Redefining Renewable Fuels

Interim Report - July 2025

A demonstration of the long-term adaptability and economic feasibility of E30 consumption in non-flex fuel vehicles

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Executive Summary

This project evaluated the long-term feasibility of using a 30% ethanol fuel blend (E30) compared to the conventional 10% blend (E10) in standard, non-flex fuel vehicles. Using on-board diagnostic (OBD) trackers in 94 vehicles, the study monitored engine performance metrics including fuel trims, oxygen sensor readings, coolant temperatures, and throttle behavior. This interim report summarizes findings from the first twelve months of data collection, with approximately twelve more months remaining before the final report is issued.

The E30 and E10 groups comprised a broad cross-section of state vehicles, including sedans, pickups, SUVs, and vans, with engine sizes ranging from 1.4L inline-four cylinders to 5.7L V8s. The vehicles represented several major manufacturers including Chevrolet, Ford, Dodge, and Jeep and spanned model years from 2003 to 2023. This variety ensures that the study's findings are relevant and applicable across a wide range of Nebraska’s current non-flex fuel fleet.

Vehicles running on E30 collectively traveled 218,329.68 miles, while E10 vehicles traveled 191,838.91 miles, providing a strong empirical foundation for comparison. Results showed that vehicles on E30 experienced only minor, expected adjustments in fuel trims, which stayed within manufacturer specifications. No significant differences in downstream oxygen sensor performance or other critical engine metrics were observed, indicating mechanical compatibility with E30.

For vehicles 2020 – 2024, average E30 fuel economy was 20.75 miles per gallon (MPG) and 22.03 MPG for E10, a 5.8% E30 reduction. For vehicles 2003 – 2019, average E30 fuel economy was 17.08 MPG and 15.81 MPG for E10, a 7.5% E30 advantage. Cost savings of 16.28% per gallon were achieved due to lower E30 fuel prices. To date, the state of Nebraska has saved $263,149.77 in fuel costs through this demonstration. If all 822 eligible non-flex fuel vehicles in the state fleet transitioned to E30, annual ethanol usage would rise by 77,027.5 gallons and CO_2 emissions would decrease by approximately 265.74 tons. Scaling this further, if 10% of Nebraska's registered non-flex fuel vehicles adopted E30, ethanol consumption would increase by nearly 17 million gallons annually, accompanied by an estimated 60,000-ton reduction in CO_2 emissions.

In conclusion, these results support E30 as a practical, low-risk strategy for reducing fossil fuel dependence and carbon emissions across Nebraska’s existing vehicle fleet with potential for broader adoption in the near and long term.

I. Background and Motivation

As the global energy transition progresses toward renewable sources, the transportation sector continues to be a major consumer of fossil fuels. In 2023, the United States consumed approximately 137.05 billion gallons of finished motor gasoline, averaging around 376 million gallons per day [1]. Given the current average vehicle lifespan of approximately 13 years, a substantial portion of the existing fleet will remain reliant on internal combustion engines in the near term [2]. Accordingly, the integration of renewable fuels that are compatible with conventional engine architecture—such as ethanol-blended gasoline—offers an immediate and pragmatic strategy for reducing the environmental impact of the transportation sector [3].

Ethanol, a renewable alcohol primarily derived from agricultural feedstocks such as corn and sugarcane, has been used in internal combustion engines since the 19th century [4]. Presently, the majority of commercial gasoline vehicles in the United States are certified for ethanol blends up to 15% (E15), while flex fuel vehicles are designed to accommodate blends as high as 51 – 83% ethanol (called E85). Recent research has expanded interest in intermediate blends such as E30 (30% ethanol, 70% gasoline), examining their effects on vehicle material compatibility, emissions, and performance. Studies have shown that higher ethanol concentrations may marginally increase the corrosion rate of certain metallic materials, though these changes remain well below the critical threshold of acceptable corrosion rate of 0.0025 mm/year [5]. Similarly, the effect of ethanol blends on elastomer degradation has been reported to be negligible relative to the inherent variability among different elastomer types [6]. Investigations have also been conducted into the impact of high ethanol content on engine oil performance metrics, including friction coefficient and wear scar diameter, and those studies indicate minimal variation even at ethanol concentrations up to E85 [7].

The influence of ethanol content on vehicle emissions has also been extensively characterized. Multiple studies have demonstrated that increasing ethanol concentration generally results in decreased emissions of greenhouse gases and criteria pollutants, including nitrogen oxides (NO_x), carbon monoxide (CO), and unburned hydrocarbons (HC) [8]. While some discrepancies in reported emission values exist—attributable to factors such as blend uniformity, injection method, and testing protocol—the overall trend consistently indicates reductions in pollutant emissions as ethanol content increases [9].

Finally, the impact of ethanol blending on engine performance and fuel economy has been investigated in several experimental settings. Although ethanol possesses a lower volumetric energy density than gasoline, this limitation is partially offset by its higher octane number and superior combustion efficiency. Experimental evidence suggests that increased ethanol content contributes to higher cylinder pressure and temperature, improved combustion efficiency, and reductions in knock tendency and combustion duration. These changes can, to a considerable extent, mitigate fuel economy penalties traditionally associated with lower energy density. Overall, trends across various test configurations point toward modest gains, reinforcing the viability of intermediate ethanol blends such as E30 for wider adoption in the conventional vehicle fleet.

II. Methodology

Tracker Selection

OBD trackers (On-Board Diagnostics trackers) are devices that plug into a vehicle's OBD-II port to monitor various parameters related to the vehicle's performance, diagnostics, and health. These trackers collect real-time data from the vehicle's engine control unit (ECU) and provide insights into engine status, vehicle location, driving behavior, and emissions performance. OBD trackers can detect engine issues by monitoring parameters like engine temperature, fuel system status, absolute load, throttle position, and many other parameters. They also provide diagnostic trouble codes (DTCs) when a problem occurs.

Some parameters that an OBD tracker captures from an ECU are discussed below.

