CRC

ANNUAL REPORT

2023-2024

COORDINATING RESEARCH COUNCIL, INC.

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PART ONE

STATE OF THE COUNCIL

STATE OF THE COUNCIL – 2023-2024

A technical committee formed over a century ago for the purpose of conducting cooperative research between the automotive and fuel industries, government scientists, and academia became the Coordinating Research Council (CRC) in 1942. As a 501(c)(3) nonprofit association organized to conduct scientific research for the benefit of the public, CRC offers a structure and protection for stakeholders to work together, solve problems, investigate the unknown, improve products, and inform the development of regulations and standards. The final results of the research conducted by or under the auspices of CRC are available to the public.

2023-2024 was a period of significant activity and growth for the Council. The Sustainable Mobility Committee (SMC) formed in 2021 expanded in membership, as it was designed to provide a technical platform for new stakeholders to get involved with the CRC member industries. Topical working groups were formed to focus the efforts of the researchers within this expansive community. This Committee also conducted several new research projects that spanned the range of topics within the Committee's broad vision, including examination of electric vehicle charging activity, battery durability factors, the potential of low carbon liquid fuels, possible impacts on air quality from vehicle electrification, the implications of zero emissions rules for light-, medium-, and heavy-duty vehicle charging and refueling infrastructure, and updated knowledge of the carbon intensity of biofuels. In addition to funding research, the Committee organized several new technical events to enhance the collective knowledge for the community served by this research.

The Auto-Oil Committees of CRC continued their longstanding research programs in their current areas of focus. The Atmospheric Impacts Committee published the results of studies that expand the understanding of ozone formation, improved understanding of inventory from background, wildfires, and non-combustion sources, while also partnering with the SMC to better understand the potential impacts of vehicle regulations. The Advanced Vehicle/Fuel/Lubricants (AVFL) Committee examined composition and emissions impacts of hydrogenated vegetable oil as a diesel fuel blendstock, explored the impact of the motor octane number on engine performance, and published reviews of available literature on lubricant – aftertreatment interactions and the impact of battery pack thermal conditioning. The Performance Committee partnered with AVFL on motor octane number research, and published reports in support of ASTM International standards development and expanded knowledge of diesel injector deposit formation. The Emissions Committee and its Real World Emissions & Emissions Modeling Group were prolific in this time period, publishing reports on alternative oxygenate fuels on emissions, portable emission measurement systems, fuel effects on emissions (studies of light-duty, gasoline direct injection, and heavy-duty engines), a new particulate matter (PM) index formula, other modeling and testing procedure studies, and a series of remote sensing emissions measurement projects that completed a series of annual measurement campaigns performed for decades.

The CRC Aviation Committee (AVC) published fuel quality surveys in partnership with the Energy Institute, as well as a guide on jet fuel thermal stability and the results of fuel property testing of both jet and aviation gasoline fuels.

Technical events continued to be part of CRC's activity 2023-2024, with the annual events of the Real World Emissions Workshop and the Aviation Committee Meetings serving large audiences of researchers in these respective fields. The Sustainable Mobility Committee added new events in late 2022 (hosted by the National Renewable Energy Laboratory) and in both 2023 and 2024 in partnership with the Society of Automotive Engineers. There were continued biennial events: the 8th Life Cycle Analysis Workshop (hosted by Argonne National Laboratory in 2023) and the 11th Mobile Source Air Toxics Workshop (hosted by California Air Resources Board in 2024). A special event focused on the technical aspects of handling liquid hydrogen was hosted by NASA for the AVC and SMC in December of 2023.

Government scientists and researchers continue to be welcomed into CRC research involvement through working groups (Fuels for Advanced Combustion Engines, Real World, Atmospheric Impacts), workshop organizing committees, and the SMC Partner Member group.

CRC technical reports are internally peer-reviewed by the project panels, working groups, committees, and research partners that oversee the research and are then made available on the CRC website, www.crcao.org. Select research projects are also reported in peer-reviewed literature, and some workshops also produce summaries and proceedings.

Details on these completed studies and ongoing CRC committee projects appear in Part Two of this Annual Report. Released Final Reports issued since the last CRC Annual Report are listed in Part Three. Organization and Membership are presented in Part Four.

PART TWO

DETAILED REPORTS OF CRC PROJECTS

EMISSIONS COMMITTEE

The Emissions Committee originated from the Air Pollution Research Advisory Committee (APRAC) that facilitated collective effort with the National Air Pollution Control Administration from 1968-1982. The Emissions Committee focuses its research to address current and future regulatory needs and to understand and define the effects that changes in automotive hardware, fuel compositions, and the interactions of the two have on automotive emissions related to air quality and air borne toxics.

The primary research areas of the Emissions Committee are in new vehicle emissions, fuel market quality, fuel effects on emissions, providing data for octane and additives to support ASTM deliberations, and to support interaction with relevant regulatory agencies such as CARB and EPA.

Recent research by the Emissions Committee has focused on furthering understanding of advanced Tier 3 and beyond engines, alternative and oxygenated fuels, and the use of Portable Emissions Systems.

The Real World Working Group advances the mission of the Emissions Committee by allowing interactions and collaborative efforts with agencies and other industry partners. In particular, the Real World Group focuses its effort to determine the contribution of vehicle and fuel source emissions to the environment and how current computer models reflect these contributions.

In 2023, the Real World Working Group advanced its collaborations through CRC Project RW-120 to understand the short-term impacts of renewable- and bio-diesel fuels on heavy-duty low NO_x engines through collaborations with Truck and Engine Manufacturers (EMA), CARB, and EPA. The Working Group has also hosted the annual Real World Emissions Workshop for over 30 years.

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After 30 years of research with Denver University developing databases of emissions inventories from fleets based on roadside measurement devices, The Real World Group has recently sunset its research focus on Roadside Measurement Devices, with a final effort to compare existing commercial roadside emissions measurement devices as part of the E-119-3 and RW-105 Project Series.

REAL WORLD VEHICLE EMISSIONS WORKSHOP

CRC Project No. E-110

Leaders: M. Viola
J. Baustian

Scope and Objective

For three decades, CRC has held annual vehicle emissions workshops, gathering international experts in the field of vehicle/engine emissions to discuss the latest activities in modeling, measurement, and analysis.

The inaugural CRC Emissions Workshop convened as the "CRC-APRAC Vehicle Emissions Modeling Workshop" on October 30 and 31,1990. It was the first time that representatives from government agencies, universities, automotive and oil industries, and consulting and testing firms active in examining vehicle emissions inventories were assembled in one location with 117 participants engaging in discussions and twenty speakers presenting in four technical sessions including EMFAC7 and MOBILE4 Models, Model Evaluations, Laboratory Vehicle Emissions Studies, and On-Road Emissions Studies.

In three decades of annual events, the Real World Emissions Workshop has grown into an international event, hosting over 250 participants representing more than a dozen countries. Its 30-year history has spanned an era where the public has benefited from large reductions in vehicle tailpipe emissions, brought about by improvements in emissions control technologies and fuels, leading to demonstrable improvements in air quality. Program topic areas include novel and new research in:

- Air Quality
- Emissions Modeling
- Off-Road / Non-Road Emissions

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- Emissions Measurement Methods
- Fuel Effects on Exhaust Emissions
- Improving the Emissions Inventory
- Particulate Emissions and Measurement
- Emissions Control Measures (I/M) and OBD
- In-Use Emissions for Light- and Heavy-Duty Vehicles
- Non-Tailpipe Emissions
- Sensors and New Technology

Current Status and Future Program

The 2023 Workshop was held at the Renaissance Long Beach in California from March 26-29, 2023. Keynote presentations were given by Jed Mandel, President of Truck and Engine Manufacturers, and Christopher Tennant, Executive Director of CRC, along with over 50 technical presentations. A workshop summary was posted to the CRC website. The 2024 Workshop was held March 10-13, 2024 at the Hyatt Mission Bay in San Diego, CA. Nearly 220 registrants from 12 countries enjoyed keynote presentations from Matt Spears, Executive Director of Global Regulatory Affairs at Cummins, and David Kittleson, Professor of Mechanical Engineering at University of Minnesota. The 2024 workshop is planned for April 13-16, 2025 at the Marriott Long Beach in Long Beach, CA.

EVALUATION AND STATISTICAL ANALYSIS OF REMOTE SENSING DEVICES AND TECHNOLOGY

CRC Project No. E-119-3/ E-119-3a

Leaders: M. Viola
J. Baustian
R. Sager

Scope and Objective

Since the early 1970's, many heavily populated US cities have violated the ever-changing National Air Quality Standards (NAAQS) established by the EPA pursuant to the requirements of the federal Clean Air Act. The NAAQS regulate emissions of six criteria pollutants: carbon monoxide (CO), nitrogen oxides (NOx), particulate matter (PM), lead, ground-level ozone (O3), and sulfur dioxide (SO2). CO levels are elevated primarily due to direct emission of the gas; and ground-level ozone, a major component of urban smog, is produced by the photochemical reaction of NOx and hydrocarbons (HC). Ambient levels of particulate emissions can result either from direct emissions of particles or semi-volatile species, or from secondary reactions between gaseous species, such as ammonia (NH3) and nitrogen dioxide (NO2). On-road vehicles continue to serve as one of the sources for atmospheric criteria pollutant emissions, contributing CO, volatile organic compounds (VOCs), NH3 and NOx to the national emission inventory. Ambient air measurements taken over the last three decades illustrate the dramatic emissions reductions from on-road sources achieved by the automotive and petroleum industries.

The Fuel Efficiency Automobile Test (FEAT) device is responsible for the historical CRC record of on-road emissions data for over three decades. Alternate remote sensing device (RSD) measurement systems may provide an opportunity for future data collection campaigns. The objective of Project E-119-3 was to evaluate other RSD systems' ability to measure on-road emissions (CO, CO2, and HC, NO and NO2, SO2 and NH3 and PM) over a five-day period, making real time comparisons to the FEAT device. Measurements also captured evaporative and PM emissions when available to complement emissions measurements from the FEAT device. Under Project E-119-3a, statistical comparisons of the three RSD datasets will be done to compare and contrast each system's consistency or variability to measure and record data across a range of operating conditions.

Current Status and Future Program

Three RSD vendors collected data during a test campaign in Phoenix, AZ in April 2021. Four Final Reports from each of the RSD vendors were completed and are available on the CRC website, including one from HEAT, posted August 2022; one from Opus Inspection, posted August 2022; on from Denver University, posted April 2022. The fourth report is a statistical analysis of all fleet data, by Charles Blanchard, posted April 2023. In addition, an accompanying report from Revecorp on CRC Project RW-105 was published in April 2023.

LIGHT-DUTY PORTABLE EMISSIONS MEASUREMENT SYSTEM (PEMS) PURCHASE AND STATISTICAL ANALYSIS PROJECT DEVELOPMENT

CRC Project No. E-122-2/ E-122-2a/ E-122-2b/ E-122-2c

Leaders: M.B. Viola
P. Loeper

Scope and Objective

With Europe adopting the use of portable emissions measurement systems (PEMS) to determine light-duty emissions, there is a greater interest in the functionality and use of these systems.

The objective of Project E-122-2 is to understand PEMS performance in measuring changes during on-road and chassis-roll tests, using the on-road cycle developed in CRC Project E-122, which incorporates city, urban, and highway driving. Several engine technologies are represented in the four-vehicle test fleet, which are being tested with five fuels with varying properties to investigate how well PEMS can detect fuel property impacts on emissions. Summer and winter market fuels, each having a low and high Particulate Matter Index (PMI), as described by the Honda method, are being used for testing. Additionally, a Tier 3 certification fuel is used to ensure no vehicle shift in tailpipe emissions is encountered. Each fuel is tested multiple times in each vehicle to understand the variation in emissions that occur and how they change on the same route on a daily basis. A PEMS measures the tailpipe emissions for both the road and chassis testing, and results are compared to repeat chassis-dynamometer emissions testing. Specific goals of this project include determination of the following:

- Repeatability of the chassis roll testing to compare to the PEMS unit.
- Repeatability and accuracy of PEMS unit under real on-road driving conditions and changing ambient temperatures.

- Ability of the PEMS to measure differences in gaseous and PM emissions with respect to changes in PMI and/or Vapor Pressure (VP) of the fuel; and,
- The correlation of exhaust flow measurement of CO2 from the individual PEMS system with direct vehicle exhaust flow meter from the test cell and with constant volume sampling (CVS) bags.

To make certain the testing data collected would be suitable for statistical analysis, a statistician (CRC Project E-122-2a) developed the test matrix for this project, defining:

- Number and sequence of testing on each fuel and vehicle;
- Vehicles of each technology to test, (one hybrid or two of the same type, etc.); and,
- Market fuels to test and what fuel properties to investigate.

Current Status and Future Program

The Final Report for this project was published January 2023 on the CRC Website.

PUBLICATION OF THE STORY OF THE (NEAR) ELIMINATION OF GASOLINE VEHICLE EMISSIONS

CRC Project No. E-130

Leaders: B. Just

Scope and Objective

Since the 1970's and earlier, the dramatic reductions of automotive pollution have contributed to significant improvements in air quality. CRC Project E-130 seeks to produce an easily understood historical story of how automotive emissions have been reduced to present-day levels and to educate a broad audience of the achievement of near-zero gasoline vehicle emissions accomplished over many years. Existing literature and accounts from industry and government agency participants directly involved in the research, investigations, and regulatory development that enabled this achievement will be included. The project is divided into three phases:

- Phase 1: Identify and acquire literature and conduct and document interviews of expert individuals working on emissions reductions technology during the period of focus.
- Phase 2: A technical publication writer will compile and distill all the information collected by the contractor in Phase 1. The deliverable will be a pamphlet or publication that presents the story to a broad, non-technical audience.
- Phase 3: Additional publications or reporting avenues will be explored.

Current Status and Future Program

Steve Welstand and Dr. Kent Hoekman, consultants, have been contracted for Phases 1 and 2 of this project. A journal article highlighting the early years (1940's-50's) was published in

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"Atmosphere" in November 2021. The completed work is expected to be published by SAE by 2026.

