

Earth Day at the EcoCAR 2 lab

Tyler Rose, Outreach Coordinator, UW EcoCAR 2 Team and Tom Egel, Consulting Engineer, MathWorks



Earth Day is our favorite holiday around the UW EcoCAR 2 lab. From our standpoint, this time of the year encourages people to celebrate the ways in which they can help reduce vehicle emissions and fuel consumption. We will be showcasing our team's EcoCAR 2 efforts alongside the Puget Sound Clean Cities Coalition at the Earth Day festivities put on by the University of Washington. In our booth, we will be talking to the community about vehicle emissions, and we'll use computer monitors to show a demonstration of MathWorks software and our simulated vehicle dynamics.

The EcoCar competition is instrumental in developing the automotive engineers of the future. The students on the UW EcoCAR team are involved in many aspects of new vehicle development using Model-Based Design methods develop and deploy the complex control algorithms required for hybrid vehicles.

The hybrid drive system being developed by our team will reduce emissions in two primary ways.

First, a Remy electric traction motor will be fitted to drive the rear wheels of the vehicle. Powered by an A123 Systems plug-in rechargeable battery pack, the electric drive system will operate completely independently from the internal combustion engine. For the first 40 to 50 miles of driving, depending on conditions, the car will not burn any petroleum-based fuel whatsoever. Based on a report by the US Department of Transportation, 78% of drivers typically drive less than 40 miles round-trip per day. Under these conditions, it is likely that the user could operate a vehicle such as ours for many days or even weeks without ever starting the internal combustion engine. Of course, emissions are produced to generate the grid electricity necessary to recharge the battery packs, but this additional output is merely a fraction of the emissions emitted by a standard internal combustion engine.

Second, we will be harnessing the power density of diesel to lessen fuel consumption. The standard GM 2.5L gasoline engine in the Chevy Malibu is a highly efficient gasoline engine. However, their small 1.7L diesel engine will provide us with greater fuel efficiency. For the technically inclined, one liter of gasoline contains 34MJ of energy, whereas one liter of diesel contains 38.6MJ. Simply put, the diesel will allow us to achieve a higher miles per gallon measure per volume unit of fuel than with the gasoline engine. Additionally, we will be using B20 biodiesel provided by Propel Fuels. Twenty percent of the diesel fuel is made from a sustainable vegetable-oil base in the B20 blend, further reducing the dependence on fossil fuels. In order to coordinate the virtual connection between the internal combustion engine and the electric motor, we first need to model the characteristics of the vehicle.

Simulink, from MathWorks, is the platform for Model-Based Design. Model-Based Design methods are critical to developing the complex control algorithms used in today's hybrid vehicles. We use Simulink to build a mathematical model of every drivetrain component in the car. With these models we can simulate the entire vehicle in a virtual world to verify that our control strategy works safely for our vehicle architecture. Furthermore, the models of each component have efficiency calculations which can tell us how much energy is used and wasted by each component. We can also determine the overall vehicle efficiency for each of its fuel types by driving the simulated vehicle over standard federal drive cycles. By simulating our vehicle's performance over these drive cycles, we can track how changes to the control strategy will affect the vehicle efficiency, emissions, and drivability. We can then use these simulation results to select the best control strategy for each situation the vehicle encounters.

Our diesel engine has efficiency and emissions maps that can tell us how efficiently it should operate under all conditions. If the diesel engine is our primary propulsion source (such as when our battery charge is low), we can use these maps to execute an operating strategy known as engine load shifting. To accomplish this load shifting, we first look to see if we can decrease diesel engine emissions by forcing the engine to provide more torque (at the same RPM) than requested. We do this by making the rear electric motor apply negative torque and generate electricity. The effect is sort of like regenerative braking, but instead of slowing down the vehicle,

Earth Day at the EcoCAR 2 lab

Published on Electronic Component News (<http://www.ecnmag.com>)

we just make the engine work harder to turn the rear motor load, driving the engine into an operating region where it is more efficient and produces fewer emissions. Using Simulink models of the components, we can calculate in real time how much negative torque should be generated by the rear motor to produce the lowest emission levels. In the process, we also generate electricity which will eventually allow the user to switch back to using the electric motor as the main propulsion source.

Model-Based Design is used extensively in industry and is critical to hybrid vehicle development due to the lack of legacy designs for this new class of vehicles. The EcoCAR competition provides the students at UW with an opportunity to learn about Model-Based Design and how it can be applied to solve complex engineering problems.

Five tips for a greener car

1. Do routine maintenance: Regular oil changes will help keep your engine healthy. A healthy engine runs more efficiently and returns better gas mileage. Remember to service other areas of the engine, too, such as changing the spark plugs, air filter, fuel filter, and other wear items per the guidelines in your vehicle's manual.
2. Don't neglect an engine light: If your vehicle's engine light is on, something is wrong even if it doesn't feel like it. Many causes of an engine error code are emissions related, e.g. faulty fuel cap, emissions system leak, fuel mixture too lean/rich, etc. Make sure to investigate and repair any causes of an engine code to ensure proper emissions control.
3. Do monitor tire pressure: Tires are an oft neglected vehicle component. Maintaining proper inflation and alignment can reduce rolling resistance and improve gas mileage. Manufacturer recommendations for tire pressure can usually be found on a sticker in the doorjamb or in the vehicle's manual.
4. Don't buy worthless products: Virtually any product advertised on television to improve gas mileage is junk. In fact, they usually produce the opposite effect. Many devices are fitted in the air tract which actually restricts flow and causes the engine to run inefficiently. Most fuel additives are vehicle snake oil.
5. Do take that junk out of the trunk: That folding table, hockey gear, and set of golf clubs in your trunk is a lot of extra weight. Removing all that excess stuff from your car will lighten the load that the engine has to move. An engine with less weight to move won't have to work as hard and will return higher fuel mileage.

Source URL (retrieved on 12/27/2014 - 11:46pm):

http://www.ecnmag.com/blogs/2012/04/earth-day-ecocar-2-lab?qt-video_of_the_day=0