- **Engine RPM:** Measures the engine's revolutions per minute (RPM), showing how fast the engine is running. It helps diagnose engine speed, idling behavior, and overall performance.
- **Vehicle Speed:** Monitors the vehicle's speed based on sensor input from the transmission or wheel sensors.
- **Coolant Temperature:** Measures the temperature of the engine's coolant, preventing overheating and ensuring that the engine operates within safe temperature limits.
- **Mass Air Flow:** Monitors the amount of air entering the engine, allowing the engine control unit (ECU) to adjust fuel injection for proper air-fuel balance.
- **Fuel Level:** Shows the percentage of fuel remaining in the fuel tank, useful for tracking fuel consumption and planning refueling.
- **Intake Air Temperature:** Tracks the temperature of the air entering the engine. It helps regulate fuel injection as air temperature impacts combustion efficiency.
- **Short-Term Fuel Trim (STFT):** STFT measures the immediate adjustments made by the ECU to the fuel delivery in response to real-time sensor data, usually to correct for deviations in the air-fuel ratio. It reflects how the ECU adjusts fuel levels to maintain optimal combustion.

- **Long-Term Fuel Trim (LTFT):** LTFT represents longer-term adjustments the ECU makes to the fuel mixture over time, based on trends in the STFT. It reflects how the ECU adapts fuel delivery to changes in engine conditions like wear, sensor degradation, or altitude.
- **Commanded Throttle:** Commanded throttle is the throttle position that the ECU requests based on driver inputs, engine load, and operating conditions. It represents what the ECU wants the throttle to do, regardless of the actual throttle plate position.
- **Absolute Throttle Position:** Absolute throttle refers to the actual position of the throttle valve, measured as a percentage from fully closed (0%) to fully open (100%). This is the real-time position of the throttle plate.
- **Relative Throttle Position:** Relative throttle measures the throttle position within its operational range. It is the percentage of throttle movement relative to the typical operating range, rather than the full 0-100% range. This value may reflect throttle behavior more in line with driving habits and specific driving conditions.

For this project, three OBD trackers were initially shortlisted:

Freematics ONE+, Kiwi 4, and HEM OBD Mini Logger. Upon evaluation, the Kiwi 4 was excluded due to discontinuation by the manufacturer. The remaining devices, Freematics ONE+ and HEM OBD Mini Logger, were tested extensively across vehicles from manufacturers including Ford, Jeep, Chevrolet, and Dodge to assess compatibility. Both devices met the project's requirements; however, the HEM OBD Mini Logger was selected for several reasons:

- **Compact Size:** Its smaller dimensions reduce the risk of disconnection issues due to user movement, especially given the varied placement of OBD ports in vehicles.
- **Comprehensive Data Capture:** Out-of-the-box, it could capture a broader range of engine metrics compared to the Freematics ONE+.
- **Domestic Manufacturing:** Being manufactured in the United States, the HEM OBD Mini Logger offered easier access to support and troubleshooting during the project.

These factors collectively made the HEM OBD Mini Logger the preferred choice for this study.

Vehicle Selection

To facilitate the formation of two distinct vehicle groups for evaluating the performance of E30 and E10 fuel blends, an approved list comprising 822 vehicles from the State of Nebraska Transportation Services Bureau (TSB), State Patrol (SP), Department of Transportation (DOT), and Games and Parks (G&P) were provided. Initially, this list lacked critical details necessary for effective classification, such as manufacturer, engine type, engine displacement, driveline configuration, and transmission type. To address this, a Python script was developed to extract the required information from various online databases using each vehicle's Vehicle Identification Number (VIN).

Upon acquiring the comprehensive vehicle data, the fleet was systematically categorized based on key parameters. This classification enabled a thorough assessment of how different vehicle configurations respond to E30 and E10 fuel blends.

Owner	Make	Model	Year	VIN
TSB	Chevrolet	Malibu	2023	1G1ZC5ST1PF118416
SP	Dodge	Durango	2021	1C4RDJAG6MC864651
G&P	Ford	F-150	2023	1FTFW1E55PKF73204

Owner	Make	Model	Year	VIN	Fuel type	Engine	Displacement	Driveline	Transmission
TSB	Chevrolet	Malibu	2023	1G1ZC5ST1PF118416	Gasoline	L4	1.5L	FWD	6 Speed
SP	Dodge	Durango	2021	1C4RDJAG6MC864651	Gasoline	V6	3.6L	AWD	8 Speed
G&P	Ford	F-150	2023	1FTFW1E55PKF73204	Gasoline	V8	5.0L	AWD	6 Speed

Figure 1: Vehicle Feature Enrichment

For the E30 group, vehicle selection was influenced by proximity to E30 fueling stations, which were limited to Grand Island, Lincoln, and Omaha. This geographic consideration ensured that selected vehicles had consistent access to E30 fuel throughout the study. In contrast, the E10 group was not subject to geographic constraints. However, to maintain balance between the groups, the selection of E10 vehicles was adjusted to mirror the characteristics of the E30 group. Additionally, all flex fuel vehicles were excluded to eliminate variability and focus the study on the effects of E30 and E10 blends on conventional, non-flex fuel engines.

Despite meticulous planning, maintaining the initial diversity of the vehicle dataset proved challenging due to frequent updates from participating agencies. Factors such as vehicles being taken out of service, changes in usage intensity, and inaccuracies in location data contributed to fluctuations in the dataset. Consequently, the diversity of the vehicle pool diminished over time. Nevertheless, concerted efforts were made to preserve as much diversity as possible in the vehicle classifications, thereby ensuring the robustness and validity of the study's findings. Preserving diversity in the dataset ensures a broad representation of vehicle characteristics, including make, model year, engine displacement and type. Figure 2 provides a visual summary of the current state of dataset diversity across these parameters.

Figure 2: Distribution of Vehicle Features

ETL (extract, transform, load) Pipeline

With the tracker data files organized in the designated OneDrive folder uploaded by the users, the development of the ETL (Extract, Transform, Load) pipeline begins by downloading these files locally. The raw output files from the trackers are in the proprietary IOS format, specific to the tracker manufacturer. To convert them into a usable format, the manufacturer's proprietary software—DawnEdit—is used to transform the IOS files into CSV format.

After conversion, the resulting Excel files are stored in tracker-specific folders. For example, all data files from tracker “X” are stored in a folder named “X.” A Python script is then employed to iterate through each folder, extract the data from all available files, format the data according to predefined table schemas, and insert it into a Microsoft SQL Server database. Each tracker has a dedicated table in the database, named after its corresponding tracker ID.