IMPACTS OF E15 ON NOX EMISSIONS

CRC Project No. E-133

Leaders: M.B. Viola
P. Loeper

Scope and Objective

The current fleet is using gasoline-ethanol blends of 90% gasoline and 10% ethanol in gasoline internal combustion engines. There are many vehicles that now accept E15 blends. However, E15 is still not the prevalent fuel in the market and there is much discussion on how the additional ethanol may impact NOx emissions.

The objective of Project E-133 is to conduct chassis dynamometer vehicle testing as well as PEMS emissions testing with E15 fuels to determine the impact additional ethanol may have on NOx emissions. Additional gaseous and PM emissions will also be measured to understand all criteria and particulate impacts. This testing uses newer Tier 3 certified vehicles for testing, the same vehicles used in Project E-122-2.

Project E-133 was conducted using vehicles from Project E-122-2 as well as the PEMS unit currently owned by CRC. Two winter market E10 fuels used in E-122-2, one low-PMI and one high-PMI fuel, were splash blended to E15. Additionally, two summer market E10 fuels, one low-PMI and one high-PMI fuel were also splash blended to E15. Testing was conducted after E-122-2 Tier 3 Certification fuel at the end of Winter and Summer testing using the same on-road and chassis-dynamometer drive cycle as from CRC projects E-122 and E-122-2.

Current Status and Future Program

The Final Report was published on the CRC website in April 2023.

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LIGHT-DUTY PEMS PHASE 3: EFFECTS OF ALTITUDE, GRADE, AND LOW TEMPERATURE ON PEMS PERFORMANCE TEST PROGRAM

CRC Project No. E-134/a

Leaders: M. Henderson
P. Loeper

Scope and Objective

With Europe adopting the use of portable emissions measurement systems (PEMS) to determine light-duty real world emissions, there is a greater interest in PEMS functionality and use. The California Air Resources Board (CARB) and the Environmental Protection Agency (EPA) are also conducting tests in the United States with light-duty vehicles to determine PEMS viability to measure real world on-road emissions. This is in addition to the normal Federal Test Procedure (FTP-75), Highway Fuel Economy Test (HWFET), and US06 Supplemental Federal Test Procedures (SFTP) chassis dynamometer testing. There are several PEMS manufacturers producing these units and some studies have been conducted to understand how they perform compared to normal chassis dynamometer testing. This project investigates the use of multiple engine technologies and different fuel properties at altitude, steep grades and at low temperatures to determine PEMS performance in measuring emission changes during on-road and chassis roll tests.

The objective of Project E-134 is to use the on-road cycle, developed in the E-122 project which incorporates city, urban and highway driving. This study is to be conducted at altitude and use steep grades for the test cycle under winter low temperature conditions. The same on-road test cycle and grades are conducted on a chassis roll. Emissions measurements are taken at the tailpipe including all gaseous emissions and gravimetric particulate matter

(PM) emissions. Simultaneously, PEMS emissions are taken. Measures are taken to ensure the vehicle exhaust system is always kept at ambient pressure at the tailpipe on the chassis roll during testing.

Several engine technologies are used for testing along with different fuel properties to investigate how well PEMS can detect fuel property impacts on emissions. This test program uses two Winter fuels with low and high PMI, as described by the Honda method.

Current Status and Future Program

The contract for statistical design of experiments and analytical support of the test program was awarded to SwRI. The test program was conducted in winter 2023/2024 by 44 Energy. A Final Report is expected in early 2025.

EMISSIONS COMMITTEE

TIER 3 GDI VEHICLE TECHNOLOGIES EFFECTS ON PARTICLE EMISSIONS OPERATING WITH DIFFERENT FUELS

CRC Project No. E-135

Leaders: E. Barrientos
G. Lilik
M. Viola

Scope and Objective

New vehicle technologies geared towards Tier 3 compliance such as increasing fuel injection pressure and atomization have shown potential significant benefits to reduce particle emissions from gasoline direct-injection (GDI) engines. The expected vehicle technology trend is that as emissions regulations become more stringent, more deployment of these technologies may be required. Furthermore, fuels containing a high proportion of heavy aromatics (C9+) compared to market average and certification fuels, characterized with a high PMI, have been found to generate higher particulate emissions.

Moreover, CRC Projects E-94-2 and E-94-3 have indicated a potential link between an increase in PMI and ethanol content with increased PM emissions. Evaluation of interactions of fuel composition (i.e., PMI, aromatic content, and ethanol content) with different vehicle technologies used to meet Tier 3 emissions standards, such as higher injection pressure among others, and their effect on particulate, particle and gaseous emissions is of interest for future vehicle/fuel co-optimization to comply with upcoming emission regulations.

The purpose of this project is to improve understanding of fuel injection pressure impact as well as other technologies on tailpipe emissions from GDI vehicles. The project evaluated a specific fuel matrix comprised of fuels with low and high PMI, and different ethanol contents on vehicles with different technology packages including fuel injection pressures (e.g., 150-200 and 350+ bar).

Current Status and Future Program

The contract for this project was awarded to SwRI. The Final Report was issued on the CRC website in April, 2024.

EMISSIONS COMMITTEE

SIMULATED DISTILLATION AND ANALYSIS OF FUELS

CRC Project No. E-137

Leaders: P. Loeper
J. Jetter

Scope and Objective

Since its introduction in a 2010 SAE paper (2010-01-2115), use of the Particulate Matter Index (PMI) metric in research related to fuel properties and resultant impact on vehicle emissions has become increasingly common. The formula has been modified to better evaluate emissions effects of ethanol level in gasoline blends (e.g., in CRC Projects RW-107-2 and RW-107-3a).

However, determination of PMI for a given fuel necessitates performing a detailed hydrocarbon analysis (DHA) which, in addition to being inherently time consuming, can lead to variable results across labs due to gas chromatogram (GC) post-processing methods. In the recent NPRM for light-duty vehicle emissions (EPA, April 2023), EPA staff acknowledge the usefulness of PMI as a strategy to reduce tailpipe emissions for legacy vehicles. Given the challenges related to DHA-derived PMI, they suggest use of Simulated Distillation (SimDis ASTM D7096) as a time- and cost-effective method to quickly identify and regulate higher boiling point components in market gasoline fuels.

Application of SimDis for gasoline fuels is unconventional; therefore, this project seeks to better understand how SimDis data compares to conventional methods for characterizing gasoline (D86, DHA, etc.) Leveraging leftover fuels from previous CRC projects (E-122-2, E-133, and RW-107-3), thirteen fuel samples were submitted for SimDis D7096, D86, DHA, enhanced DHA (SSI method), updated SimDis (as described in EPA NPRM), and VUV analysis.

Using results from these fuel analyses, the main objectives of this project are to:

- Perform an analysis of data for the 13 fuels including DHA per ASTM D6730, SimDis data per ASTM D7096, boiling range by atmospheric distillation per ASTM D86 and PMI data based on vacuum ultraviolet (VUV) spectroscopy per ASTM D8369. Calculate PMI and PME based on both D6730 DHA and D8369 VUV.
- Identify data gaps, correlations to methods and/or fuel properties (e.g., PMI to SimDis boiling fractions), and emissions data from three CRC projects (E-122-2, E-133, and RW-107-3).
- Explore how EPA's use of SimDis and a 'distillation cut' could impact fuels in this set (e.g. would a 3% distillation cut exclude fuels that may not necessarily lead to high emissions i.e. C10+ aromatic content?).

Current Status and Future Program

DRI was awarded the contract to perform the analysis for CRC Project E-137. The Final Report is anticipated in early 2025.

EMISSIONS COMMITTEE

LOW NOX AND NMOG MODELING

CRC Project No. E-140

Leaders: S. DeCarteret
M. Viola
P. Loeper

Scope and Objective

Current emissions measurement capabilities may not be sensitive enough to measure very low NOx and NMOG (HC, CH4) emissions that will be required for future Light-Duty and Medium-Duty vehicles for certification at SULEV levels. One potential area of concern is the impact of test weight. With traditional CVS technology, dilute volume increases as test mass increases requiring the instrumentation to measure lower concentrations. The uncertainty and limitations of the current sampling and analytical systems technology over the range of test weights need to be understood in order to identify potential areas for improvement.

The objective of CRC Project E-140 is to develop a model to demonstrate and identify opportunities to reduce the uncertainty of the current technology used for chassis dyno light- and medium-duty certification testing. The model developed seeks to incorporate variables which contribute to measurement uncertainty. Analysis of the modeling results shall provide a sensitivity analysis identifying the contribution of each factor to the overall uncertainty. Based on the results, recommendations for areas of improvement and future study shall be included.

Current Status and Future Program

The project was awarded to SwRI. The Final Report was issued on the CRC website in September, 2024.

BRAKE AND TIRE WEAR LITERATURE REVIEW

CRC Project No. E-143

Leaders: G. Gunter
M. Moore

Scope and Objective

As tailpipe Particulate Matter (PM) emissions from Light Duty (LD) vehicles declined, other types of PM emissions became more important. LD vehicles emit at least five types of PM: tailpipe, brake wear, tire wear, road wear, and resuspended road dust. Although measurement methods are still in development, total combined PM emissions for brake, tire, and road wear are estimated at about 30 mg/mi. This is an order of magnitude greater than the tailpipe PM regulatory limit of 3 mg/mi. Battery Electric Vehicles (BEV) emit four of the five types of PM; all except tailpipe PM. Some government regulatory agencies have begun studies of certain types of non-tailpipe PM including PM from brake wear.

The objective of this project is to perform a literature review of recent (past 15-years) of light duty and heavy duty vehicle emissions of non-tailpipe PM. Topics of interest including:

- Magnitude of non-tailpipe PM emissions, preferably expressed in units like mg/mi to allow comparison with tailpipe PM emissions levels and regulatory standards.
- Source apportionment of non-tailpipe PM emissions including brake wear, tire wear, road wear, resuspended road dust, etc.
- Test methods to generate non-tailpipe PM.
- Test methods to measure non-tailpipe PM emissions, including methods to discriminate PM from various sources.
- Characterization of non-tailpipe PM, including chemical composition, morphology, and particle size distribution.

- Test methods to characterize non-tailpipe PM emissions.
- Strengths or weaknesses of particular test or measurement methods, especially affecting their ability to accurately estimate emissions from real-world on-road vehicles.
- Factors known to control or affect magnitude or type of non-tailpipe PM emissions.
- Methods proposed to control or reduce LD vehicle non-tailpipe PM emissions.

Current Status and Future Program

LINK Engineering has been contracted for Project E-143, which is expected to conclude early in 2025. A Final Report will be made available on the CRC website.

IMPACT OF ALTERNATIVE DIESEL FUELS ON OBD ROBUSTNESS

CRC Project No. E-144

Leaders: S. Funk
G. Gunter

Scope and Objective

Availability of biofuels and renewable fuels is expected to increase, driven by federal and state policies like Federal Renewable Fuels Standards (RFS) and California Low Carbon Fuels Standard (LCFS) and other state mandates. While the impact of renewable fuels on engine and aftertreatment performance has been studied in other projects, the impact of fuel properties on OBD robustness is not well understood.

Fuel properties such as oxygen content, cetane number, and heating value are expected to affect combustion performance such as air-fuel ratio and exhaust energy. If combustion performance is altered, engine and aftertreatment sensors will measure the change in response. Differences in air fuel ratio may lead to differences in fuel system diagnostic response. Differences in heating value may lead to differences in exhaust temperature, affecting diagnostics based on exhaust energy, such as Diesel Oxidation Catalyst monitoring and Cold Start Emissions Reduction System monitoring. Because diagnostic thresholds are typically calibrated with standard fuel, a vehicle exposed to an alternative diesel fuel may false fail diagnostics due to the changed sensor response exceeding diagnostic thresholds. At this time, it is not well understood all of the interactions among fuel properties and sensor response and how diagnostic system performance is affected.

This project seeks to understand the impact of renewable fuels on diagnostic robustness by investigating variation in key inputs to diagnostic strategies by testing a range of alternative fuels on a variety of vehicle technologies.

Current Status and Future Program

The project was awarded to FEV. Testing continues into mid-2025, as is expected to be completed near the end of the year.

UNDERSTANDING DIESEL CONTAMINATION IN GASOLINE AND ITS EFFECTS ON PMI AND PME

CRC Project No. E-145

Leaders: J. Eckstrom
I. Tibavinsky

Scope and Objective

Small amounts of diesel contamination into gasoline may occur during transport to refueling sites since fuel transport trucks are rarely dedicated to diesel service or gasoline service. The higher boiling and aromatic compounds found in diesel fuel could have an impact on PMI and PME if found in sufficient quantities.

The objectives of CRC Project E-145 are to determine whether the diesel contamination that may occur in the distribution of gasoline leads to a significant impact on PMI/PME. A fuel set will be prepared to include a range of diesel contamination approximating the level of contamination that may occur and which includes diesel fuels with low and high aromatics and gasolines with low and high PMI/PME. The PMI/PME of these fuel blends will be measured to assess the significance of contamination on PMI/PME. The project will also assess which test methods are effective at detecting contamination, and determine the criteria and detection threshold for each.

Current Status and Future Program

Southwest Research Institute has been contracted for CRC Project E-145. Work is underway, and is expected to continue into 2025.

EMISSIONS COMMITTEE

LIQUID LEAKER TEST VEHICLE DETECTION IN E-119-3 RSD TEST CAMPAIGNS

CRC Project No. RW-105

Leaders: R. Sager
J. Baustian
M. Viola

Scope and Objective

Remote Sensing Devices (RSDs) are open path spectrometers which measure the emissions of large number of in-use vehicles in a short period of time on the road as vehicles pass through the beam of the spectrometer. In addition to measuring gaseous pollutants emitted from the tailpipe, RSDs may have the capability to measure particulate matter and evaporative emissions of hydrocarbons.

