Low-Carbon Liquid Fuels for U.S. Road Transportation

RECOMMENDATIONS

Low-carbon, drop-in liquid fuels are required as a complement to vehicle electrification initiatives to achieve the national goal of a carbon-neutral economy by 2050, as fleet turnover will take decades. The following actions are recommended to support a national low-carbon light duty vehicle fleet:

1. Expand beyond currently used feedstocks: Accelerate process research and pilot demonstrations of economically viable advanced low-carbon liquid fuel production from biomass beyond 1st generation feedstocks for on-road transportation.

2. Increase carbon utilization: Study and plan for higher biofuel yields via greater utilization of biomass carbon, including addition of electricity and hydrogen and/or capture of byproduct CO_2 emissions streams for sequestration.

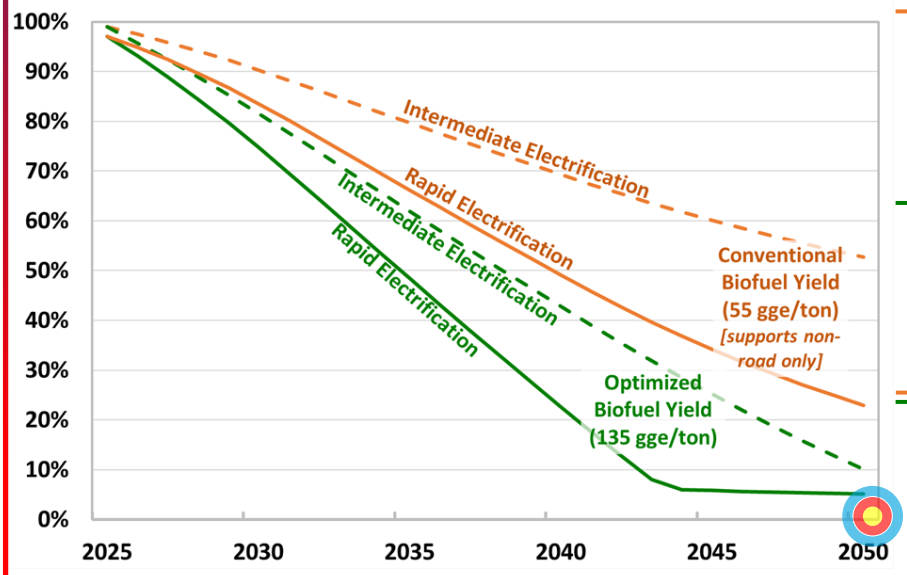
3. Conduct total-cost-of-ownership (TCO) analyses on the marginal cost of drop-in bio-based liquid fuels with a set of assumptions that are defined in conjunction with industry stakeholders.

These activities are consistent with the U.S. Government's Blueprint for Transportation Decarbonization[1] and should help align activities of the relevant Technologies Offices. USCAR is available to help guide research and reports and urges the U.S. DRIVE / 21st Century Truck Net-Zero Tech Team and other stakeholders to pursue the aforementioned activities to accelerate decarbonization of the on-road fleet through the use of low-carbon liquid fuels.

Nationally-stated greenhouse gas (GHG) emissions reduction goals[2] for 2030 (50% reduction from 2005 level) and 2050 (carbon-neutral) require wholesale changes in vehicle propulsion systems and the transportation energy supply chain. Electric vehicles (EVs), powered by clean electricity or hydrogen, are a primary pathway for reduced light-duty vehicle (LDV) emissions, but fleet turnover requires decades, even with aggressive EV sales rates. A complementary pathway for the non-EV portion of the fleet is a transition from fossil-based fuels to drop-in bio-based liquid fuels produced at high yields using clean electricity and hydrogen for process energy.

The analysis described in this whitepaper illustrates the national transportation GHG emissions reduction potential from available biomass resources that, using conventional yields, would only be sufficient to support non-road transport modes (aviation, marine, rail, off-road). The analysis also shows how high-yield biofuel processes complement and accelerate emissions reductions with rapid on-road electrification and become critical if electrification proceeds less rapidly.

Figure 1: U.S. Transportation GHG Emissions Reductions *for Scenarios with Rapid or Intermediate Electrification of On-Road Vehicles and with Conventional or High Yields for Biofuel Production*



Even with rapid electrification, transportation GHG emissions cannot reach carbon-neutral levels in 2050 with conventional biofuel yield. (Volume insufficient to support on-road demand.)

However, increased biofuel volumes enabled by optimized (2.5x greater) biofuel yield enable substantially greater emissions reductions. (Displacement of fossil fuels for on-road transportation.)

If electrification proceeds at a lesser pace (Intermediate scenario), greater biofuel availability from optimized yields becomes critical in ensuring a low-emissions fleet by 2050.