To ensure data integrity and prevent duplication, the script maintains a log in a separate table within the database. This log records key metadata such as the names of valid files, the number of files successfully processed, and the count of any corrupted files for each folder. If a file has already been logged as processed, the script will automatically skip it during subsequent runs. This mechanism is especially beneficial when handling large volumes of data on a recurring basis— such as quarterly uploads—by significantly reducing redundant workload and processing time.

In addition, a validation script was developed to verify the integrity of the ETL process. This script cross-references the list of tracker-specific folders with the corresponding tables in the database. It also compares local file metadata (e.g., file names, valid file counts, and corrupted file counts) against the entries in the log table. This comprehensive validation ensures consistency between the file system and the database, reinforcing the reliability of the ETL pipeline.

Parameter Reduction

During the tracker configuration phase, each OBD device was set up to collect the maximum number of parameters available from a vehicle's Engine Control Unit (ECU). However, due to manufacturer-specific restrictions, not all parameters are universally accessible across different vehicle models. For instance, odometer readings were successfully captured from Chevrolet Cruze and Malibu models, but the same information was unavailable from the Jeep Cherokee's ECU.

This variability extended to several other parameters as well, including ethanol content in the fuel, engine oil temperature, and others. As a result, in order to conduct a consistent and comparable analysis across all vehicles, it became necessary to identify a core set of parameters that were commonly available.

To address this, a Python script was developed to query the tracker-specific tables in the database, extract all recorded parameters, and identify the subset of parameters consistently present across most participating vehicles. These common parameters form the basis of the subsequent analysis. A summary of these universally available parameters is provided in Table 1 below.

Table 1: Consistent Vehicle Features

DTC count	Time since engine start	Engine coolant temperature
Timestamp	Abs load value	Ambient air temperature
Fuel level	Commanded throttle	Catalyst temperature
Oxygen sensor	Abs. Throttle position	Engine idle time
LTFT	Relative throttle position	Control module voltage
STFT	Fuel consumption (MAF)	Barometric pressure
RPM	Fuel consumption (MAP)	Latitude
Speed	Intake air temperature	Longitude

III. Results and Discussion

STFT, LTFT and Downstream O2 Sensor

To evaluate air-fuel regulation and exhaust gas feedback under E30 fueling, we analyzed LTFT, STFT, and downstream oxygen sensor (O2) voltages for vehicles operating on E30 and E10 (Fig. 3). The LTFT distribution for E30 was significantly right-shifted compared to E10. Furthermore, the histogram for E30-LTFT was also broader, with greater positive skewness, indicating a higher frequency of long-term enrichment events (Fig. 4).

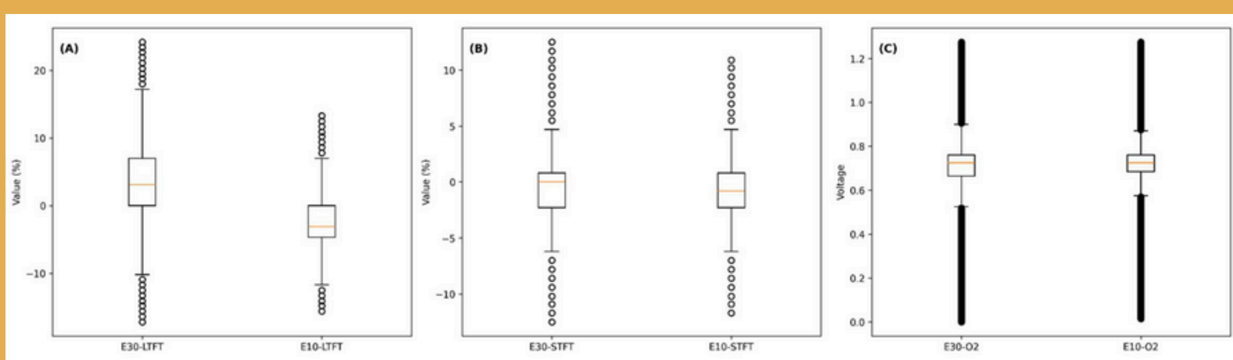

Figure 3: Variability in LTFT (A), STFT (B), and Downstream O_2 (C) Sensor Output Across Fuel Types

These findings are mechanistically consistent with the stoichiometric air-fuel ratio (AFR) requirements of ethanol-containing fuels. Pure gasoline has a stoichiometric AFR of 14.7:1, while ethanol requires 9.0:1. The effective stoichiometric AFR for E30 is approximately 13.34:1, necessitating a higher volumetric fuel injection to maintain stoichiometry [10]. The observed elevation and broadening of LTFT under E30 reflects this compensation by the engine control unit (ECU), which gradually adjusts long-term fuel delivery in closed-loop mode to correct for systematic lean conditions.

In contrast, STFT distributions were closely aligned between fuel types. Histogram analysis revealed both distributions were symmetrical and tightly concentrated around zero. This indicates that real-time feedback adjustments in AFR, regulated via the upstream O2 sensor, remained effective under both E30 and E10. The ECU's short-term correction loop was therefore not impaired by the increased oxygen content of E30, corroborating previous findings of ethanol-blend compatibility in modern control systems [11].

