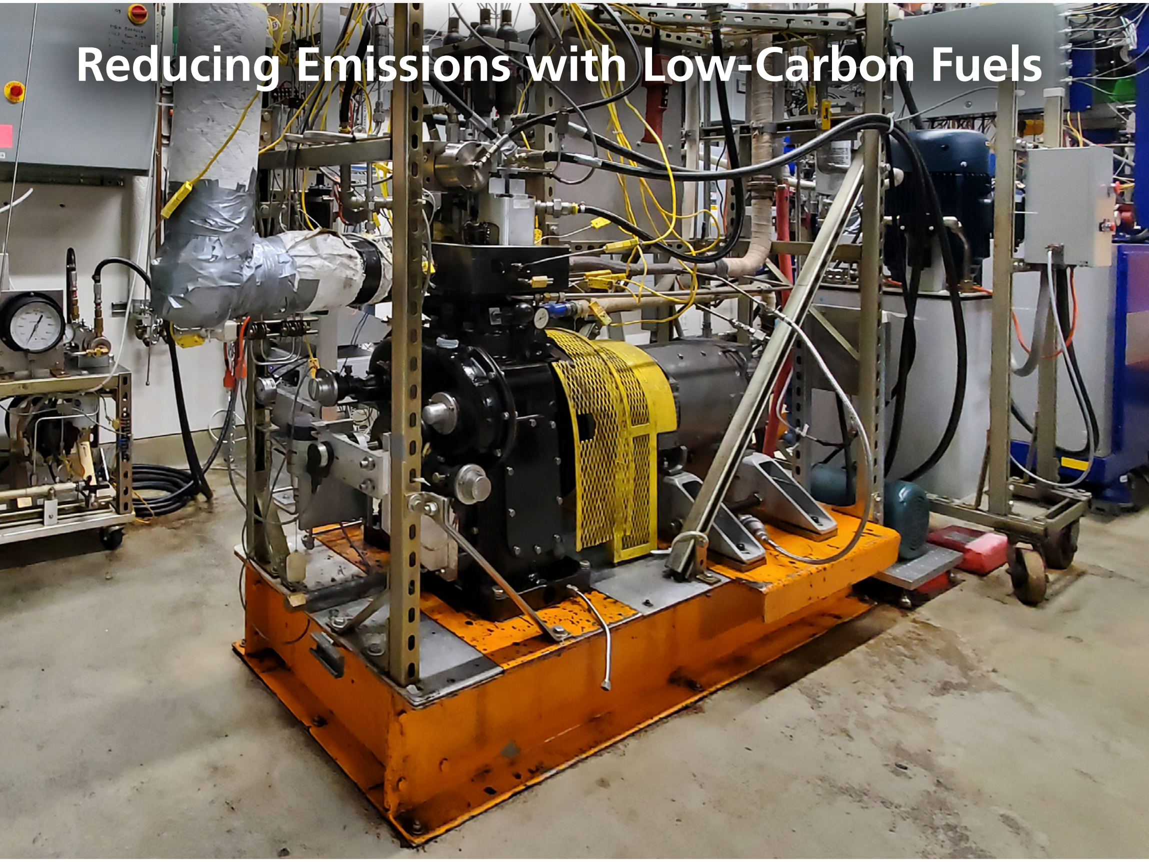
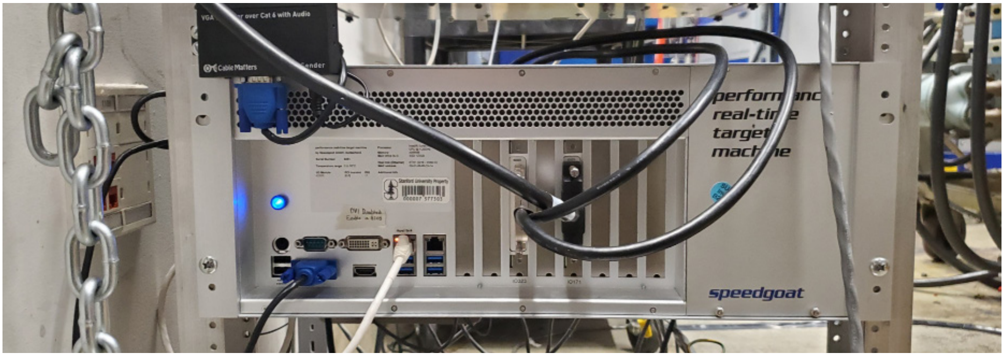
# Stanford University

## Reducing Emissions with Low-Carbon Fuels



speedgoat
real-time simulation and testing




**Researchers at Stanford University's Advanced Energy Systems Lab rely on a Performance real-time target machine to control an experimental engine. With this testing setup, they reduce emissions and optimize engine performance by using renewable fuels.**