Supporting Information

GOAL: USCAR members (Ford, General Motors, Stellantis) share a common interest in increasing low-carbon liquid fuels availability for the LDV and medium and heavy-duty vehicle (MHDV) fleets as a complement to ongoing electrification efforts. USCAR requests the support of the U.S. Department of Energy (DOE) and other stakeholders in accelerating the development and deployment of low-carbon liquid fuels to adequately serve both on-road (including LDV and MHDV) and non-road (e.g., aviation, marine, rail) applications.

BACKGROUND: The U.S. transportation sector annually consumes over 200 billion gasoline gallons equivalent (gge) of liquid fuels, primarily gasoline, diesel, and jet fuel[3]. Bio-based fuels comprise 15 billion gge[3] with the remainder largely petroleum-based, making transportation the highest greenhouse gas (GHG) emitting sector of the U.S. economy[4]. An analysis was conducted by USCAR to consider the effect of joint benefits of both biofuels and vehicle electrification on national transportation GHG emissions.

METHODOLOGY: On-road energy demand was modeled using Argonne National Lab's VISION 2022 tool[5], incorporating vehicle sales, propulsion type and efficiency, miles traveled, and turnover based on projections from DOE's 2022 Annual Energy Outlook (AEO)[6]. Non-road fuel demands for aviation, marine, rail, and off-road segments were drawn from AEO and were held constant across scenarios.

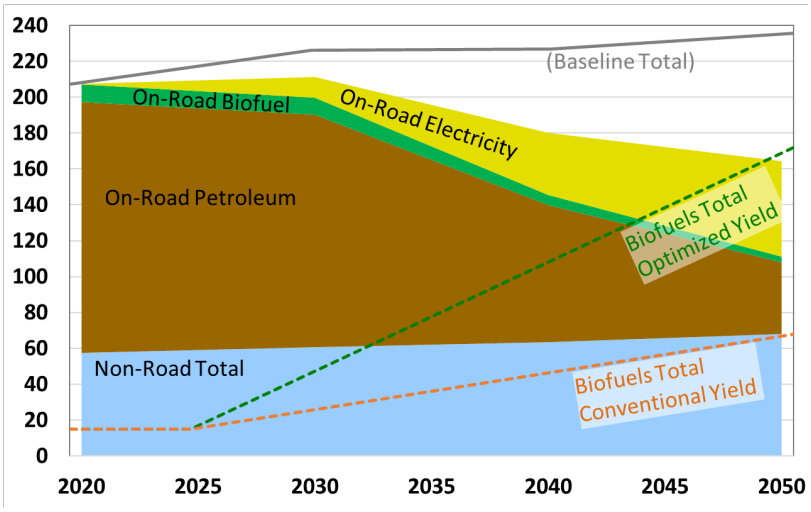
To model the transition of the on-road fleet from liquid combustion fuels to electricity, USCAR modeled three electrification scenarios through 2050. EV sales shares for 2050, along with resultant liquid fuels consumption, are shown in Table 1. Energy demand profiles for the two bookend scenarios (slow and rapid electrification) are shown in Figure 2. For GHG accounting purposes, all EVs were assumed to be powered by zero-carbon electricity, and bio-based liquid fuels were assumed to provide an 80% reduction in carbon intensity relative to petroleum-based fuels.

Two bio-based fuel supply potentials were considered (dashed lines in Figure 2). The lower dashed line is based on DOE's 2023 Billion Ton Report[7], assessing U.S. biomass availability and potential fuel yields based on 30-35% carbon utilization (55 gge per short ton dry biomass), with potential fuel volumes ramping up to 70 billion gge by 2050. The upper dashed line is based on the same biomass resource, but instead employs an optimized (2.5x higher) biofuel yield, corresponding to a carbon utilization rate of 80%[8], that ramps fuel volumes up to 170 billion gge by 2050. The baseline Slow Electrification scenario assumes no increase in biofuel volume from today's level.

Table 1: *Electrification Scenarios and Liquid Fuels Consumption for On-Road Transportation*

Electrification Scenario	EV Sales Basis	2050 EV Sales Shares for LD, MD, HD	2050 Liquid Fuels Consumption
1) Slow (Baseline)	DOE 2022 Annual Energy Outlook[6]	15%, 0%, 0%	232 billion gge
2) Intermediate	Rapid (BNEF) x ½	45%, 39%, 23%	176 billion gge
3) Rapid	BNEF Long-Term EV Outlook 2023[9]	89%, 78%, 46%	112 billion gge

Figure 2: *U.S. Transportation Energy Consumption for Rapid Electrification Scenario (Billions gge)*



Total liquid fuel consumption in the rapid electrification scenario declines to about half of that of the baseline (slow electrification) scenario by 2050. Potential biofuel volumes based on conventional biofuel yield (orange dashed line), as assumed in the Billion Ton Report, could satisfy non-road transport by 2050. However, achieving the optimized (2.5x higher) biofuel yield (green dashed line) allows volumes to additionally cover all on-road transport needs for the rapid electrification scenario by 2040 and for the intermediate scenario by 2050 (not shown).

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