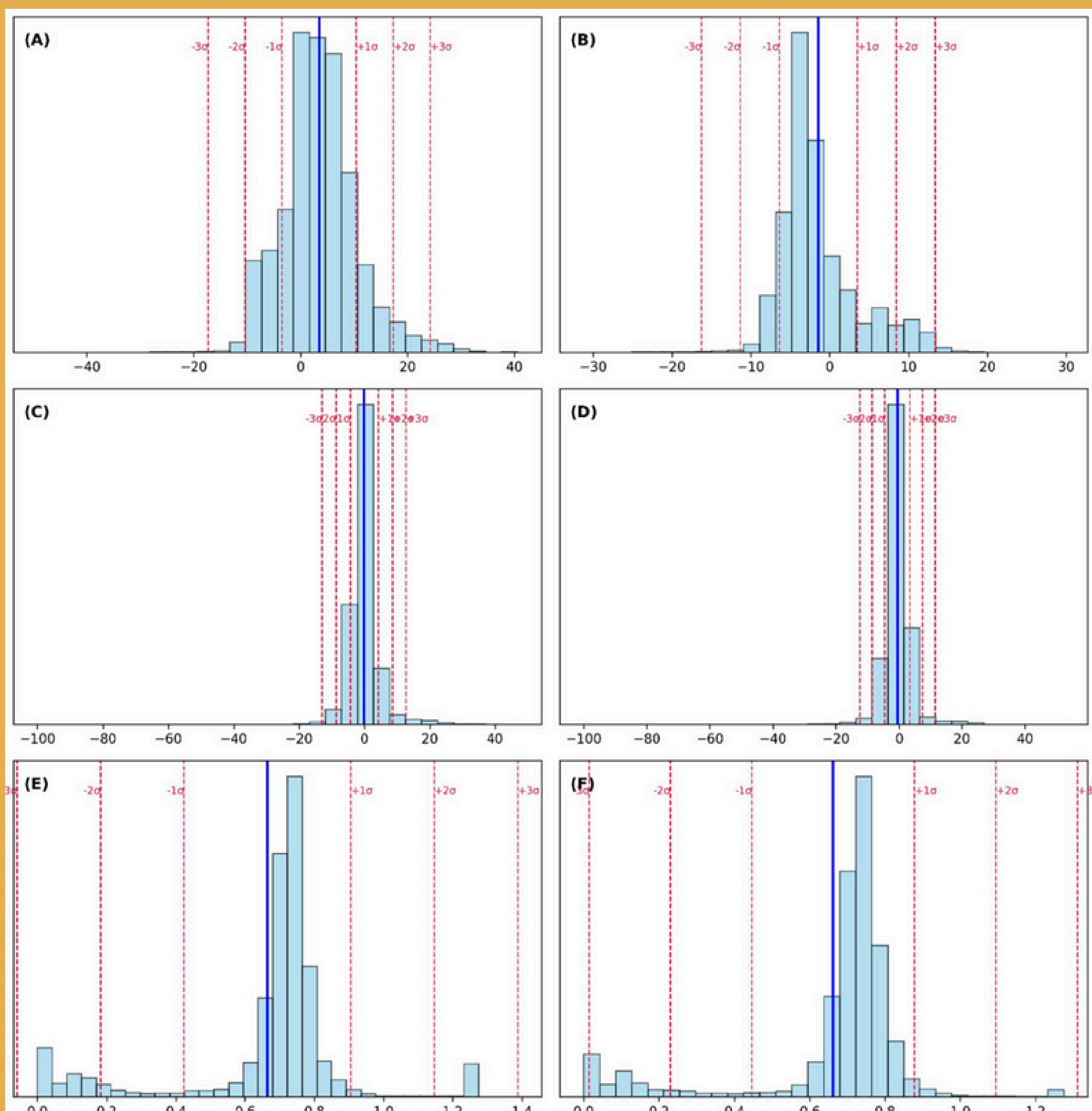

Figure 4: Data Distribution of E30 LTFT (A), E10 LTFT (B), E30 STFT (C), E10 STFT (D) E30 O2 (E), and E10 O2 (F)

Downstream O2 sensor voltages (Bank 1, Sensor 2) exhibited nearly identical distributions across fuel groups. These voltages reflect post-catalyst exhaust gas oxygen content and are indirectly indicative of catalyst oxygen storage behavior. The similarity in downstream sensor distributions suggests that catalytic efficiency and stoichiometric balance were maintained under both conditions.

These observations align with the findings from Phase 1 of the demonstration, which conducted a year-long study on non-flex fuel vehicles operating on E30 and E15 [12]. Their research demonstrated that while LTFT values increased under E30 due to the higher oxygen content, the magnitude of this change remained below manufacturer thresholds (20–25%), and downstream O2 sensor readings remained stable, indicating effective ECU adaptation to E30 fueling.

In summary, while LTFT distributions shift upward and widen under E30 to accommodate ethanol's lower energy density and altered stoichiometric ratio, STFT and downstream O2 sensor behavior remain stable. These findings collectively indicate that modern ECU strategies effectively manage E30 fueling through long-term adaptation, without compromising real-time fuel control or emissions after-treatment.

DTC Count

A focused evaluation of Diagnostic Trouble Codes (DTCs) observed in vehicles fueled with E30 revealed several codes that may be associated with the use of mid-level ethanol blends in non-flex fuel platforms. Most notably, multiple vehicles (e.g., trackers 6708, 6534, 6536, 6546, 6676, 6699) recorded P0171 (System Too Lean – Bank 1) and P0174 (System Too Lean – Bank 2), indicating lean combustion conditions. These codes are mechanistically consistent with the increased oxygen content and lower volumetric energy density of E30, which can lead to leaner-than-expected mixtures, especially during transitions or before the engine control unit (ECU) completes adaptive fuel trimming.

In addition, vehicle 6708 logged P0449, an evaporative emissions system code. While not directly linked to ethanol use, it could potentially be influenced by ethanol's higher vapor pressure or may reflect an unrelated hardware fault. Vehicle 6564 reported P0325 (Knock Sensor Circuit Malfunction), which may not be directly related to E30 but could result from combustion pattern changes misinterpreted by the knock detection algorithm. One vehicle (6699) also recorded P0562 (System Voltage Low), which is unrelated to fuel composition and instead reflects an electrical or charging system fault.

Importantly, it was confirmed that vehicle 6545 was erroneously fueled with E85 instead of E30. This deviation from the intended protocol is the most probable cause of the P0171 and P0174 lean condition codes observed in that vehicle, due to the significantly lower stoichiometric air-fuel ratio and different fuel control requirements of E85. Therefore, this case was excluded from E30-related DTC interpretation.

Further investigation is planned to determine whether the remaining lean condition codes observed under E30 are transient phenomena (e.g., sensor delay or cold-start behavior) or reflect systemic limitations in the fuel adaptation capabilities of the vehicles tested. This analysis will include reviewing correlated parameters such as short-term and long-term fuel trims, O2 sensor outputs, and engine load.

In contrast, DTCs observed in the E10 group were not investigated, as E10 is a widely approved and commercially accepted fuel for conventional gasoline vehicles. Its compatibility with most engine calibrations and emissions systems is well established, and any observed DTCs in this group are presumed to arise from unrelated mechanical or electrical issues not attributable to fuel composition.