The objective of CRC Project RW-105 is to understand the capabilities of RSD systems to measure and interpret high evaporative emitters as well as PM emissions. Three RSD systems were co-located at a single test site under CRC Project E-119-3. During the test campaign, the RW-105 contractor operated test vehicles equipped with PEMS measurement systems and drove through the RSD roadside location. The vehicles were set up as liquid leakers to identify each RSD system's capability of detecting evaporative emissions. Additionally, a vehicle with zero emissions was driven through the test site several times per day releasing known levels of pollutants to serve as calibration points.

Current Status and Future Program

Revecorp was selected as the contractor for Project RW-105, and collaborated with three RSD system vendors contracted separately under CRC Project E-119-3.

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Co-location of all four vendors in Phoenix, AZ was successfully completed in in April 2021. The Final Report for this project was posted alongside the E-119-3 reports in April 2023.

EMISSIONS COMMITTEE

VALIDATION OF THE NEW PM INDEX FORMULA

CRC Project No. RW-107-3/a

Leaders: J.J. Jetter
R.P. Lewis
M. Moore

Scope and Objective

Although EPA, Honda and others have confirmed that the PM Index can reasonably predict the relative particulate-forming tendency of a gasoline, the CRC Project RW-107 revealed that the original PM Index exhibited an ethanol bias. A more robust PMI formulation was developed in RW-107-2, in which correlation with measured PM was improved, and the ethanol bias eliminated. The new formulation incorporates multiple enhancements. This third phase of the CRC RW-107 project series will validate the new form of the PM Index equation using a fresh dataset, including a range of PMI values, vehicle technologies, and fuel formulations.

The data required for the PMI validation consist of PM emission measurements from the first phase of a cold-start LA92 cycle, and analyses of the test fuels. Vehicle testing was conducted to collect PM filter samples from the dilution tunnel during the LA92 and measure gaseous emissions (NOx / CO / HC / etc.) A fleet of vehicles including PFI and GDI technologies were tested. Test fuels included E0, E15, and E20 blends, which were all based on winter and summer market fuels. The E0 fuels are required to confirm that the ethanol bias has been removed in the new PMI formula.

Data collected will be used to validate the PME equation developed within RW-107-2.

Current Status and Future Program

SwRI was awarded this contract for vehicle testing which has been integrated into the Projects E-122-2 and E-133 combined test matrix. Rincon Ranch consulting was awarded the contract for RW-107-3a to perform the overall analysis. The Final report for these efforts was published September 2023. The report includes a PME Calculator.

EMISSIONS COMMITTEE

EVALUATION OF SHORT TERM FUEL IMPACTS ON LOW NOX ENGINE EMISSIONS

CRC Project No. RW-120

Leaders: E. Barrientos
S. McConnell
S. Berry

Scope and Objective

To investigate NOx reduction potential for establishing future emissions standards, SwRI, in partnership with EPA and CARB, evaluated different technologies and methods to lower NOx emissions from HD vehicles with minimal increase to CO2 emissions. Aftertreatment performance under various operating cycles and aging conditions was measured. Project RW-120 seeks to further evaluate and develop low NOx technologies with a focus on low load optimization and regulatory cycles. This SwRI project was conducted, in part, to support EPA's Clean Trucks Plan rulemaking.

As a follow-up to the efforts at SwRI, it is of interest to understand potential fuel-related impacts on aftertreatment performance and durability. As performance demands for aftertreatment systems are expected to increase substantially in 2027+, it is imperative to understand the impact of alternative fuels on engine and aftertreatment performance. Fuels of interest include biofuels such as biodiesel and renewable diesel. The fuel blends included B20 and B50 fuel blended with CARB diesel, as well as RD100 and blends of RD with biodiesel and CARB diesel. The testing also included common market diesel fuels to assess sensitivity to specifications such as aromatics, cetane, and sulfur. Operating conditions included low-load cycles and incorporate the aftertreatment system used in the CARB low NOx technology assessment. CRC Project RW-120 sought to determine the impact of alternative fuels on system performance related to engine-out NOx and soot level and was performed with the ongoing CARB and EPA low NOx programs at SwRI. Impact of fuel composition on emissions levels was measured.

Current Status and Future Program

The Final Report was published August 2023.

EMISSIONS COMMITTEE

NATIONWIDE PMI AND FUEL SURVEY FOR SUMMER AND WINTER MARKET FUELS AND STATISTICAL ANALYSIS

CRC Project No. RW-121/ CM-138-22 and RW-121-2/ CM-138-22-2 / RW-121a

Leaders: M. Moore
P. Loeper
R. Lewis

Scope and Objective

The SAE paper (2010-01-2115) that introduced PMI (particulate matter index) is still widely cited in discussions concerning PMI ranges in market fuels. In the time since, PMI has become an increasingly used metric in gasoline particulate fuel research, and the original 2010 SAE paper serves as the primary reference for representative PMI values. Updated PMI data from market fuels would prove useful in developing more-relevant gasoline fuel effects studies.

The objective of this project is to perform analyses of market fuel samples to provide an overview of PMI values for U.S. market gasoline fuels that are offered during summer and winter seasons. Each sample will be analyzed for DHA, VUV, and SimDis methodologies for comparison to identify correlations in regional/ PADD trends as well as seasonal correlation and SimDis.

Current Status and Future Program

During Summer 2022, 168 fuel samples were collected and 85 fuel samples were collected during winter 2022/2023. Data were collected through multiple analytical tests on all fuels. DRI was contracted to provide a statistical analysis and reporting on both summer and winter fuels, which is anticipated in early 2025.

ADVANCED VEHICLE/FUEL/LUBRICANTS COMMITTEE

The Advanced Vehicles, Fuels, and Lubricants (AVFL) Committee focuses its research on vehicles, fuels, and/ or lubricants which are three years or more out from current production. With this focus, its current research topics include engine and fuel fundamentals and efficiency improvements, as well as advanced automotive hardware and new fuel formulations effects on emissions.

The Fuels for Advanced Combustion Engines (FACE) is a Working Group of the AVFL Committee, which is a made up of AVFL member companies and other invited stakeholders, including participants from National Laboratories. The mission of the FACE working group is to define the fuel impacts on performance of emerging advanced combustion systems. Examples of advanced combustion systems are low temperature combustion (LTC), lean burn direct injection (LBDI), homogenous charge compression ignition (HCCI), and high efficiency clean combustion (HECC), just to name a few.

The Lubricants Advisory Panel of the AVFL Committee is a collaboration of CRC member companies and other invited stakeholders. The AVFL technical scope includes evaluation of the impacts of current lubricants on advanced vehicle and future lubricants on current or advanced vehicles. The AVFL Committee organized a panel of engine lubrication experts from industry who serve as a resource for projects in any of the CRC committees. The AVFL Lubricants Advisory Panel is also developing studies focused primarily on lubricant impacts for consideration by the full committee. Project areas of interest to the panel include impacts of new fuels such as biodiesel on lubricant performance and impacts of new engine technologies on lubricant performance. Activities of the panel are consistent with the original Charter of CRC "in developing the best combinations of fuels, lubricants, and the equipment in which they are used."

AVFL COMMITTEE

The goal of the panel is not to set lubricant testing specifications, nor to develop an engine test for lubricant certification, but rather to perform sufficient testing to make recommendations regarding suitability of test elements. These recommendations would then be provided to existing lubricant standards-setting organizations that may develop lubricant specifications and engine wear tests as they see fit based on project findings.

IMPROVED DIESEL SURROGATE FUELS FOR ENGINE TESTING AND KINETIC MODELING

CRC Project Nos. AVFL-18 and AVFL-18a

Leaders: S. McConnell
S. Wagnon

Scope and Objective

The objective of these projects is to establish and evaluate a methodology for formulating and testing surrogate fuels, a mixture of generally less than a dozen pure compounds that matches certain selected characteristics of a target diesel market fuel composed of many hundreds to thousands of compounds. Surrogate fuels can enable a better understanding of fundamental fuel composition and property effects on combustion and emissions formation processes in internal combustion engines.

Project AVFL-18 has been a successful collaboration with researchers at several DOE national laboratories: Sandia National Laboratory (SNL), National Renewable Energy Laboratory (NREL), Lawrence Livermore National Laboratory, Pacific Northwest National Laboratory, and Oak Ridge National Laboratory; as well as a Canadian federal laboratory (CanmetENERGY), and the Army Research Laboratory.

Research was extended under Project AVFL-18a to facilitate the development of second-generation surrogates with improved capabilities for matching market diesel fuels, blending engine research test quantities of surrogates, as well as single-cylinder engine and combustion vessel testing of selected surrogate fuels. SNL has performed optical engine measurements on the surrogate fuels; results from this research will be reported.

AVFL COMMITTEE

Current Status and Future Program

Project AVFL-18 began in 2009, and has resulted in multiple publications and reports that are available on the CRC website. The project panel continues to meet to review data and progress. Additional journal articles are anticipated to be published from this research.

DETAILED HYDROCARBON ANALYSIS (DHA) AND PARTICULATE MATTER INDEX (PMI) IMPROVEMENT

CRC Project No. AVFL-29-3

Leaders: G. Gunter
V. Reilly

Scope and Objective

Over the past ten years, great improvements have been made with predictive particulate emissions indices (correlative mathematical models) based on fuel composition. Examples of these particulate indices (PI) are the Honda Particulate Matter Index (PMI) and the General Motors Particulate Evaluation Index (PEI). Both indices include the detailed molecular compositions of gasoline fuels and are weighted by those compounds which contribute the most in particulate emission as determined by controlled vehicle emission and fuel correlation studies. Because gasoline can be mixtures of hundreds of hydrocarbon compounds, these laboratory methods typically include the use of high-resolution chromatography separation techniques such as detailed hydrocarbon analysis (DHA), which can identify upwards of 500+ compounds.

In the past, a number of DHA methods have been used to identify aromatic compounds: ASTM D6729, ASTM D6733, ASTM D6730 and many other in-house laboratory methods. A previous CRC Project (AVFL-29-2) showed that differences in DHA method as currently practiced in industry produce variations which affect PMI.

The intention of CRC Project AVFL-29-3 is to study ways to improve inter-lab variability for DHA and PMI, with the ultimate goal of creating a standard procedure for data needed to calculate the PMI from the improved DHA method currently under development. The project will provide data via an interlaboratory that can be used to inform methodology development and improvement.

Current Status and Future Program

An Interlaboratory Study is underway with 39 participants. Each laboratory has received the same set of samples to analyze following recommended procedures. The labs will provide raw data for analysis by a statistician. The statistician will provide a detailed analysis of these data and recommendations in a report expected late 2025.

EFFECTS OF BOOST PRESSURE AND FUEL COMPOSITION ON COMBUSTION KNOCK CHARACTERISTICS

CRC Project No. AVFL-32

Leaders: S. McConnell

Scope and Objective

The main objective of Project AVFL-32 is to learn how boosting affects the knock characteristics of fuels with varied levels of important hydrocarbon classes found in modern commercial gasolines. A secondary objective is to investigate how boosting affects the operation of the standard RON Cooperative Fuel Research (CFR) test engine and what further information would be required to propose modifications to the octane test method to improve the correlation between octane number and knock propensity in modern SI engines.

During Phase 1 of this research, several fuels of similar RON rating, but varied chemical composition, were analyzed under standard RON conditions on the instrumented CFR F1/F2 engine at Argonne National Laboratory. Important parameters affected by fuel composition during RON testing, despite constant RON level, include indicated mean effective pressure (IMEP), lambda, onset of auto-ignition, peak rate of heat release during auto-ignition, and knock over-pressure (mean amplitude of pressure oscillations), and more.

Phase 2 is exploring how increased boost pressure on the CFR engine affects the knocking characteristics of several fuels with similar RON and varied chemical composition.

AVFL COMMITTEE

Current Status and Future Program

Project AVFL-32 is being conducted by Argonne National Laboratory. Two journal articles have been published on Phase 1 and are accessible via the CRC website. A Phase 2 journal article is being prepared.

FUNDAMENTAL STOCHASTIC PRE-IGNITION (SPI) STUDY

CRC Project No. AVFL-33/ AVFL-33-2

Leaders: E. Chapman
G. Gunter

Scope and Objective

Stochastic pre-ignition (SPI) is an abnormal combustion process that initiates combustion prior to spark discharge in boosted spark ignition engines. SPI has been shown to be heavily influenced by both operating conditions and fuel and lube properties. The goal of Project AVFL-33 is focused on understanding the role of fuel-wall interaction on SPI, and to characterize the impact of fuel properties on wall wetting and how this affects SPI frequency and severity in a gasoline turbocharged direct injection (GTDI) engine. Fuel properties of interest include composition (e.g., alcohols, aromatics, isoparaffins, olefins) and heavy-end volatility.

The approach is to perform dynamometer testing of a GTDI engine at SPI-prone conditions to determine fuel effects on SPI and influence of wall wetting. Wall wetting is being determined by completing real-time Fuel-in-Oil (FiL) analysis using a dry sump oil system and fuel dye fluorescence detection. The active cylinder is instrumented with pressure transducers to collect the SPI/LSPI event data. Wall wetting will be quantified while measuring SPI/LSPI count for each oil and fuel combination.

Current Status and Future Program

The project is being performed by Oak Ridge National Laboratory (ORNL). Testing and analysis for Phase 1 have concluded, and results were presented at SAE Energy & Propulsion Conference & Exhibition, November 7-9, 2023. Phase 2 Testing is now underway at ORNL. A Final Report on both phases will be delivered at the conclusion of the project.

AVFL COMMITTEE

ADVANCED CHARACTERIZATION OF E-117 DIESEL FUELS

CRC Project No. AVFL-34

Leaders: M. Viola
R. Lewis

Scope and Objective

The goal of Project AVFL-34 is to use advanced characterization techniques to better understand differences in fuel composition that could help explain emissions differences observed in CRC Project E-117, "Combustion and Emissions Characteristics of a Medium-Duty Vehicle Operating on a Hydrogenated Vegetable Oil Renewable Diesel."

