FLUX HYBRIDS

Data Report

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Purpose
To understand the efficacy/utility/purpose of Flux Hybrids' conversion kit technology, we will present the fuel economy of a vehicle tested before and after it was converted and driven along the same real-world routes. The vehicle is a 2008 Ford Ranger 3.0L V6 Automatic fitted with a 2.6kWh lithium-ion battery pack, an electric motor, and controller. The values observed from testing the vehicle after conversion represent the improvements of the Flux Hybrids 1st Generation kit (Gen1), made in conjunction with a pilot program for the Facilities division fleet of North Carolina State University. Subsequent generations of the Flux Hybrids kit, which are currently being developed, will produce even greater gains in efficiency, reliability, durability, and reduction of emissions.

Methodology
Testing was done on hundreds of miles replicating EPA-created routes made to show fuel economy over city and highway driving conditions. These tests were done in conjunction with the work of Professor Christopher Frey at North Carolina State University for the National Science Foundation. Field data collection was done using a Portable Emissions Measurement System (PEMS).

In recent years, PEMS have been developed that increase the feasibility of measuring vehicle activity and emissions under real-world operating conditions (1, 2). PEMS are becoming an increasingly accepted alternative to the use of laboratory-based chassis dynamometer measurement methods (3). Dynamometer tests can be conducted for a transient speed profile and can be replicated, but may not be adequately representative of real-world conditions at a particular location. In-use measurements are made under real-world conditions, but are subject to variability from one run to another even for the same vehicle, driver, and route because of variations in traffic and ambient conditions. Thus, a key challenge to the use of PEMS data is to quantify the most significant sources of variability from field measurements to help inform field study design.

Route selection was aimed at ensuring broad coverage of the transportation network characteristics including road grade and facility class (e.g., freeways, arterials). Two origin and destination (O/D) pairs were selected: one between North Carolina State University (NCSU) and north Raleigh (NR), and the second between NR and Research Triangle Park (RTP). NR is a major residential area, and many people commute from NR to either inner Raleigh (as represented by NCSU) or to RTP. For each O/D pair, three alternative routes were identified with each route including a mix of roadway types (e.g., interstate highways, major arterials, minor arterials, and feeder/collector streets) and variations in road grade. These emissions are typically a factor of 3-10 higher than those estimated for a fleet average using MOBILE6, adjusted from an average g/mile to an average g/sec basis. Data were collected for both travel directions of each route.

The selection of time of day was intended to capture the variability in emissions due to temporal variations in traffic flow. Data collection was typically carried out from 6:00 to 11:00 a.m. and from 4:00 to 7:00 p.m. The typical peak travel flow in the morning period is from NR to either

NCSU or RTP, with a reversal of peak traffic flow in the afternoon. The variation in average travel times by route and time of day are detailed in the Supporting Information.

The instrument was calibrated every day of data collection. The instrument was warmed up in the laboratory and then installed onto the vehicle. The emissions measurements focused on hot stabilized emissions; therefore, the vehicle was warmed up for 15 min before the measurements started. Data collection included a driver and a second person who was in charge of the instrument and data logging.

Many factors have been shown to influence vehicle emissions, including vehicle type (4, 5), vehicle dynamics such as speed and acceleration (6–8), traffic flow conditions (9–11), ambient conditions (12, 13), roadway infrastructure (14), and driver behavior (15–17). Some of these factors can be controlled in a field experiment based on the choice of vehicles, routes, drivers, and scheduling of data collection activities. However, some of these factors, such as traffic and ambient conditions, cannot be controlled. Thus, a fuel economy increase can be estimated, but cannot be guaranteed for a particular vehicle or fleet.

Results

The raw data is attached in the file "results_191019_2008_Ford_Ranger_191101_WY.xlsx". For your convenience we have distilled pertinent data on improvements as shown below in Table 1.

Table 1: Gen1 Measured Improvements

2008 Ford Ranger pickup truck	City cycle	Highway cycle	Combined cycle
MPG, stock/OEM	15	20	17
MPG, after conversion	35	32	34
MPG improvement	+133%	+61%	+100%
Emissions reduction	-49%	-25%	-40%

The results from the tests were used to improve our understanding of the system model. Using this increased understanding, we were able to simulate the system and predict the impact of several additions, shown in Table 2. These improvements constitute our 2nd generation kit and we are in the process of implementing these systems on our prototype Ford Ranger.

Table 2: Generation 2 Improvements Simulation Results for a 2008 Ford Ranger

Flux Hybrids Kit Gen2 simulation	City cycle	Highway cycle	Combined cycle
MPG, stock/OEM	15	20	17
MPG, after conversion	41	36	39

MPG improvement	+173%	+80%	+129%
Emissions reduction	-60%	-32%	-48%

Reliability

The lithium-ion batteries used in this test showed, with life-cycle analysis, the ability to last for longer than 15 years. The mechanical and electrical components, most of them off-the-shelf or simple machines, have already been tested by their manufacturers and proven through our trials to far outlive the batteries.

Summary

Proven through extensive testing and data collection, the addition of a Flux Hybrids conversion kit to your OEM vehicle will add a significant fuel efficiency increase and, given an appropriate use case, can pay for itself in fuel well before the life of the vehicle is over. In tandem with the fuel efficiency increase is an output emissions decrease that can assist in meeting carbon reductions goals and regulations.

The average US driver would have their kit pay off in 65k miles.

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