Table 2: DTCs from Various Trackers

Tracker	Group	DTC	Description
6553	E10	P219A	• Bank 1 Air/Fuel Ratio Imbalance
6555	E10	P0562	• System Voltage Low
6569	E10	P0101 P0106 P015D P0171 P0174 P0335 P3400	• MAF Sensor Circuit Range/Performance • MAP Sensor Circuit Range/Performance • O_2 Sensor Delayed Response – Lean to Rich (B2S1) • System Too Lean (Bank 1) • System Too Lean (Bank 2) • Crankshaft Position Sensor Circuit Malfunction • Cylinder Deactivation System (Bank 1)
6668	E10	P0131 P0151	• O_2 Sensor Circuit Low Voltage (B1S1) • O_2 Sensor Circuit Low Voltage (B2S1)
6669	E10	P0011 P0013 P0420	• "A" Camshaft Timing Over-Advanced (Bank 1) • "B" Camshaft Position Actuator Circuit/Open (Bank 1) • Catalyst Efficiency Below Threshold (Bank 1)
6682	E10	P0562	• System Voltage Low
6708	E30	P0171 P0174 P0449	• System Too Lean (Bank 1) • System Too Lean (Bank 2) • EVAP System Vent Valve/Solenoid Circuit Malfunction
6534	E30	P0171	• System Too Lean (Bank 1)
6536	E30	P0171	• System Too Lean (Bank 1)
6546	E30	P0171 P0174	• System Too Lean (Bank 1) • System Too Lean (Bank 2)
6564	E30	P0325 P3449	• Knock Sensor 1 Circuit (Bank 1) Malfunction • Cylinder Deactivation System – Exhaust Valve Control Circuit/Open (Bank 1)
6676	E30	P0171	• System Too Lean (Bank 1)
6693	E30	P0562	• System Voltage Low
6699	E30	P0171 P0174	• System Too Lean (Bank 1) • System Too Lean (Bank 2)

Fuel Economy Comparison

Fuel economy analysis was conducted by comparing vehicle mileage for E10 and E30 vehicles in two different model year ranges: 2003 – 2019 and 2020 – 2024. This range approach was used because of the unbalanced nature of the dataset. Some of the vehicles did not have the required data for the timeframe under consideration. As a result, the number of vehicles considered for this calculation is less than the total number of vehicles. Furthermore, from the trackers, fuel economy values were observed from both the mass air flow (MAF) sensor and manifold absolute pressure (MAP) sensor. In general, MAF data is more accurate when compared with MAP data. However, some vehicles do not provide the MAF economy values; in those cases only, the MAP economy value was utilized.

For vehicles 2020 – 2024, the average fuel economy for vehicles operating on E30 was 20.75 miles per gallon (MPG), compared to 22.03 MPG for vehicles on E10. This represents a reduction in fuel economy of only 5.8% for E30, which is more than offset by E30's 16.3% price advantage (see below). For vehicles 2003 – 2019, the average fuel economy for vehicles operating on E30 was 17.08 MPG, compared to 15.81 MPG for vehicles on E10. Note that for this model year range, the E30 vehicles achieved 7.5% greater fuel economy than E10 vehicles. Given that ethanol has a lower volumetric energy density, this was somewhat unexpected. One reason this occurred might be that E30's higher octane means it simply outperformed E10 in the vehicles considered, or perhaps it was due to the engine parameter of the participating vehicles in the calculation. Regardless, further data and analysis is needed, which will be included in the final report.

E30 was found to have a lower retail price than E10. From accumulated fuel pricing data through February 2025, the average price of E30 in Nebraska was $2.70 per gallon, while E10 averaged $3.22 per gallon, resulting in a 16.28% price advantage for E30. Prior studies have demonstrated that modern engine management systems adapt effectively to mid-level ethanol blends like E30, leveraging ethanol's higher octane rating to enable more efficient spark timing and reduced engine knock, thereby helping to mitigate efficiency losses. Together, these findings support the economic viability of E30 in non-flex fuel vehicles under real-world driving conditions.

Engine Coolant Temperature

Engine coolant temperature (ECT) was analyzed to determine whether fueling with E30 induces any measurable changes in engine thermal regulation compared to E10. As shown in Figure 5, vehicles operating on E30 exhibited a lower median ECT of approximately 190.4 °F, compared to 198.5 °F for E10. Despite the ~8 °F difference in medians, both groups maintained operating temperatures well within the expected thermal range for spark-ignition engines [13].

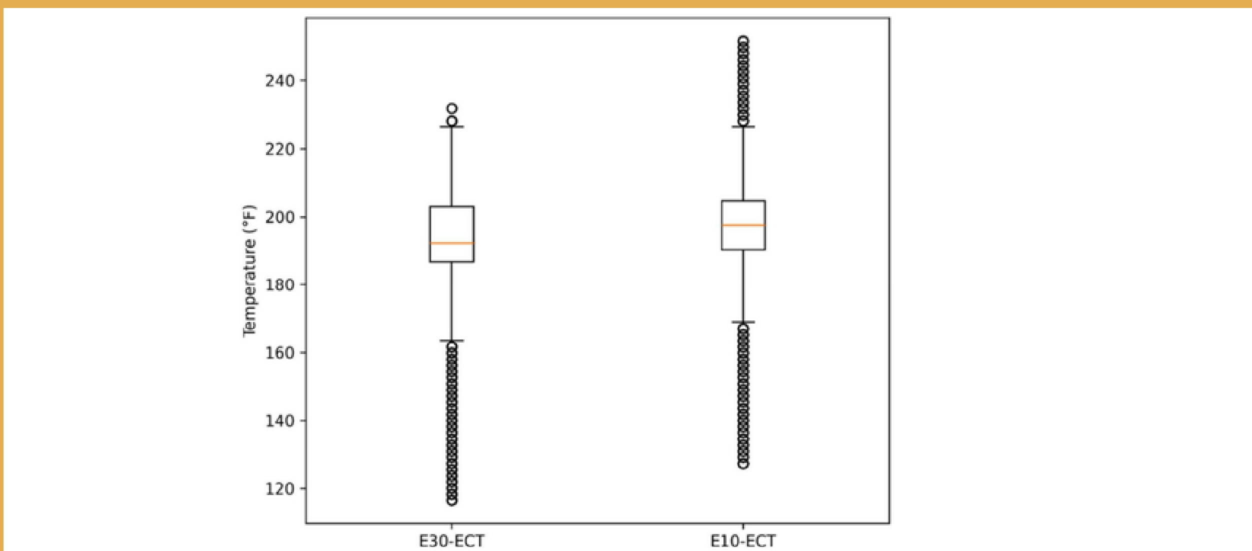

Figure 5: Variability in ECT Across Fuel Types

The present findings align with those reported by Alsiyabi et al. (2021), who investigated long term E30 use in non-flex fuel vehicles and observed a slight increase in average engine temperature for E30 relative to E15 (197 °F vs. 195 °F), with both remaining below thresholds associated with thermal concern (240–250 °F) [12]. While our dataset shows a lower median ECT for E30, the overall interpretation is consistent—engine temperatures under E30 remain well regulated and within safe limits.