The Pacific Northwest National Laboratory (PNNL) and CanmetENERGY performed detailed fuel composition analyses on fuel samples provided from Project E-117.

Current Status and Future Program

The SAE journal article, "Detailed Compositional Comparison of Hydrogenated Vegetable Oil with Several Diesel Fuels and Their Effects on Engine-out Emissions," was published online by SAE International Journal of Fuels and Lubricants as of February 2023. A link is available on the CRC website.

IMPACT OF MON ON ENGINE PERFORMANCE

CRC Project No. AVFL-36 / CM-137-19-1

Leaders: A. Iqbal
S. McConnell

Scope and Objective

The primary objective of this project is to investigate the impact of fuel MON on engine anti-knock performance under a wide range of operating conditions, including those where the sensitivity weighting factor between RON and MON (K) may be positive (and potentially greater than 0.5). Testing under a wide range of operating conditions will help establish the relevance of fuel MON for modern engines, including from the perspective of durability and safe operation. To this end, the study will evaluate the impact of MON at multiple operating conditions including but not limited to:

- High speed high load (high power) operation with elevated air charge temperatures. This engine operation regime is representative of real-world driving conditions such as towing a trailer up a steep grade on a hot day. For future powertrains, this operating regime is expected to become even more challenging as criteria emission regulations are driving elimination of enriched engine operation as a strategy for managing exhaust gas temperatures.

- Knock-limited part load operation which is relevant for drive cycle fuel economy. This operating regime is of interest for downsized boosted SI engines.

AVFL COMMITTEE

Current Status and Future Program

This project was awarded to Forschungsgesellschaft für Energietechnik und Verbrennungsmotoren (FEV) in 2020, but faced numerous delays. Testing on engines one and two was completed. The Final Report is available on the CRC website as of March 17, 2023.

USING SEPARATION-ENHANCED ISOTOPE RATIO MASS SPECTROMETRY TO ENABLE INCREASED RENEWABLE CARBON CONTENT IN TRANSPORTATION FUELS

CRC Project No. AVFL-38

Leaders: R. Lewis

Scope and Objective

Biogenic carbon is typically quantified using 14C analysis by accelerator mass spectrometry (AMS), ASTM D6866 Method B, which is available at a limited number of commercial labs because of stringent requirements for labs also handling 14C tracers. Project AVFL-38 will demonstrate the ability to use chemical separations in combination with stable isotope analysis to track the distribution of biogenic carbon across co-processed fuel streams, by compound, chemical class, or boiling point range, while obtaining a biogenic carbon balance for representative refinery conditions.

This work will apply chemical separation approaches as part of the isotope ratio mass spectrometry (IRMS) analyses, enabling biogenic carbon tracking in fuel product streams by boiling point (BP) range, by chemical class, or even by compound. Focusing on subclasses of compounds within the sample increases sensitivity to shifts in isotope value within that subclass, which would otherwise be obscured by sample complexity when using bulk IRMS (or AMS) analysis. This improved resolution will provide greater insight into the chemical processes that are occurring when co-processing bio- and fossil-derived feeds. Results from each separated fraction will be compared with bulk analysis to determine if detection limits, accuracy, or precision are improved.

Sample sets from industry (fossil and renewable feeds, and each liquid product stream) will be tested using bulk IRMS, and a separation approach (typically gas chromatography (GC)) followed by IRMS. By focusing on fuel fractions rather than analysis of all carbon atoms in the sample, differences in stable isotope distributions can be used to provide advanced quantification of the persistence of biogenic feeds through a refining process. These measurements can be used for process optimization, and the refiner, having additional process information, can obtain a renewable carbon balance.

Current Status and Future Program

DOE awarded Project AVFL-38 to the team in May 2021. Project team participants include Pacific Northwest National Laboratory, Natural Resources Canada, CanMet Energy, and Argonne National Laboratories. The Final Report is expected early 2025.

LOW PHOSPHOROUS LOW ASH GASOLINE ENGINE OIL TO MEET FUTURE EMISSION REQUIREMENTS – LITERATURE REVIEW AND EXPERIMENTAL

CRC Project No. AVFL-39 / AVFL-39-2/ E-139-2

Leaders: G. Gunter
N. Tyrer

Scope and Objective

Phosphorous (P), which is present in engine oils as antiwear additives, can enter the aftertreatment system when engine oil leaks past the piston rings or through the crankcase ventilation system and burns in the combustion chamber and leaves through the exhaust stream. P is a known catalyst poison.

Increasingly stringent regulations on particulate emissions from vehicles may require the use of gasoline particulate filters (GPF) in spark ignition engines. Project AVFL-39 was to perform a literature review to understand the effects of lube oil formulations and phosphorous levels catalyst and GPF efficiencies, and to understand how lube additives affect ash accumulation on and pressure drops across the GPF.

The focus of Project AVFL-39-2/ E-139-2 is to further understand how lower P concentration enables catalyst protection and the ash levels acceptable for GPF future emissions levels through experimental work and catalyst aging.

Current Status and Future Program

SwRI completed the literature review under CRC Project AVFL-39, and the Final Report was published on the CRC website in June 2023. The experimental work in Phase 2 is contracted with FEV and is expected to continue through Q2 of 2025.

AVFL COMMITTEE

DEVELOPMENT OF ADVANCED COMPRESSION IGNITION GASOLINE RATING METHODS ON A VARIABLE COMPRESSION RATION CFR ENGINE

CRC Project No. AVFL-40

Leaders: S. McConnell
J. Waldman

Scope and Objective

The scientists, engineers, and analysts of the Co-Optimization of Fuels & Engines (Co-Optima) initiative are investigating fuels and engines as dynamic design variables that can work together to boost efficiency and performance, while minimizing emissions. Potential benefits include dramatic improvements in vehicle fuel economy and increases in the use of domestically sourced fuel for transportation.

Project AVFL-40 explores the possibility of a modified CFR F1/F2 octane-rating engine to rate fuels for Advanced Compression Ignition (ACI) engines using a set of homogeneous charge compression ignition (HCCI) test conditions. After upgrading the CFR engine at Argonne National Laboratory (ANL) to operate over a wider range of fuel properties, air/fuel ratio, thermodynamic, and temporal test conditions, a detailed characterization of at least 15 gasoline blends with bio-fuel blend stocks will be evaluated. These data will be correlated to that from ACI engines in the Co-Optima program to identify a down-select of key HCCI fuel rating conditions and fuel properties for ACI engines.

The purpose of Project AVF:-40 is to obtain a better understanding how a homogeneous charge compression ignition (HCCI) fuel rating metric on the variable compression ratio (CR) CFR F1/F2 octane test engine is affected by a wider range of fuel properties, engine speed, lambda, and thermodynamic conditions than currently operable on the carbureted CFR engine at Argonne National Laboratory (ANL).

Current Status and Future Program

CRC has executed a CRADA with DOE and ANL for Project AVFL-40. A Final Report is expected to be issued as a journal article, with an Executive Summary available on the CRC website anticipated in early 2025.

AVFL COMMITTEE

DUCTED FUEL INJECTION (DFI) MULTI-CYLINDER ENGINE DEMONSTRATION

CRC Project No. AVFL-44

Leaders: S. McConnell
E. Chapman

Scope and Objective

Ducted fuel injection (DFI) is a simple, mechanical technology to enhance the preparation of fuel/charge gas mixtures within the combustion chambers of diesel engines. DFI with low-net-carbon fuels can dramatically reduce climate-forcing and pollutant emissions while enhancing efficiencies. DFI could be implemented within a decade or less, providing a pragmatic technology option for fighting climate change and improving air quality in a cost-effective manner, particularly for difficult-to-electrify sectors.

Project AVFL-44 seeks to facilitate the commercial adoption of this promising technology, quantifying the magnitude of its potential benefits by providing the first complete and robust multi-cylinder engine demonstrations of DFI over industry-standard test cycles using a low-net-carbon fuel.

The ultimate objective of this project is to implement DFI in a multi-cylinder engine with a low-net-carbon fuel, demonstrating at least 70% lower engine-out particulate matter (PM), NOx, and net-carbon emissions without an efficiency penalty over steady-state and transient test cycles vs. operation of the baseline engine utilizing conventional diesel combustion and petroleum-based diesel fuel. If the goal is achieved, it will represent an unprecedented advancement in modern engine technology. This would move the DFI technology from its current technology readiness level (TRL) of 4 to beyond TRL 5, substantially de-risking the technology and thereby removing a barrier to rapid and widespread industry adoption. We believe that the technology could be transferred to industry for successful implementation when it has reached approximately TRL 6 (see Section 3.0).

The expected outcomes of Project AVFL-44 include: 1) learnings from the first implementation of DFI in a multi-cylinder engine; 2) comparisons of performance and engine-out emissions datasets with and without DFI as well as with and without low-net-carbon fuel under standard steady-state and transient test cycles; 3) improved understanding of the attributes of the DFI technology in terms of combustion-system integration, part cost, manufacturing, durability, operating costs, and certification; 4) significantly enhanced stakeholder engagement in the development of DFI; and 5) further exploration and optimization of DFI for implementation in production-viable engine architectures. All these learnings are critical for enabling the decision analyses that stakeholders use when prioritizing potential future technology paths.

Current Status and Future Program

CRC has executed a CRADA with Sandia National Laboratories, John Deere, Clean Fuels Alliance, and Cummins. Project AVFL-44 is active.

AVFL COMMITTEE

IMPACTS OF THERMAL CONDITIONING ON BATTERY PACKS, EFFICIENCY, RANGE, AND GHG REDUCTION-LITERATURE REVIEW

CRC Project No. AVFL-45

Leaders: I. Tibavinsky
V. Raja-Mohan

Scope and Objective

As the light-duty automotive segment shifts increasingly fast towards electrification to minimize GHG emissions, challenges remain regarding EV use under different weather conditions throughout the year. Lithium-ion batteries have benefited over the last decade from material science improvements through increased energy and power density. Although widely adopted, these batteries suffer from aging at high temperatures and significant performance degradation at low temperatures, posing a challenge for automotive applications, especially during vehicle start-up but also influencing shutdown and maintaining thermal conditions even while parked and not "powered on" or charged.

One way to counter the impact of cold weather conditions is to warm the battery. However, as much as 22% reduction in the range of electric vehicles is attributable to onboard battery thermal conditioning systems, and would an energy-optimal heating/cooling strategy alleviate this range drain?

The proposed literature review will aggregate information to address questions on the four main aspects of thermal conditioning: hardware, software, user patterns, and sensitivities to environmental factors. Information will be collected about

- Battery thermal preconditioning methods relevant to automotive applications being used and explored in different settings,

- Impacts of each of these methods on overall energy efficiency, charging time, vehicle range, battery life, and GHG Scopes 1, 2, and 3, as defined by the Greenhouse Gas Protocol [2], and
- An analysis on the viability of the different methods and the gaps in research areas where future focus will be needed for EV development and GHG abatement.

Current Status and Future Program

The contract for CRC Project AVFL-45 was awarded to University of Michigan in February 2023. A Final Report was published on the CRC website in December 2023.

AVFL COMMITTEE

FUELS FOR ADVANCED COMBUSTION ENGINES (FACE) WORKING GROUP

The AVFL Committee formed the FACE Working Group to foster collaboration with other industry and government research laboratory experts. The mission statement for this group was developed in 2005 and updated in 2015. The original mission of the FACE group was to recommend sets of test fuels well-suited for research so that researchers evaluating advanced combustion systems can compare results from different laboratories using the same set (or sets) of fuels.

The FACE group is composed of volunteers from industry, government, and academia. Its membership includes researchers from the fuel industry, as well as members representing the engine, automobile and emission control technology manufacturers, academia, and U.S. DOE and Canadian National Laboratories. The collaboration includes scientists and engineers from ANL, LLNL, NREL, ORNL, PNNL, SNL, and NRCAN/CanmetENERGY.

An initial key activity of this group was in developing two sets of fuels for research in advanced combustion in the diesel and gasoline ranges. The diesel fuel set, defined in 2007, became commercially available for purchase from Chevron Phillips Chemical Company, LLC (CPChem). Extensive characterization work has been performed by laboratories participating in the FACE Working Group; a summary of standard analyses of these fuels is available from the CRC website.

The Final Report, "FACE-1 Chemical and Physical Properties of the Fuels for Advanced Combustion Engines (FACE) Research Diesel Fuels" was published on the CRC website in 2010, after an accompanying conference paper was given at the 2009 SAE Fall Powertrains, Fuels, and Lubricants Meeting.

A gasoline-range fuel set design was also developed by the FACE Working Group. All ten fuels were blended in large batches and became commercially available for sale from CPChem. Detailed characterization of the gasoline fuel set is available on the CRC website in tabular form and further documented in CRC Final Report AVFL-24, "FACE Gasolines and Blends with Ethanol: Detailed Characterization of Physical and Chemical Properties" (2014).

The FACE Working Group has generated a number of projects conducted by the AVFL Committee: AVFL-16, AVFL-18, AVFL-19, AVFL-23, AVFL-24, AVFL-26, AVFL-31, AVFL-32, AVFL-38, AVFL-40, and AVFL-44.

The Group meets regularly throughout the year to review project status, share results from various member research projects in support of the Group's mission, and to develop ideas for future research projects.

AVFL COMMITTEE

AVFL LUBRICANTS ADVISORY PANEL

The AVFL Committee technical scope includes evaluation of impacts of current lubricants on advanced vehicles and future lubricants on current or advanced vehicles. The AVFL Committee organized a panel of engine lubrication experts from industry that serves as a resource for CRC Committees and Project Panels to consult on matters involving lubricants. The AVFL Lubricants Panel is also developing studies focused primarily on lubricant impacts for consideration by the full Committee.

The Panel meets periodically to develop project ideas for consideration by the AVFL Committee. The recently completed Projects AVFL-28, AVFL-28-2, and AVFL-28-3 GTDI Lubes Wear Test Development, AVFL-37 Thermal and Electrical Properties of EV / HEV Lubes, and ongoing Projects AVFL-39 / E-139 Lube Effect on Catalyst GPF Aging Literature Review and AVFL-39-2 / E-139-2 Lube Effect on Catalyst GPF Aging Experiments were developed by this Panel.