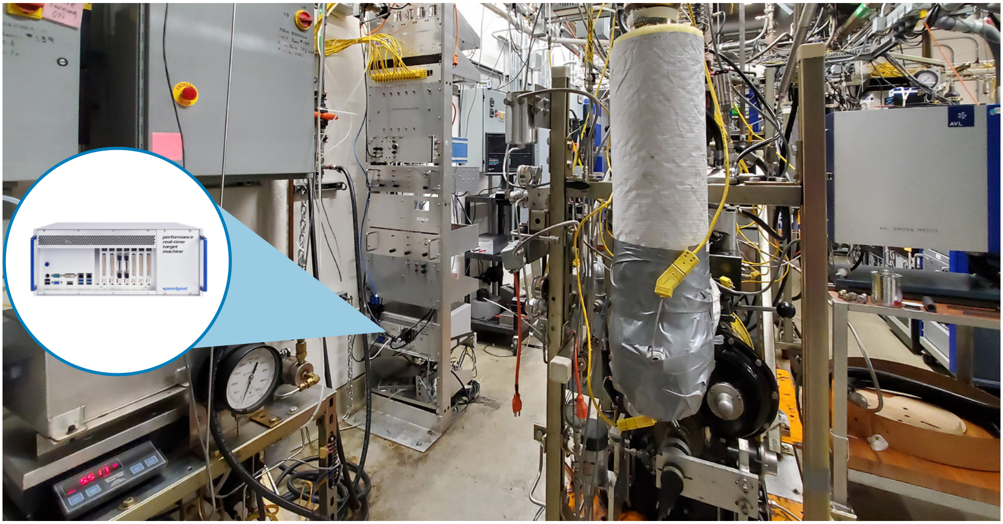
Stanford University's Advanced Energy Systems Lab (AESL) contributes to a more eco-friendly and sustainable future. They are enabling the use of low-carbon or alternative renewable fuels within traditional combustion engines.

Combustion engines are an integral part of the global economy, and transportation sector trends indicate an increasing demand for diesel combustion engines in the coming decades. They are used widely in demanding applications, such as long-haul trucking and backup power, because they deliver reliable performance under continuous, high-load conditions. However, traditional diesel engines will struggle to meet increasingly stringent global emissions standards, even with the complex and costly after-treatment systems used today.

Researchers at Stanford take an innovative approach to avoid emission drawbacks of diesel engines using low-carbon fuels. They have applied thermal barrier coatings (TBCs) to in-cylinder components to create a high-temperature environment in the engine. This enables the use of low-carbon fuels instead of diesel fuel while simultaneously improving performance.

Traditional engines using lower-carbon fuels can meet current and future emissions regulations with simple, inexpensive after-treatment systems. The researchers in the AESL are currently exploring the use of ethanol and natural gas in these engines.

Coating technology maintains the beneficial characteristics of traditional diesel engines while lowering their environmental impact.



Stanford University Advanced Energy Systems Lab testing setup with an integrated Performance real-time target machine.

It requires only minor changes to existing diesel engine technology, making rapid adoption of cleaner engines possible.

The technology can help realize significant emissions reductions in the near term and provide a clear path to using renewable fuels once commercially available.

### Forging New Paths

Since AESL's experimental engine setup requires processing various analog and digital I/O, such as signals from quadrature encoders, the research team faced computational processing power constraints with the previous testing setup. Furthermore, they wanted to use existing MATLAB® code to parametrize Simulink® models, create visualizations, and log data.

Therefore, they implemented the cost-effective, scalable, and fully Simulink integrated Performance real-time target machine as the experimental engine's engine control unit (ECU).

Among the controlled quantities are intake air pressure, valve actuation control using PWM generation, and fuel injection, all synchronized using the quadrature decoder functionality of the configurable FPGA IO323 I/O module. Furthermore, the IO171 thermocouple & strain I/O module monitors the temperature at several points in the intake and exhaust lines and the engine head.

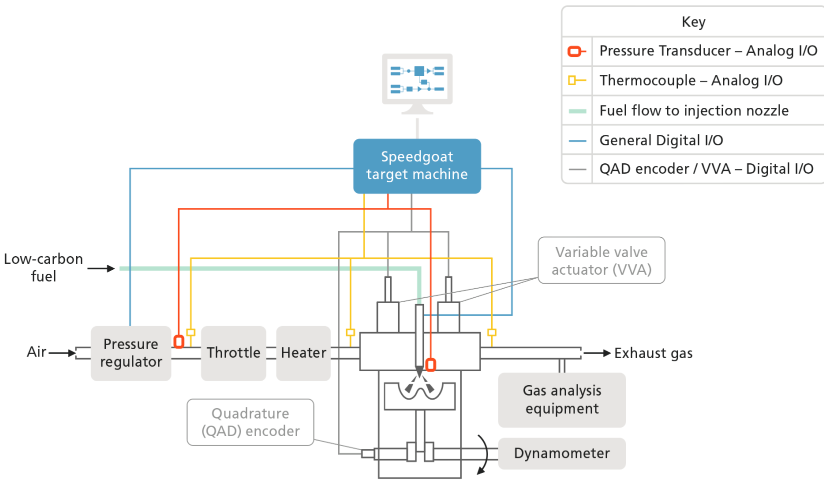
Researchers can now determine the most environmentally friendly non-traditional hydrocarbon compositions with the data provided by this control system. In addition, its seven I/O module slots have the advantage that new functionalities can be added to the Performance real-time target machine if needed.

Thanks to these promising results and the flexibility provided to adapt the system when needed, researchers at Stanford will continue to use Speedgoat solutions for future projects dedicated to exploring new energy systems that are more efficient, more powerful, and much more environmentally friendly.

> "We needed a reliable and fast controller. Speedgoat provided a cost-effective solution that handles various signal types and is reprogrammable as our experimental engine setup changes. Furthermore, the Speedgoat technical support department was incredibly responsive and helpful."

Jacob Alvarez, Graduate Researcher at Stanford University Advanced Energy Systems Lab

## Diagram of the Experimental Engine



**Utilized Speedgoat products:**
» Performance real-time target machine
» IO171 I/O Module
» IO323 configurable FPGA I/O Module

**Utilized MathWorks products:**
» MATLAB®
» Simulink®
» MATLAB Coder™
» Simulink Coder™
» Simulink Real-Time™

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