Although ethanol's higher latent heat of vaporization could theoretically reduce combustion chamber and intake charge temperatures [14], this effect does not consistently translate to reduced coolant temperature under steady-state operation. Engine cooling systems are governed by thermostat-controlled circuits and fan activation thresholds that moderate temperature within a narrow band across operating conditions. The observed difference in ETC may instead reflect transient variability, vehicle-specific thermostat behavior, or differences in driving patterns rather than a systemic thermal impact of E30.

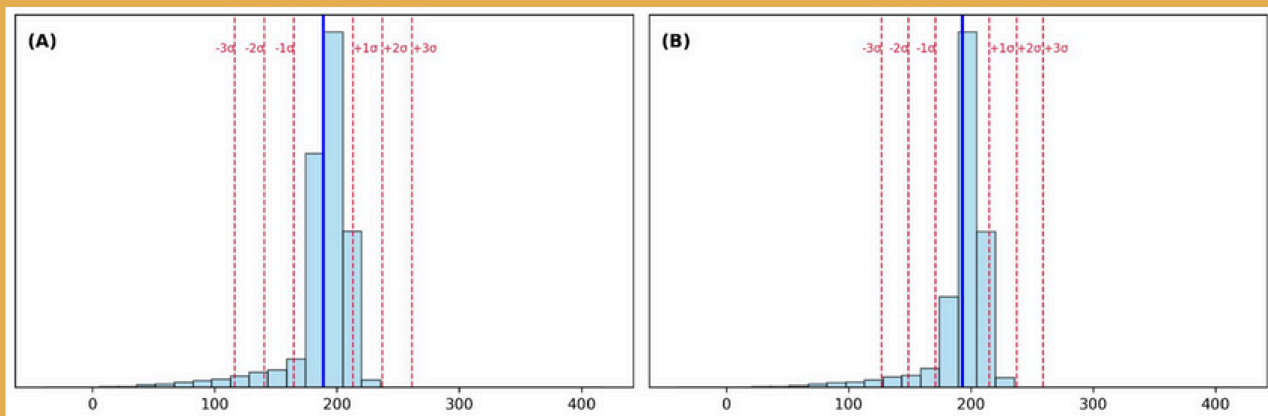

Figure 6: Data Distribution of ECT for E30 (A) and E10 (B)

Importantly, no vehicles in either group exhibited coolant temperatures exceeding critical thresholds. These findings indicate that E30 is thermally compatible with modern engine cooling architecture and does not induce abnormal heating or cooling behavior under representative driving conditions.

Catalytic Converter Temperature

Catalyst converter temperature (CT) was examined to assess whether the increased oxygen content and altered combustion dynamics of E30 affect post-combustion thermal behavior. As shown in Figure 7, vehicles operating on E30 exhibited a higher median CT of approximately 660 °F, compared to 580 °F for E10, indicating a rightward shift and broader distribution under E30 fueling. Histogram analysis further corroborated this pattern as illustrated in Figure 8.