ATMOSPHERIC IMPACTS COMMITTEE

The Atmospheric Impacts Committee (AIC) evolved from the Air Pollution Research Advisory Committee (APRAC) that facilitated collective effort with the National Air Pollution Control Administration from 1968-1982. The AIC is dedicated to enhancing the scientific foundation and regulatory framework for air quality management. The committee's overarching goal is to direct its resources toward improving the predictive capacity of air quality science to guide effective regulation. This includes advancing emission inventories, atmospheric chemistry understanding, and air quality modeling systems.

The drivers of the AIC's efforts stem from the ongoing necessity to improve air quality. Regulatory demands, driven by the need to reduce mobile source emissions, are grounded in scientific analysis and modeling of emissions and their impacts on air chemistry and physics. These regulatory frameworks encompass tools like National Ambient Air Quality Standards (NAAQS) for ozone and particulate matter, state implementation plans, and updates to the National Emissions Inventory (NEI) and the EPA's MOVES (Motor Vehicle Emissions Simulator) model.

The AIC helps to focus its research portfolio by holding periodic workshops to identify the most urgent research needs for air quality. The 2022 Air Quality Research Needs (AQRN) Workshop and 2018 Southern California Ozone Research Symposium (SCORES) identified the top research area needs which are now used to prioritize funding on an annual basis. The topic areas of recent focus include meteorology modeling, mobile source and biogenic emissions modeling, emissions processing through tools like SMOKE, and leveraging global models for boundary condition analysis. Air quality models are applied to simulate chemistry and transport processes, projecting future scenarios, and assessing control options for regulatory compliance.

ATMOSPHERIC IMPACTS COMMITTEE

Other projects in the research portfolio described below address non-combustion emissions in urban environments, primary organic aerosol emissions, and the effects of VOC/NOx chemistry on tropospheric ozone production. This portfolio underscores the AIC's commitment to addressing both traditional and emerging challenges in air quality science and regulation.

DEVELOPMENT AND EVALUATION OF DATABASES AND ESTIMATION METHODS FOR PREDICTING AIR QUALITY IMPACTS OF EMITTED ORGANIC COMPOUNDS

CRC Project No. A-108

Leaders: C.G. Rabideau

Scope and Objective

CRC Project A-108 brings together an expert panel to evaluate the structure-reactivity and other estimation methods needed to develop complete detailed mechanisms and make recommendations for approaches judged to be the most consistent with available knowledge. This is analogous to the work of the International Union of Pure and Applied Chemistry (IUPAC) or NASA kinetic data panels, or the books on atmospheric mechanisms by Calvert and co-workers, but it is focused on compiling and evaluating estimation methods rather than the underlying experimental data themselves. As with these other efforts, this project has significant in-kind and ongoing support with periodic updates as new data and methods become available.

The expert panel consists of "full active participants" as well as "observers" who occasionally weigh in with their expertise. The panel members assembled into various working groups to organize the efforts, objectives, tasks, and current status of the work of each group.

The working groups include the following:

- Project Coordination and Leadership
- Preparation of a Perspective Article
- MAGNIFY/EUROCHAMP-2020/MCM Coordination
- Experimental Data Collection
- Quantum Calculation Data Collection

- Organic SAR Group/ Estimates for Reactions of Organic Compounds
- Radical SAR Group/ Estimates for Reactions of Organic Radicals
- Estimates for Photolysis
- Chemical Mechanism Working Group
- Thermochemistry Working Group
- Mechanism Generation Working Group

Current Status and Future Programs

A multi-year contract was awarded to UC Riverside in April 2017 and has been extended through 2025.

A perspective article that provides a general overview of gaps for improving atmospheric kinetic modeling was published in the "International Journal of Chemical Kinetics." A second journal article on the experimental database has been published in "Earth System Science Data" (June, 2020). A third journal article on estimation of rate constants for reactions of organic compounds under atmospheric conditions has been published in "Atmosphere" (September, 2021).

THE INFLUENCE OF NO_X ON SECONDARY ORGANIC AEROSOLS AND O_3 FORMATION: CHAMBER STUDY

CRC Project No. A-113

Leader: C.G. Rabideau

Scope and Objective

The complex interplay of VOCs and NOx on atmospheric ozone formation (e.g., the ozone isopleth) requires a detailed, mechanistic understanding of the underlying chemical processes leading to its formation. Similarly, it has become readily apparent that condensable species formed in peroxide rich (low-NO) environments and organic nitrate formation in higher NOx environments both contribute significantly to enhanced aerosol formation. Classic environmental chamber experiments using VOC and NO/NO_2 mixtures may miss important SOA formation pathways leading to errors in atmospheric predictive models. As stringent NOx controls continue to reduce ambient NOx levels, it is critical that secondary pollutant formation be evaluated under such peroxide rich (low NOx) environments to greatly improve prediction of secondary pollutants under future environmental situations.

Within this project, specifically designed novel environmental chamber experiments will elucidate the key roles of NO_x on SOA formation and investigate the role of peroxide chemistry. These large chambers are designed to study atmospheric chemistry at low NOx concentrations (atmospherically relevant NOx loadings).

Primary objectives of Project A-113 are to:

- Design new experimental methods using environmental chambers to elucidate the interplay of NOx with select anthropogenic and biogenic precursors at atmospherically relevant (current and projected) oxidant levels;

- Identify SOA formation potential of select VOC precursors within these well-controlled environments;
- Evaluate ozone prediction under these scenarios; and,
- Provide guidance to regional air quality models on how to implement improvements to SOA predictive models.

Current Status and Future Program

This study directly addresses one of the Research Needs (Influence of NOx on SOA Formation and Ozone) from the CRC Air Quality Modeling Research Needs (AQMRN) Workshop held in February 2016.

The multi-year project began in January 2018 with UC Riverside. The Final Report was posted on the CRC website January 2023.

CHARACTERIZING PRIMARY ORGANIC AEROSOL EMISSIONS FROM IN-USE MOTOR VEHICLES

CRC Project No. A-114/ RW-111

Leader: M.E. Moore

Scope and Objective

It has been shown that primary organic aerosol (POA) mass from combustion emissions evaporates as it is diluted to ambient conditions. The semi-volatile partitioning of a large fleet of gasoline vehicles has been demonstrated on a chassis dynamometer and the volatility profiles have been quantified using a combination of thermodenuder and mass spectrometer analysis. Large scale model studies have also shown that treating POA compounds as semi-volatile has a significant impact on the average magnitude of emissions from combustion sources as well as on the spatiotemporal variability of organic aerosol (OA) concentrations, particularly in urban areas and close to sources. Although many chemical transport models (CTMs) now include POA semi-volatile partitioning, standard emissions measurements procedures do not collect the information needed to inform gas/particle partitioning calculations.

Current vehicle emissions measurements report total hydrocarbons, non-methane organic compounds, and particulate mass. However, in order to calculate OA partitioning, one needs to know how the emissions themselves respond to swings in the pollutant particle concentrations, for example. Without this information, many CTMs have relied on ambient OA measurements to constrain the total OA mass emitted from combustion sources like vehicles, and parameters vary widely depending on the model and application. While there has been extensive recent work on the detailed measurement of POA volatility and composition, these scientific findings need to be connected to standard measurements and methods that are the most common source of data for emissions inventories and models like CMAQ.

Current Status and Future Program

The goal of this project is to quantify the volatility profile and particle concentration in exhaust emissions. Measurements focus on physical properties of exhaust, both particulate and gas-phase concentrations.

Results from this study will be used to:

- Confirm that varying dilution leads to organic evaporation behavior that is consistent with published volatility profiles and partitioning theory,
- Better understand the interpretation of existing emissions datasets where particle concentration and volatility information does not exist,
- Determine the accuracy and limitation of using dilution factor to quantify the volatility profile of individual vehicles during standard emissions measurement efforts, and
- Add to the growing body of data documenting the volatility profiles of individual vehicles by tier, model, and model year, etc.

West Virginia University was awarded the contract for Project A-114/RW-111 in February 2019, which is expected to be completed in 2025.

THE RISING IMPORTANCE OF NON-COMBUSTION EMISSIONS IN URBAN ATMOSPHERES

CRC Project No. A-125

Leaders: B. Ghosh
C.G. Rabideau

Scope and Objective

The urban atmosphere is complex and rapidly changing. The long-term trend is that emissions of VOCs, IVOCs, SVOCs, and NOx from combustion sources, primarily traffic, are decreasing. I/S/VOC emissions from non-combustion sources may be stable or even increasing. Furthermore, non-combustion sources emit a wide range of organic compounds not typically found in traffic emissions such as organic nitrogen and sulfur compounds. Sub-daily spatial-temporal variations in emission mean that the source mix and possibly the chemical regime (e.g., VOC/ NOx) changes rapidly both in time and space at the intra-urban scale.

The goal of Project A-125 is to improve the understanding of how anthropogenic emissions from multiple source sectors vary spatially and temporally in dense urban areas, and how emissions of both organic species and NO_x from these sources impact $PM_{2.5}$ and O_3 formation at the urban scale.

A mobile laboratory will collect measurements from a series of quasi-stationary sites in Pittsburgh and New York City in different macroenvironments, distributed across space and time. Collected measurements will constrain primary anthropogenic emissions and quantify secondary $PM_{2.5}$ and O_3 production potential.

ATMOSPHERIC IMPACTS COMMITTEE

Current Status and Future Programs

This project meets the primary objectives of the SCORES and AQRN Workshops. The multi-year effort was awarded to Carnegie Mellon University in 2021. The Final Report was made available on the CRC website in November 2024.

AIR QUALITY RESEARCH NEEDS WORKSHOP II

CRC Project No. A-127

Leaders: S. Winkler
C. Rabideau

Scope and Objective

To identify the needs of the air quality research community, CRC AIC committee and CARB co-sponsored the 2022 Air Quality Research Needs (AQRN) Workshop, held at U.C. Davis, November 8-9, 2022. The main purpose of this workshop is to bring together researchers from academia, federal and state agencies, industry, and other stakeholders to brainstorm and develop a focused research agenda that can be used by CRC, CARB and other organizations to help guide future air quality research. The first AQRN Workshop was held in 2016 and was a successful collaborative event that resulted in recommendations of five key focus areas for future AQ research. These results have been guiding AIC's project solicitation and funding prioritization since 2017. With the rapidly-evolving energy and regulatory landscape, the AQRN Workshop II seeks to identify emerging research needs that could bridge scientific gaps for development of efficient control strategies and sound regulatory policies.

The Workshop was organized around four main themes: emissions, meteorology, chemistry, and regional and local air quality modeling. Invited speakers on each theme presented an overview of the current state of science, research gaps, and initial thoughts of future research needs. These ideas were discussed further in breakout sessions attended by all workshop participants to generate a list of research issues within each theme. These final lists were voted on by all attendees to prioritize the top ten research focus areas.

ATMOSPHERIC IMPACTS COMMITTEE

Current Status and Future Programs

The second AQRN Workshop was held November 8-9, 2022 at U.C. Davis in Davis, California. A summary of the workshop, outcomes, and top ten research needs identified is available on the CRC website. A summary of the Workshop was published in AWMA EM Plus Q2 2023 issue.

QUANTIFYING THE EFFECTS OF VOC/NOX CHEMISTRY ON TROPOSPHERIC OZONE PRODUCTION: YIELDS OF ORGANIC NITRATES FROM REACTION OF SUBSTITUTED ORGANIC PEROXY RADICALS WITH NO

CRC Project No. A-128

Leaders: G. Myers
B. Ghosh

Scope and Objective

The formation of atmospheric secondary pollutants, including ozone and secondary organic aerosol (SOA), is driven by non-linear chemistry involving volatile organic compounds (VOCs) and oxides of nitrogen (NOx). Direct control on ozone formation occurs via the reaction of organic peroxy radicals with NO. The peroxy radicals (RO2), generated following reaction of OH with a VOC compound (RH), react with NO via two pathways, the first major channel generating ozone (via NO2 photolysis) and the second limiting ozone formation via organic nitrate (RONO2) production.

Thus, quantification of the organic nitrate formation yield for the full range of temperature and pressure conditions and VOCs encountered in the troposphere is of critical importance in constraining model uncertainty regarding tropospheric ozone production, and determining the efficacy of NOx vs VOC controls on ozone production. Detailed chemical models (e.g., Leeds MCM; GECKO-A; UC-Riverside MechGen) would employ the data obtained directly; more condensed mechanisms (e.g., SAPRC, Mozart, GEOS-Chem, RACM, and variants) would employ the data through the 'lumping' that occurs for complex VOC chemistry.

Organic nitrate yields from the oxidation of alkanes have been reasonably well studied, and demonstrate the inherent complexity – nitrate yields depend on the size and structure of the peroxy radical, as well as on temperature and total pressure. To date, however, only limited/no information is available regarding nitrate yields from the chemistry of oxygenated VOCs, including alcohols, carbonyls, ethers, and multifunctional species. Thus, we propose here environmental chamber studies aimed at quantifying organic nitrate yields in the chemistry of these oxygenated VOCs, with the broad goal of improving the representation of VOC/NOx chemistry in air quality models.

The objective of the Project A-138 is to improve the state of knowledge regarding the yields of organic nitrates in VOC oxidation, and thus to further constrain model representation of the effects of VOC/NOx chemistry on ozone and secondary organic aerosol production. Nitrate yield determinations in the reactions of organic peroxy radicals with NO will focus on radicals derived from oxygenated VOCs, including ketones, alcohols, ethers, and multi-functional species, for which very little information is available. Through studies of compounds of variable size and structure, and over ranges of temperature and pressure (in some cases), a set of 'rules' will be developed that can be used by air quality modelers to describe organic nitrate (and, hence, ozone) production for the wide variety of VOC encountered in the troposphere, particularly in urban areas. The classes of compounds under investigation have been identified as products of standard VOC chemistry, 'volatile chemical products' emissions, as well as (in some cases) potential alternative fuels.