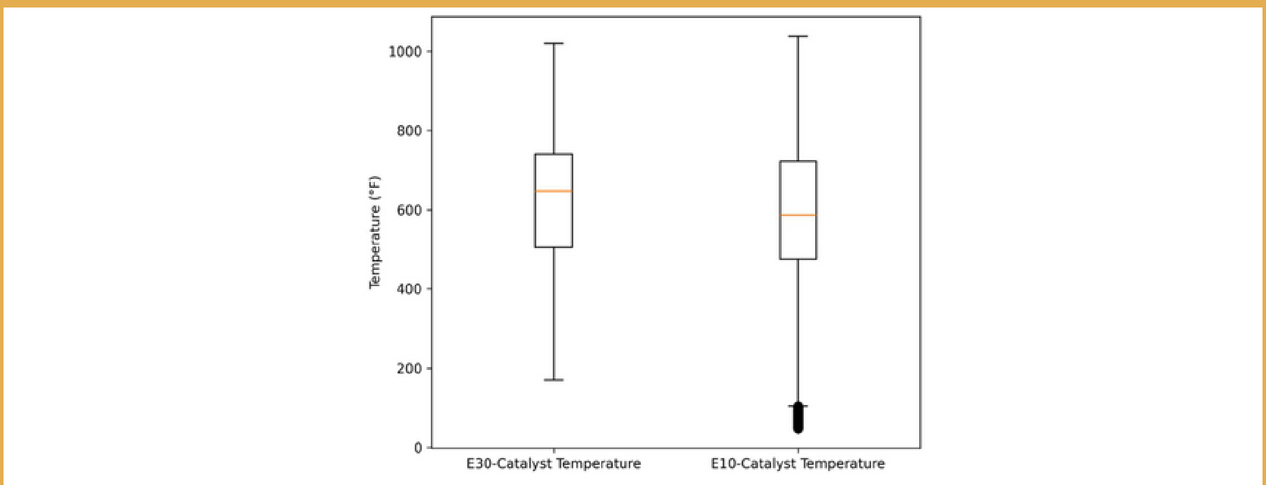

Figure 7: Variability in Catalyst Temperature Across Fuel Types

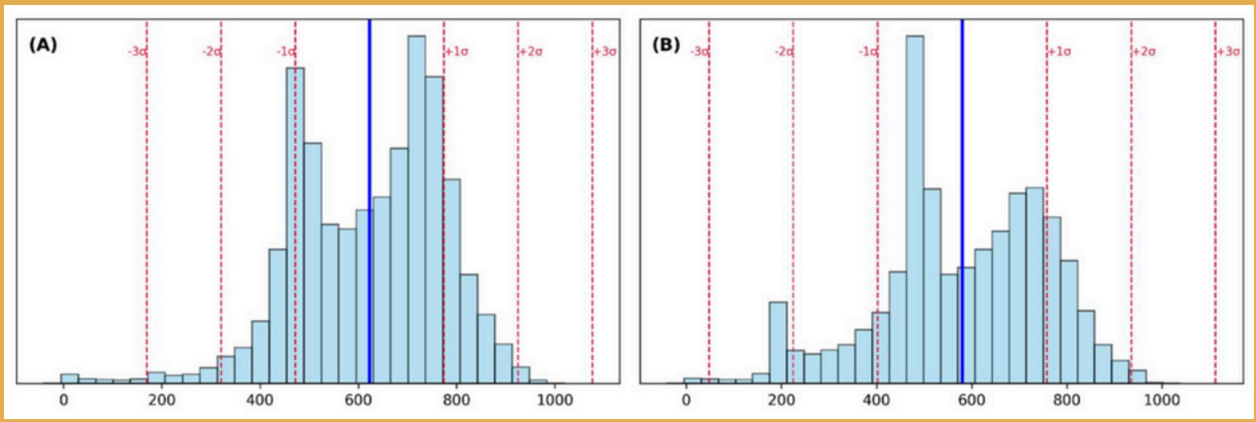

Figure 8: Data Distribution of Catalyst Temperature of E30 (A) and E10 (B)

The elevation in CT associated with E30 is consistent with the thermochemical properties of ethanol-blended fuels. Ethanol contains a higher oxygen content than gasoline and exhibits a faster flame speed, leading to earlier and more complete combustion that increases exhaust gas enthalpy and post-cylinder thermal energy [15]. These effects have been shown to produce elevated exhaust gas temperatures, particularly during cold-start and catalyst warm-up periods. Similar trends were observed in previous research which reported that increasing ethanol in fuel blend shortens three-way-catalyst light-off time under FTP-75 (a regulatory test that begins with the engine and catalyst at ambient temperature) cold-start conditions [16]. Shortening three-way-catalyst light-off time refers to how quickly the catalytic converter reaches its light-off temperature—the point at which it begins converting incoming CO, HC, and NO_x to harmless products.

Higher CT values can be beneficial during cold-start conditions, as they accelerate catalyst light off, the point at which the catalytic converter begins effectively converting NO_x, CO, and HC emissions. Maintaining elevated catalyst temperatures above the light-off threshold also improves conversion efficiency during transient operation [13]. In the present dataset, while E30-fueled vehicles consistently exhibited higher CTs, no values exceeded the thermal protection, indicating thermal compatibility under normal driving conditions.

In summary, the increase in catalyst temperature observed with E30 is attributable to its higher combustion completeness, increased flame speed, and exhaust heat content. These thermal characteristics enhance catalyst performance, particularly during warm-up and light-load conditions, without inducing thermal overstress under real-world operation.

Throttle

The comparative analysis of throttle parameters indicates that vehicles operating on E30 exhibit consistently higher values for commanded throttle (CT), absolute throttle (AT), and relative throttle (RT) compared to those using E10. Additionally, the interquartile range and tail distribution are broader under E30, reflecting greater variability and higher average throttle input as shown in Figure 9. This trend is attributable to two well-established engine control responses to mid-level ethanol blends.

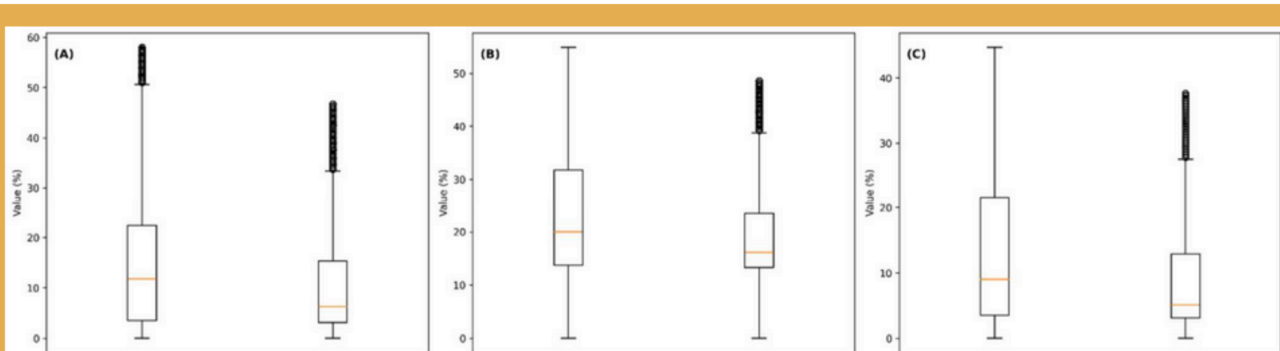

Figure 9: Variability Commanded Throttle(A), Absolute Throttle(B) and Relative Throttle(C) Across Fuel Types

First, ethanol's volumetric lower heating value is approximately 34% lower than that of gasoline, necessitating increased fuel flow to maintain equivalent energy delivery. Consequently, the ECU compensates by increasing throttle opening to meet torque demands. Similar findings were reported by Yanowitz and McCormick, who documented higher fuel and airflow requirements with mid-level ethanol blends across multiple vehicles tested on standard drive cycles [17]. Karavalakis et al. further supported this trend, observing increased airflow and throttle activity with increasing ethanol content [18].

Second, ethanol's higher octane rating (~100 RON for E30) permits operation with more advanced spark timing and higher compression ratios without knock. This enables increased engine load and improved thermal efficiency, especially under moderate-to-high load conditions. Leone et al. showed that increasing ethanol content allowed greater knock tolerance and spark advance, directly enhancing volumetric efficiency [12].