Current Status and Future Program

Project A-125 began in April, 2022 and will continue until February 2025.

OBSERVATION-BASED QUANTIFICATION OF BACKGROUND CONTRIBUTIONS TO MAXIMUM US O3 CONCENTRATIONS

CRC Project No. A-129

Leaders: S. Winkler
C. Rabideau

Scope and Objective

Since at least the 1940s, urban areas of the United States have suffered from degraded air quality, one main indicator of which is elevated ozone concentrations. Through large reductions of anthropogenic emissions of photochemical ozone precursors, great improvement has been made, but several areas of the country still exceed the 2015 National Ambient Air Quality Standard (NAAQS) for ozone. The NAAQS requires that the Ozone Design Value (ODV) not exceed 70 parts-per-billion (ppb, defined as nmole ozone/mole air). The ODV is defined as the 3-year average of the annual fourth highest daily maximum 8-hour average (MDA8) ozone concentration; it thus represents ~98th percentile of MDA8 values observed in the warm half of the year, when those four highest values generally occur. A time series of ODVs observed at a particular monitoring station is thus a smoothed measure of the temporal evolution of the maximum ozone concentrations impacting that location.

The purpose of Project A-129 is to examine the existing record of ozone concentrations measured in the southwest US, including the interior portions of southern California and the states of Nevada, Utah, New Mexico, and Texas. Routine ozone monitoring began in the US in the early 1970s and continues to the present. The accumulated data set provides the basis for an observational-based quantification of ozone air quality improvement over 4 to 5 decades, the relative contributions of background ozone transported into the

US and that produced domestically, and the relative importance of domestic contributions from industrial and urban emissions, agricultural emissions, and wildfire emissions. Although this approach could be applied to any percentile of the measured surface ozone distribution, this project will focus on ODVs based on the 2015 ozone NAAQS. Since the four highest MDA8 O_3 concentrations are generally recorded in the warmer half of the year (i.e., the ozone season) the ODV corresponds to ~ 98th percentile of MDA8 values recorded at a site during the ozone season. This focus is chosen to maximize the policy relevance of the results, since it is the maximum ozone concentrations that are associated with the strongest health, crop and ecosystem impacts, and is hence the statistic upon which the NAAQS is based. The purpose of this project is to examine this ozone measurement record in a particularly relevant region of the US – the southwest, which is recognized to have the largest impacts from transported background ozone.

Current Status and Future Program

An Executive Summary of the project is available on the CRC website, and two journal articles are pending publication.

MOBILE SOURCE AIR TOXICS WORKSHOP 2024

CRC Project No. A-131

Leaders: C. Rabideau
S. Winkler
S. Yoon

Scope and Objective

The objective of this Workshop is to bring together key individuals and organizations working on current issues of mobile source air toxics for in-depth technical discussions in a workshop format. The Atmospheric Impacts Committee, in conjunction with CARB, hosted the 2010, 2013, 2015, 2017, 2019, and 2021 CRC Mobile Source Air Toxics (MSAT) Workshops in Sacramento following the previous workshops held in Houston in 2002, Scottsdale in 2004, and Phoenix in 2006 and 2008. Each of these events brought together key government, academic, industry researchers, and stakeholders working in this area. The 2021 Workshop was held virtually February 7-10, 2022, with co-sponsors including CARB, API, HEI, and SCAQMD. A summary article was published on the CRC website

Current Status and Future Programs

The 2024 Workshop was held at CARB in Riverside, CA February 13-14, 2024. Sessions included Policy, Regulatory Opportunities, and Accountability; MSATs from Battery Electric, Hydrogen and Alternative Fueled Vehicles and Energy Production and Storage; Measurements and Modeling of Vehicle Emissions of MSATs; Non-Road: Marine; and, Air Quality and Exposure Measurements and Modeling of MSATs. A summary report of the Workshop is available on the CRC website.

ATMOSPHERIC IMPACTS COMMITTEE

OZONE FORMATION AND ITS SENSITIVITY TO NOX AND VOCS FROM VOLATILE CHEMICAL PRODUCT, MOBILE SOURCE, AND BIOGENIC EMISSIONS IN URBAN CENTERS

CRC Project No. A-132

Leaders: S. Winkler
B. Ghosh

Scope and Objective

The objective of Project A-132 is to analyze data from the recent RECAP campaign (Re-Evaluating the Chemistry of Air Pollutants , Los Angeles, funded by CARB/SCAQMD/CRC), the SUNVEx (Southwest Urban NOx and VOC Experiment , Las Vegas) campaigns in the summer of 2022, the 2023 AEROMMA (Atmospheric Emissions and Reactivity Observed from Megacities to Marine Areas in Los Angeles, Chicago, New York, funded by NOAA) flights, and supporting laboratory / chamber studies from the SCENTS (Secondary organic aerosol Chamber Experiments for Non-Traditional Species, funded by NSF) 2022 campaign. Data analysis addresses the response of ozone and organic aerosol to changes in VOC and NOx and determines urban biogenic emissions from AEROMMA flights across Southern California with a main focus on Los Angeles and comparisons with flights over New York, Chicago and Toronto.

Current Status and Future Programs

This contract was awarded to NOAA. The project activities were initiated in May 2023. A journal article is in preparation, and an Executive Summary of the project will be published on the CRC website in early 2025.

IMPROVED TREATMENT OF FIRE EMISSIONS FOR OZONE AND PM 2.5 MODELING

CRC Project No. A-133

Leaders: C. Rabideau
G. Myers
E. Chapman

Scope and Objective

Smoke from wildfires have been known to contribute to elevated PM2.5 and ozone concentrations in the U.S. for many years. Emissions from fires can affect air quality thousands of kilometers downwind.1 In more recent years, massive wildfires in California have adversely affected air quality in Utah2 and Colorado3 and even as far downwind as the East Coast.4 Emissions from wildfires can elevate ozone and PM2.5 concentrations to above the National Ambient Air Quality Standards (NAAQS). With Climate Change, the summers are getting hotter and longer, drought is occurring and wildfires in the western U.S. are becoming more widespread, intense and have a longer fire season so are of increasing importance to PM2.5 and ozone concentrations and visibility impairment.

To determine when fresh smoke from fires cause or contribute to a PM2.5 or ozone exceedance of the NAAQS, observed concentrations can be used to infer that fire emissions were present (e.g., elevated carbon or PM2.5/CO ratio approach, Jaffe et al., 2020; Jaffe et al., 2022). However, when more aged, diluted wildfire smoke is contributing to a PM2.5 or ozone exceedance, but it becomes more difficult to estimate whether fires are causing an exceedance. This is especially true when the wildfire emissions become comingled with urban area emissions. Deterministic photochemical grid model (PGM) modeling can be used to explicitly model emissions from wildfires and provide a quantitative estimate of fire contributions to PM2.5 and ozone concentrations.

This is important because if a state/tribe can demonstrate that an observed PM2.5/ozone exceedance was caused by emissions from wildfires and EPA concurs, the Exceptional Event Rule allows the observed exceedance caused by wildfires to not be considered when determining attainment/nonattainment for the region, potentially avoiding the costly repercussions from being designated a nonattainment area. However, as discussed below, the treatment of fire emissions in PGM modeling has been fairly simplistic and highly uncertain in the past. Fortunately, over the last several years there have been advancements in estimating fire emissions and their chemical speciation and plume rise.

The purpose of CRC Project A-133 is to improve the treatment of fire emissions in PGM modeling using several of the new fire datasets available and build upon recent studies that developed preliminary tools to process them for input into PGMs. The CRC A-133 study will advance these new tools for processing various fire emission datasets to obtain improved spatial and temporal characterization, chemical speciation, and injection release heights of emissions from fires. The various fire emission datasets will be tested and evaluated using existing PGM modeling databases for the western U.S. At the conclusion of the study, the new fire processing tools will be made available to the PGM modeling community along with instructions on their use along with recommendations for the best performing configurations for modeling fire emissions to simulate PM2.5 and ozone concentrations.

Current Status and Future Programs

This multi-year project was awarded to Ramboll, and started in July 2023. The Final Report was published on the CRC website in October 2024.

UNDERSTANDING O3 PRODUCTION AND PM2.5 DISTRIBUTIONS USING SURFACE AND SATELLITE DATA FOR THE MEGAFIRE YEARS OF 2020 AND 2023 ACROSS THE ENTIRE U.S.

CRC Project No. A-135

Leaders: G. Myers
S. Winkler

Scope and Objective

This study investigates the impact of the massive fires in 2023 (mainly in Canada) on air quality in the United States (U.S.). This project will build on on-going (funded) work to examine the impact of fires on air quality in 2020. Our analysis of PM2.5 (particulate matter less than 2.5 µm in diameter) and O3 for those periods show that millions of people were exposed to unhealthy air during these times and that 2020 (in the Western U.S.) and 2023 (in the Midwest and Eastern U.S.) were likely the worst air quality years in the last decade. For example, in 2020 urban sites in California had an annual fourth highest maximum daily 8-hour average (MDA8) O3 concentration that was at least 6 ppb higher than the average for the previous decade (Jaffe et al., 2022), while PM2.5 on these days was more than 20 µg m-3 higher than typical. Similarly in Chicago in 2023 (as of 8/7/23), the annual 4th highest MDA8 is more than 10 ppb higher than the mean from the previous decade and PM2.5 concentrations were also significantly enhanced. Thus, it is highly likely that both the PM2.5 and O3 enhancements were linked to wildfire emissions. While PM2.5 concentrations largely reflect the wildfire emissions and transport of primary and secondary particulate matter, O3 is more complex and depends on the initial emissions plus mixing with urban pollutants (especially NOx) and meteorology. This complexity makes exceptional event designation challenging.

ATMOSPHERIC IMPACTS COMMITTEE

The primary goals of Project A-135 are to use surface, satellite and meteorological data in a machine learning/Generalized Additive Modeling framework to understand the controlling factors on O3 production and concentrations during these fire influenced periods. This will support states' exceptional event processes and documentation for these and future years.

Current Status and Future Programs

This project was awarded to Dan Jaffe, and is expected to conclude early 2025.

GAS-PHASE MECHANISM EVALUATION: HOW SIMILAR TO MEASUREMENTS ARE CURRENT MECHANISMS AND COULD DIFFERENCES INFLUENCE SIP STRATEGIES?

CRC Project No. A-136

Leaders: C. Rabideau
S. Winkler

Scope and Objective

Three-dimensional Chemical Transport Models (CTMs) provide a representation of the atmospheric processes leading to the formation of secondary pollutants such as ozone (O3) and particulate matter <2.5 μm (PM2.5). Regulatory agencies use CTMs as one of their tools to determine what anthropogenic emissions to control and by how much to achieve the U.S. National Ambient Air Quality Standards (NAAQS) for O3 and PM2.5. Key components of CTMs are the gas-phase and aerosol-phase chemical mechanisms that connect primary emissions to secondary pollutants.

There are multiple gas-phase chemical mechanisms implemented in CTMs for regional-scale modeling. Currently, the mechanisms available for preparing U.S. emission control strategies include the Carbon Bond version 6 revision 3 (CB6r3) (Emery et al., 2015); the Statewide Air Pollution Research Center 2007 (SAPRC07) (Carter, 2010); and the Regional Atmospheric Chemistry Mechanism version 2 (RACM2) (Goliff et al., 2013.). These mechanisms have been included in both the U. S. Environmental Protection Agency (EPA) Community Multiscale Air Quality Model (CMAQ) and the Comprehensive Air Quality Model with Extensions (CAMx). Current versions of CAMx include more recent versions of the Carbon Bond mechanism, CB6r5 and CB7r1 (Ramboll, 2022). The U. S. EPA has released the Community Regional Atmospheric

Chemistry Multiphase Mechanism version 1.0 (CRACMMv1.0) in CMAQ (Pye et al., 2023), which intricately combines gas-phase and aerosol-phase organic chemistry. There are other gas-phase chemical mechanisms used for tropospheric and stratospheric modeling which are used to develop continental-scale background concentrations for U.S. control strategies.

There are recent comparisons of O3 formation when selected mechanisms are used in the same model with equivalent emissions for all mechanisms.

Project A-136 will compare O3 predictions of the CB7r1, CB6r3, SAPRC07, and RACM2 mechanisms using a 1-D version of CAMx with inputs representing areas around three Texas cities. In recent years, O3 formation in the U.S. has become limited on days exceeding the NAAQS by the availability of nitrogen oxides (NOx = NO + NO2) or trended toward this limitation, except in major urban centers (Blanchard and Hidy, 2018; Tao et al., 2022; Chen et al., 2023; Acdan et al., 2023). While we will compare O3 predictions of the mechanisms for a range of Volatile Organic Compound (VOC) and NOx emissions, our focus will be on NOx-limited O3 formation.

Current Status and Future Programs

This project was awarded to Ramboll in early 2024. The project is expected to wrap up with a Final Report available in early 2025.

MULTI-SCALE ANALYSIS OF PM SOURCES NEAR HIGHWAYS AND TRANSPORTATION CORRIDORS

CRC Project No. A-137

Leaders: K. Hamza
B. Ghosh

Scope and Objective

Emission inventories (EIs) and computer models are used to manage complex air quality issues such as PM2.5 and ozone. The models provide a connection between ambient concentrations, which can be measured, and emission inventories, which are managed by regulations. However, traditional ambient concentration measurements at surface monitoring sites provide limited data coverage that poorly constrains uncertainties in the models and the EIs. Pollution mapping by aircraft and/or satellites can provide much more data that can then be used to improve the EIs and/or models.

The objective of CRC Project A-137 is to utilize satellite data to calibrate fine-grid (1 km) air quality simulations and estimate the source contribution of on-road vehicle emissions to fine particulate matter (PM2.5) ground-level concentrations near highways and transportation corridors.

Expected breakdown of tasks includes:

- Defining modeling subdomains in three focus areas to 1-km resolution.
- Obtain and extract PM2.5 data for the 1-km subdomains.
- Perform simulations using 2016 data to determine the contribution of on-road vehicles to annual PM2.5 from the difference between the model "base case" and "on-road zero out" simulations.

- Make comparisons between 2016 and 2022 datasets to determine how emission changes from different datasets might influence findings of the fine-scale model results.

Current Status and Future Programs

CRC Project A-137 was awarded to Ramboll after an open solicitation. The project kicked off in December 2024 and is expected to continue through 2025.

PERFORMANCE COMMITTEE

The Performance Committee's history can be traced to the beginning of the Council with the formation of the Cooperative Fuels Research (CFR) Committee of the Society of Automotive Engineers (SAE). Inspired by a spirit of cooperation and a desire for technological progress that arose in the aftermath of the first World War, the Committee included manufacturers of equipment such as vehicles and engines, producers of fuels and lubricants, government researchers, and academics. In the earliest years, the National Bureau of Standards provided laboratory facilities, but as the industries supported by the Committee developed their own technical acumen, they began to take on more of the testing within their own companies to support the collective effort. The CFR Committee developed a process for cooperative research that remains with us today.

The second World War, requiring an extraordinary effort of industries in support of the Allied cause, motivated the incorporation of the Coordinating Research Council in 1942. The focus of this new company was to increase the performance and reliability of the military equipment being used to prosecute the war. Today the emphasis is on supporting all equipment, and the work is no longer labeled "Top Secret," but the principle of providing a forum for industries to work together in the interest of the public good has not changed.

The modern Performance Committee of the Council is organized as a main committee that serves in an executive capacity and 4 topical working groups that develop and execute research projects: Deposits, Diesel Performance, Gasoline Combustion, and Volatility. The working groups have a diverse membership that connects the research to a broad swath of companies and research institutions.

PERFORMANCE COMMITTEE

The research plans are driven by the technical needs of ever-changing industries and standard-setting entities such as ASTM. Research studies are conducted by the Members or by contractors funded through the Committee's budget as provided by the CRC Members.

GASOLINE ENGINE DEPOSITS

CRC Project No. CM-136

Leader: M. Sheehan
I. Tibavinsky

Scope and Objectives

The current objectives of this group are to:

- Develop test procedures for the objective evaluation of spark-ignition (SI) engine fuel and fuel additive contributions to combustion chamber deposits (CCD), intake valve deposits, and injector deposits in Port Fuel Injection (PFI) and Direct Injected (DI) vehicles.
- Determine the extent of SI fuel injector fouling and intake valve deposits and assess the adequacy of current deposit control additive dosages to prevent deposit formation.

History of the Working Group

The CRC Gasoline Engine Deposits Working Group has developed test methods and procedures for determining the quantity and impacts of deposits that form in engines that use gasoline and gasoline fuel blends. In prior decades, CRC developed specialized engines, rating techniques, and fluids to support testing and research into deposits. In recent years, the Working Group has performed research into durability impacts of fuel formulations and developed new research supporting updated intake valve deposit test methods and oxidation stability test methods.

Current Status and Future Program

<u>Gasoline Engine Intake Valve Deposit Testing</u>

ASTM D5500 is the test recognized by EPA for certifying additives to protect against Intake Valve Deposits. CARB has a separate test, and there is also a private program called the Top Tier certification test. CRC Gasoline Deposits Group is considering a re-evaluation of the test procedures to possibly update the vehicles/engine and the fuels used to assess deposit levels and the impact of fuels. The ASTM standard was implemented in 1994. Since that time there have been changes in fuel properties, engine technologies, ethanol usage rates, and new performance requirements.

The composition of the fuel sold at retail today has changed, with Tier III regulations reducing sulfur content. Since 1994, refining changes have been made and crude oil type has shifted with changing crude slates. Changes in engine technology include hybrids, FFVs (Flex Fuel Vehicle), DISI (Direct Injection Spark Ignition), turbo boost, downsizing, and VVT (Variable Valve Timing). The extent of ethanol use has also changed. The current engine test platforms, BMW 318i and Ford 2.3L (ASTM D6201), no longer represent the majority of the current vehicle population. The certification fuel requirements are also quite different from today's fuel composition.

The role of CRC is to provide data on performance but does not recommend what limits or variables should be set for standards or regulatory performance.

<u>Port Fuel Injection (PFI) Intake Valve Deposit (IVD) Test Development (CM-136-18-1)</u>

This project will develop a new engine-based test method suitable to replace existing ASTM D5500 test method for demonstrating effectiveness of gasoline detergent additives. It will conduct an engine test program to develop a final test fuel specification, test parameters, operating conditions, engine hardware requirements, and recommendations for pass / fail criteria. The work will result in an ASTM test methodology for IVD measurement and be acceptable to the EPA and potentially CARB for use in their Lowest Additive Concentration (LAC) certification test programs. This work will be completed in the Prove-out Phase of the CRC test development project. There will be a follow up Precision Phase of the project to define the repeatability and reproducibility of the test method once the Prove-out Phase is complete. The overall development project is expected to consist of three Prove-Out phases and one Precision phase.

• Phase 1 – Prove-Out Test Cycle

• Phase 2 – Prove-Out Test Fuel

• Phase 3 – Prove-Out Detergent

• Phase 4 – Precision

The project team has formed around five workstreams: Engine Test Development, Data Analysis, Test Fuel, Additives, and EPA / CARB Engagement.

Intertek was awarded the contract to perform Phases 1-3 of the study. The Final Report will be published in the first quarter of 2025.

<u>Study of Modern Gasoline Oxidation Stability with Correlations and Precision Updates to ASTM Stability Tests CM-136-20)</u>

This project's objectives are to:

- Develop a robust statistical design of experiments using ASTM D6300 for an Interlaboratory Study (ILS) on the current gasoline oxidation stability tests: ASTM D525 Pressurized Cylinder Induction Period test and the ASTM D7525 Rapid Small-Scale Oxidation Test (RSSOT).
- Execute a statistically robust ILS with participating external laboratories from the CRC project participants.
- Develop the data for updated precision statements for both tests.
- Develop a statistically robust correlation between the pressurized cylinder test and the RSSOT. Perform this task

with North American fuels to develop a robust correlation useful in multiple jurisdictions.

This project was conducted by SwRI. The final report was published on the CRC website in July 2024.

VOLATILITY

CRC Project No. CM-138

Leader: D. Kovach / A. Iqbal

Scope and Objective

The objective of the CRC Volatility Group is to investigate the relationship between vehicle driveability performance and fuel volatility characteristics.

History of the Working Group

The Volatility Group has been responsible for large-scale experimental investigations into the interaction between possible modern fuel parameters and the latest production vehicles, during extreme conditions of temperature and altitude. The most recent of these programs was the 2014 CRC Hot-Fuel-Handling Program, published in March of 2015. In recent years, the Working Group has investigated techniques for measuring driveability in a laboratory setting, conducted a workshop to train driveability raters, and developed a specialized instrumented vehicle that can be used to train raters. This vehicle was also used to investigate automated methods for measuring driveability, correlated with the human driver methods used in previous studies.

Current Status and Future Program

The Volatility Group is currently planning new research investigating the future of assessing vehicle driveability, and considering potential future research with the Sustainable Mobility Committee's Fuels Working Group.

PERFORMANCE COMMITTEE

GASOLINE COMBUSTION

CRC Project No. CM-137

Leader: B. Alexander
B. Raney-Pablo

Scope and Objective

The objectives of this group are to assess the combustion-related requirements of current production automotive vehicles, to develop methods for quantifying combustion-related fuel requirements of vehicles, and to determine effects of variables such as mileage accumulation and altitude on combustion-related fuel requirements.

History of the Working Group

The Working Group operating under the name "Octane" was renamed to the Gasoline Combustion Working Group in 2020, to reflect the broader interests of the Working Group. In the past, this group was responsible for planning large-scale investigations of the octane requirements of the in-use vehicle fleet. In recent years, the group has investigated the potential for increased efficiency from higher octane fuels, and partnered with another CRC Committee to study the impact of octane parameters on modern / future engine technology. The current focus of the group is on research to support updates to the octane measurement methods using the CFR engine, named for the Cooperative Fuels Research Committee, which became CRC in 1942.

Current Status and Future Program

"Impact Of MON On Engine Performance" (AVFL-36 / CM-137-19-1)

This Project was supported equally by the Performance Committee Gasoline Combustion Group and AVFL and is described in the

AVFL Committee section. The Final Report was published on the CRC website in March 2023.

“Alternative to Tetraethyl Lead (TEL) in ASTM D2699 and D2700” (CM-137-21)

Both ASTM D2699 and D2700 require tetraethyl lead (TEL) blends with isooctane as reference fuels to rate gasolines with ON > 100. There is a desire to develop an alternative to TEL blends for the rating of gasoline with ON > 100. Both CRC and ASTM agree that the best way forward is to identify and evaluate an alternative to TEL. The proposed literature study includes evaluating toxicity, material compatibility, availability, and cost of candidate compounds to use as an alternative to TEL. The laboratory study proceeds in two phases, including a precursor study at one lab which would run in parallel with the literature study, and a full ARV (Accepted Reference Value) study completed after the precursor study. The project is underway in coordination with an ASTM task force and CRC Aviation Committee members. The Final Report is anticipated in mid-2025.

PERFORMANCE COMMITTEE

DIESEL PERFORMANCE GROUP

CRC Project No. DP

Leader: G. Gunter
S. Lopes

Scope and Objective

The objective of the Diesel Performance Group (DPG) is to help to define the minimum diesel fuel requirements for light-duty diesel (LDD) vehicles in North America. This will be achieved by providing supporting technical data for diesel performance issues that are needed by the fuel, engine, equipment, and additive industries and can be used by technical groups such as ASTM International, the International Organization for Standardization (ISO), and the National Conference on Weights and Measures (NCWM). Much of the knowledge gained is common to other diesel applications such as heavy-duty diesel (HDD). This Group works closely with industry stakeholders and benefits from their contributions.

The Diesel Performance Group currently has the following active and inactive panels and will adjust and add new ones as needed:

Active Panels:

- Cleanliness
- Corrosion
- Deposit
- Low Temperature Operability
- Stability

Inactive Panels:

- Biodiesel & Renewable Diesel
- Cetane Number
- Lubricity

History of the Working Group

After CRC's reorganization of the mid-1990s removed heavy-duty diesel engine manufacturers from the sustaining membership model, this group was formed under the Performance Committee to continue the important technical work relating to the performance of diesel (compression ignition) engines and fuels. The large technical scope and membership of the Working Group has led to the formation of numerous panels for specific topic areas.

Panels are formed as needed to address important current technical issues, and when they are no longer needed, they become inactive. The current active panels of the Diesel Performance Group are Cleanliness, Corrosion, Deposit, Low Temperature Operability, and Biodiesel & Renewable Diesel. The Diesel Performance Group had an extensive list of publications in recent decades, including investigations of injector deposit issues, development of injector deposit test methods, and examining potential factors involved in fuel tank corrosion. The Panels have also created technical guides relating to topics within their areas of focus, including fuel cleanliness and renewable hydrocarbon diesel fuels. Additional discussion of the recent history of the Diesel Performance Working Groups is included in the following sections.

Current Status and Future Program

Cleanliness

The objective of the Cleanliness Panel is to address, to investigate, and to provide information for general housekeeping and other issues for diesel fuel. The focus is on fuel cleanliness and fuel properties that are outside the defined fuel properties in existing CRC DPG panels. These fuel cleanliness properties should have relevance from the point of diesel production to the point of customer use (refinery to vehicle fuel tank). Modern high-pressure common-rail injection systems require much cleaner diesel fuel.

PERFORMANCE COMMITTEE

The Panel generated a CRC guide to compile the best available current knowledge and practice regarding cleanliness of diesel fuel. CRC Report No. 667, "Diesel Fuel Storage and Handling Guide," was published on the CRC website in September 2014. ASTM periodically holds workshops on this topic and distributes the guide to participants.

The Panel developed a one-sheet summary guide targeted to benefit fuel station operators. CRC Report No. 672, "Preventive Maintenance Guide for Diesel Storage and Dispensing Systems," was published on the CRC website in July 2016.

The Panel meets periodically. Data on fuel haze measurements was generated and analyzed by the Panel under Project No. DP-06-20, resulting in the publication of CRC Report No. 675, "Evaluation of Diesel Fuel Haze Resulting from Water Content," published on the CRC website January 2022.

Corrosion

Accelerated corrosion has been observed in some retail underground tanks storing and dispensing ultra-low sulfur diesel (ULSD) since 2007. In addition, corrosion is affecting metallic equipment in both the wetted and un-wetted portions of some ULSD underground storage tanks (USTs). To identify the root cause of accelerated corrosion, multiple stakeholders in the diesel, vehicle, regulatory, and truck stop industries, through the Clean Diesel Fuel Alliance, sponsored a field research study by Battelle Memorial Institute in 2012.

The CRC Panel developed a protocol for selecting sites with diesel fuel systems that had severe corrosion. This was posted to the CRC website in 2014 with the goal of informing the EPA and others in their current and future research on this topic. Using the CRC protocol, the EPA, in consultation with the CRC Panel, conducted a survey of USTs in the field.

To identify possible root causes of the excessive corrosion, the CRC Panel developed a laboratory test program titled:

“Fuel Research Using the Internal Diesel Injector Deposit (IDID) Rig” (DP-04-22)

The objective of the study is to determine precision of the new test system to evaluate internal diesel injector deposits which is described in the previous CRC Project No. DP-04-17 report. The CRC Internal Diesel Injector Deposit (IDID) Test uses a combination of an injector deposition rig and a novel application of a spectroscopic instrument (Variable Angle Spectroscopic Ellipsometer, VASE) to measure deposit thickness. The intention is to conduct research as per the design of experiment test matrix designed by the CRC Diesel Deposit Panel to establish repeatability/reproducibility and sensitivity of the test rig. This project was conducted by SwRI. The Final Report was published on the CRC website in August 2024.