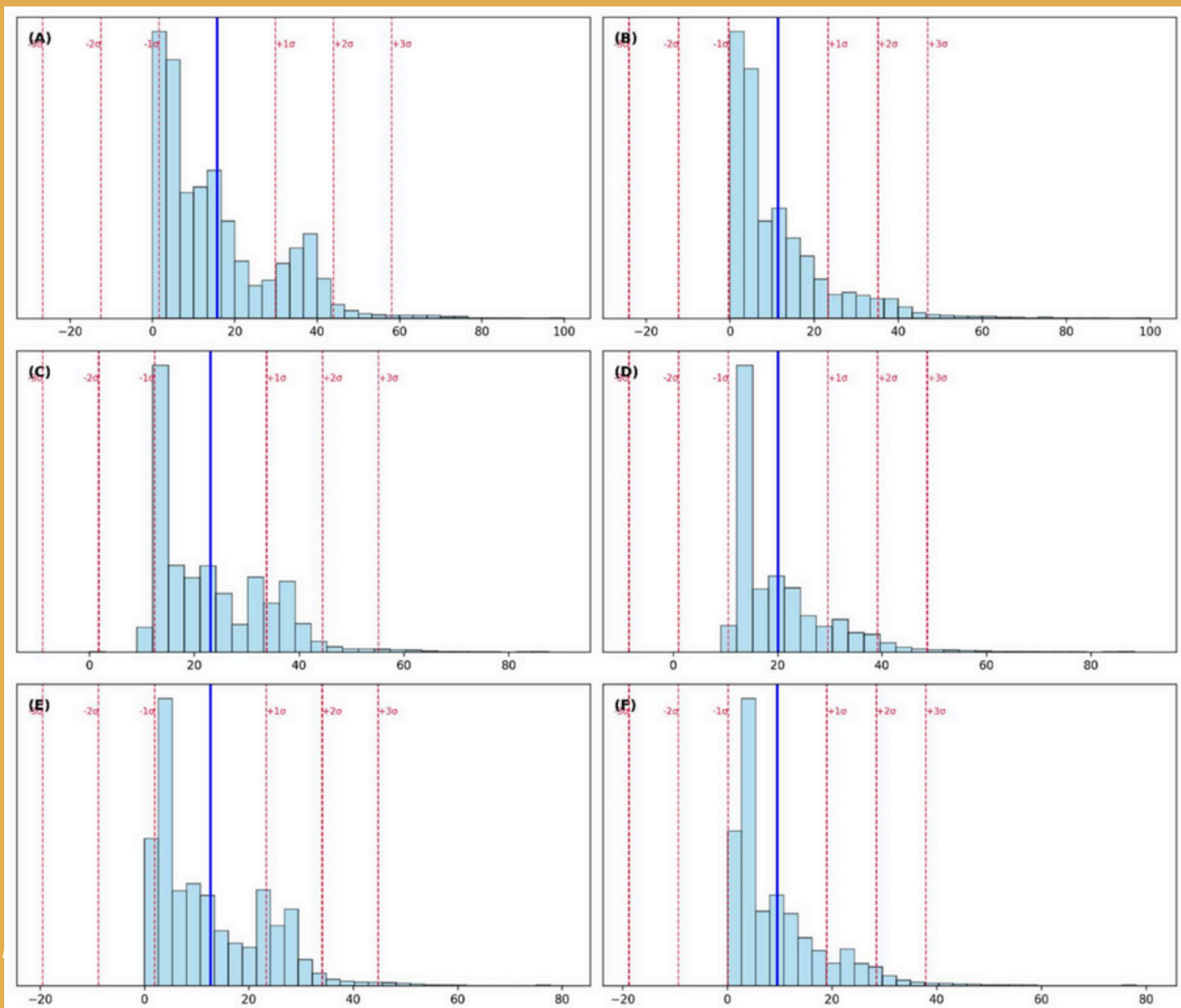

Figure 10: Data Distribution of Commanded Throttle for E30 (A) and E10 (B), Absolute Throttle for E30 (C), and E10 (D) and Relative Throttle for E30 (E) and E10 (F)

Importantly, although the E30-fueled vehicles consistently exhibited higher throttle angle values, all readings remained within safe operational margins, indicating that drivability and engine responsiveness were not compromised. Long-term durability testing of E30-fueled vehicles confirmed that the increased throttle activity did not accelerate actuator wear or induce throttle-body fouling, reaffirming the mechanical robustness of current systems under mid-level ethanol operation [4].

Conclusion and Future Work

This demonstration assessed the long-term feasibility of utilizing a 30% ethanol blend (E30) relative to a conventional 10% blend (E10) in non-flex fuel vehicles, evaluating both the mechanical adaptability and economic viability of higher ethanol integration. On-board diagnostic (OBD) trackers installed in a cohort of 94 vehicles enabled continuous monitoring of engine parameters, including short- and long-term fuel trims (STFT and LTFT), oxygen sensor signals, engine coolant temperature, and throttle characteristics.

The results indicate that vehicles operating on E30 exhibited modest shifts in fuel trim values— particularly in LTFT—reflecting expected adaptive responses to the increased oxygen content of the blend. However, these shifts remained well within manufacturer-defined tolerances, suggesting no disruption in air–fuel ratio regulation. Oxygen sensor readings across both upstream and downstream sensors remained consistent between E10 and E30 groups, underscoring effective closed-loop fuel control. Similarly, differences in engine coolant, catalyst temperatures, and throttle response, while measurable, were minor and remained within operational safety thresholds. Collectively, these findings support the conclusion that non-flex fuel vehicles are capable of accommodating E30 without compromising critical engine functions.

From an economic standpoint, vehicles operating on E30 exhibited a decrease in the average fuel economy. However, this efficiency penalty is typically offset by E30's lower retail cost. Thus, under favorable market conditions, E30 not only remains economically viable but can also contribute to reducing fossil fuel dependence.

The broader implications of these findings are significant. Given the slow fleet turnover and continued reliance on internal combustion engines, incremental strategies that incorporate higher ethanol blends offer an immediate pathway to reducing carbon intensity and air pollutant emissions in the transportation sector. A gradual shift from E10 to E30—leveraging compatibility with the existing vehicle fleet—can serve as a critical component of the energy transition.

Future research should expand upon this foundation in several directions. First, incorporating engine bay and ambient temperature measurements could help isolate thermodynamic influences on ethanol combustion and control logic. Second, the application of mechanical diagnostics will be critical for assessing long-term impacts of E30 on engine components including fuel pumps, injectors, seals, and combustion chambers. Third, including vehicles manufactured by a broader range of global automakers will help generalize the findings across diverse engine control strategies and material specifications. Together, these coarse and fine-grained investigations will yield a more comprehensive understanding of E30's implications for vehicle longevity, efficiency, and emissions control, informing regulatory policy and market adoption strategies for mid-level ethanol blends.

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