Deposit

The objective of the Deposit Panel is to identify or develop a laboratory bench top or test rig for evaluating diesel fuel’s tendency to cause internal injector deposits in diesel engines and to use a tool to evaluate possible effects by fuels, impurities, and additives.

Experts on the Deposit Panel wrote a review of potential causes of internal diesel injector deposits which was published as CRC Report 665, “Internal Diesel Injector Deposits,” October 2013.

An initial scoping study of limited screening used three in-house tests to determine if fuels which are expected to cause internal injector deposits can be differentiated from those that are not expected to form such deposits. The Delphi rig was identified as one that had the potential for this application. Results of these studies are in two CRC reports on the CRC website:

- CRC Project DP-04, "Scoping Study to Evaluate Two Rig Tests for Internal Injector Sticking," July 2012.
- CRC Project DP-04-13b, "Internal Injector Deposits: A Scoping Study to Evaluate the Delphi Test Rig," August 2013.

A comprehensive rig/engine test program was conducted to verify correlation between the Delphi rig and actual engines. Results were positive and have been documented in CRC Report DP-04-10, "Internal Injector Deposits; Correlation of the Delphi Test Rig with Production Engines," published March 2016 on the CRC website.

The Deposit Panel designed a program to set up and use the test rig at a U.S. research facility to begin evaluation of fuels, additives, and impurities. The project, titled "Fuel Research Using the Internal Diesel Injector Deposit (IDID) Rig" (CRC DP-04-17), was performed by SwRI. The Final Report was released on the CRC website in September 2019.

The Deposit Panel is planning additional research to build upon the recent publications.

Low Temperature Operability

The Panel conducted a study in which various test methods used to characterize fuel low temperature operability were evaluated for their ability to predict whether test vehicles experienced fuel-related operability problems in low temperature test conditions. Results were documented in CRC Report #649, "Evaluation of Low Temperature Operability Performance of Light-Duty Diesel Vehicles for North America," November 2007.

The Panel conducted a study of the effect of biodiesel blendstock properties on cold flow properties of biodiesel blends. Results were documented in two reports: CRC Report #650, "Biodiesel Blend Low-Temperature Performance Validation," in June 2008 and CRC Report #656, "Biodiesel Blend Low-Temperature Performance Validation," in June 2010.

The Panel has utilized members' expertise to generate CRC Report No. 671, "Diesel Fuel Low Temperature Operability Guide." The guide was written for general use by end users, fuel producers / distributors, and OEMs in providing guidance on the best ways to keep diesel vehicles operating under most low-temperature conditions. The guide was released on the CRC website in September 2016.

The Panel conducted a project titled, "Low Temperature Filterability of Diesel Fuel at Retail Pumps," using resources provided by Panel members. A test rig was used to determine limitations in dispenser filters in operation in cold temperatures. This test rig may be able to evaluate any relationship between filter pore size and operational issues at low temperatures. Reporting on this research is expected in 2025.

Biodiesel & Renewable Diesel

This Panel has a lineage from earlier research activity relating to biodiesel that had generated multiple panels, which were consolidated and updated to include renewable diesel. A guide to renewable diesel was produced by the panel in 2018 (CRC Report No. 673). Afterwards, the Panel was inactive for a short time. The Panel became active again in 2022 to develop new research investigating Biodiesel and Renewable Diesel compatibility with modern vehicles.

AVIATION FUELS COMMITTEE

The Aviation Committee (AVC) has a history spanning the existence of the Coordinating Research Council. As one of the main pillars of research activity in the decades following CRC's incorporation in 1942, it has always been an important part of CRC, and has operated continuously even though it only recently received a dedicated section in the CRC Annual Report. It was chartered in its current form as a separate, self-funded entity during CRC's reorganization of the mid-1990s. The objectives of the AVC are:

- Provide an organization and forum for aviation fuel producers, users and equipment manufacturers, government, and academia to collectively address and fund fuel research.
- Develop the technical information and data required to allow the aviation industry to resolve fuel-related problems and issues.
- Provide a forum for the dissemination of technical information, to foster relationships between the development of industry experts, and to discuss research, problems, issues, and concerns.

AVC's unique characteristics include a tiered membership model that confers the number of voting seats on the Steering Committee proportional to the funding provided. (This inspired a similar approach for the Sustainable Mobility Committee that CRC formed in 2021.)

The AVC has produced an Aviation Fuels Handbook for more than 50 years. The Handbook is a compendium of valuable technical information for aviation industry professionals, and is periodically updated with information from CRC research projects and other sources. The Handbook is offered for sale by CRC, and the proceeds are used to support future versions.

AVC's annual meeting, traditionally the 1st week of May, is open to the public at the working group level. This annual technical forum combines elements of technical workshop, including a broad range of technical presentations and networking opportunities, with the operation of the technical working groups and (for Members) the Steering Committee, which guides all aspects of the AVC research program, including funding allocation.

The current active working groups and major panels of the AVC are:

- Advanced Research and Test Methods
- Fuel Handline, Contamination, and Microbiology
- Operability
- Aviation Gasolines & Piston Fuels
- Fuel System Safety
- Fuel System Stability
- Publications
- Properties and Emissions
- Production and Delivery
- Emerging Fuels
- Thermal Stability Panel

AVIATION FUELS COMMITTEE

THERMAL STABILITY PANEL

CRC Project No. AV-24-16

Leaders: J. Sheridan
A. Carico

Scope and Objectives

There has been an increased number of incidences of jet fuels that do not meet the ASTM D1655 requirements for D3241 ("JFTOT") thermal stability at pre-airfield terminals or airport depots. The product in question does meet certification at the production point, but fails after moving through the fungible distribution system. The number and severity of these failures have caused supply chain and end user issues. The Project Panel will be investigating a number of failure mechanisms and the factors possibly involved in causing those failures.

Current Status and Future Program

The Panel is prepared to meet and authorize sample collection and testing upon occurrences of observed issues with fuel stability.

FEASIBILITY ANALYSIS: ALTERNATIVE APPROACHES TO THE REPLACEMENT OF ASTM D909 SUPERCHARGE RATING

CRC Project No. AV-28-19

Leaders: M. Rumizen
R. Gaughan

Scope and Objectives

The first goal of the project is to summarize the conditions, requirements, and rationale of the current ASTM D909 Supercharge Octane Rating test method. A great deal of information about the engine setup and test requirements can be found in the ASTM D909 test method and the CFR Engines F-4 Manual. More information likely exists in the CFR Engines Inc. archives that could provide better detailed information about the rationale of the supercharge test method. However, there is a lack of fundamental understanding regarding the actual cylinder thermodynamic conditions of the D909 test method. In the case of the RON and MON tests, there has already been some highly impactful research on instrumented RON and MON test engines [8,10-23], but there is a lack of detailed combustion measurements and analyses of the F-4 supercharge rating engine.

After a detailed literature review of previous measurements (and rationale) of the F-4 supercharge method test engine, the next step will be to instrument the F-4 engine installed at CFR Engines, Inc. and combine measurements and modeling of the engine operating conditions, cylinder conditions, and combustion and knocking characteristics. Common aviation gasolines, such as 100LL aviation gasoline and reference fuels, will be tested. This will provide the needed fundamental information about the cylinder thermodynamic conditions the test fuels are exposed to during the current supercharge test method. A Three Pressure Analysis (TPA) GT-Power model of the RON and MON engines has been developed. The GT-Power model uses measurements from actual engine experiments to provide some of the boundary conditions for the model to improve its accuracy.

Research Questions to be Addressed:

1. What are the cylinder thermodynamic conditions (or range of conditions) the fuel is exposed to during the current F-4 supercharge test method over the typical range of performance numbers?
2. How do modern cylinder pressure transducer-based measurements of IMEP (and their uncertainty) compare to the current BMEP and FMEP based IMEP calculation method?
3. In a blind test, how well does the operator-based human ear detection of “light knock” compare with a cylinder pressure transducer-based knock intensity measurement, such as the maximum amplitude of pressure oscillations (MAPO), as demonstrated for a RON test of isooctane in Figure 6?
4. From how many of the combustion cycles can knock be observed from a cylinder pressure measurement during testing of the supercharge test method?
5. How does the combustion and knocking characteristics compare between the supercharge method and the RON and MON test methods?

Current Status and Future Program

Project AV-28-19 is being conducted by Argonne National Laboratory. A final report is expected to be published in 2025.

JET FUEL & AVIATION GASOLINE HOV AND ENTHALPY DIAGRAM TESTING

CRC Project No. AV-20-20

Leaders: A. Clark

Scope and Objectives

This work is a continuation of the work done and reported in CRC Project AV-20-14, and characterized European produced jet fuels relative to American produced jet fuels. It used HOV QI data to establish both average value and level of variation with regard to a jet fuel type, and investigate if there is a significant difference between two similar fuel types that (essentially) meet the same specification, but are manufactured in different regions of the world.

Additionally, it produced Enthalpy Diagrams and Heat of Vaporization curves to a range of Avgas samples for inclusion in the CRC Aviation Fuel Property Handbook.

Current Status and Future Program

Project AV-20-20 was conducted by the University of Delaware. The final report was published in December 2023.

AVIATION FUELS COMMITTEE

UPDATE OF AVIATION GASOLINE PROPERTIES USING 100LL COFAS FROM PRODUCERS, SAMPLES ANALYSES BY AFETF, AND NEG DATA

CRC Project No. AV-30-22

Leader: A. Clark

Scope and Objectives

Project AV-30-22 partners with the FAA, and collects a new set of CoA's from producers, the AFETF data, and NEG data starting in 2011. Evaluate the current maximum lead content, graph the relationships between the properties, specifically, lead vs MON/D909, lead vs aromatic content, and variability in measured physical properties. Data should be reported by region and if possible, by blinded refinery.

Current Status and Future Program

Project AV-30-22 is being conducted by Baere Aerospace Consulting. A final report is expected to be published in 2025.

MICROBIAL TEST KIT EVALUATION

CRC Project No. AV-31-22

Leaders: M. Vaughan
J. Buffin

Scope and Objectives

Project AV-31-22 objective is to conduct an independent laboratory study to confirm the technical performance and reliability of proposed and existing IATA (International Air Transport Association) recommended methods for microbiological contamination in aviation fuel tanks.

Evaluate current and proposed IATA recommended Microbiological Test Kits and compare to reference test methods.

Test Methods to Include in Study:

- FuelStat® Resinae Plus (ASTM D8070)
- MicrobMonitor®2 (ASTM D7978)
- HY-LiTE® (ASTM D7463)
- Aidian: Easicult® TTC and Easicult®M
- San-Ai Biochecker FC
- LuminUltra® ATP (ASTM D7687) (Not currently IATA recommended but proposed and in use by some airlines with their own internally developed action levels)
- IP385/ASTM D6974 (current laboratory reference method)
- qPCR ASTM method in development (as a possible reference technology)

Test evaluation will be carried out in accordance with the protocol developed by the IATA Microbiological Contamination Panel with input from IATA member airlines, Airbus, Boeing, Embraer, US Air Force, Microbiological Experts (Echa Microbiology, FQS, Merck, Conidia Bioscience, Aidian, San-Ai Biochecker).

Simulations of fuel tanks containing contaminated fuel and water, at various levels of contamination, will be developed and then tested with each of the methods.

Current Status and Future Program

Project AV-31-22 was awarded to SGS-Portugal. A final report is expected to be published in 2025.

INVESTIGATE JP-5 VAPOR PRESSURE VALUES IN FIGURE 2-12 OF CRC FUEL HANDBOOK

CRC Project No. AV-32-22

Leaders: M. Thom
A. Clark

Scope and Objectives

Project AV-32-22 aims to identify the source of the data used in CRC Fuels Handbook for JP-5 vapor pressure and determine if it was the same as JP-7 for some reason or has always been incorrect. Another objective is to determine what contemporary JP-5 vapor pressure data indicates or determine whether there is no vapor pressure data available.

The plan is to research the potential source of the original CRC Fuel Handbook vapor pressure data. This may include DOD research reports published before or contemporary to the original publication of the CRC handbook. Sources identified shall be provided.

If this data can be located, the proposer is to perform a comparison of the data between JP-5 and JP-7 specifically, and across any other fuel data identified during Step 1.

Research contemporary data on fuel vapor pressure and determine what data indicates in comparison to the existing CRC Handbook data.

It is recognized that if no data is found, a subsequent research proposal may be submitted for developing data.

Current Status and Future Program

This project has been awarded to UDRI. A final report is expected to be published in early 2025.

SUSTAINABLE MOBILITY COMMITTEE

The Sustainable Mobility Committee (SMC) was formed by the CRC Board of Directors in March 2021. The motivation was to provide an expansive and flexible new forum for research in technology and energy transitions affecting the member industries. These transitions generated research needs outside of the scope of current committees of that time. The vision of the SMC was established to be:

A multi-stakeholder forum for collaborative scientific research studies focused on pathways towards a carbon neutral future through significant greenhouse gas reductions from mobility while seeking to understand tangential impacts

A distinguishing feature of the SMC was to offer full membership to stakeholders outside of the auto & oil industries that form the core membership of CRC. This allowed the technical community working on these challenges within the Committee's vision to expand, broadening both participation and resources to support the research program.

As the Committee's Membership and list of research projects grew, the SMC developed topical working groups under the guidance of the main (steering) committee to better align expertise from the large group of researchers with the diverse research projects within the SMC vision. Initial Working Groups developed: Electrification; Fuels, and Novel Carbon Reduction Strategies. The Life Cycle Analysis Panel (active since 2008) of the CRC Real World Group became the 4th Working Group of the SMC. A special group for government-affiliated membership was created: the SMC Partner Members.

In 2024, the Novel Carbon Reduction Strategies Working Group was renamed to the Hydrogen and Novel Carbon Reduction Working Group, reflecting a growing interest in hydrogen-focused research within the Committee.

SUSTAINABLE MOBILITY COMMITTEE

The SMC has already developed and completed a significant list of projects and technical events in its short existence, while membership and the list of potential new projects continue to grow.

SUSTAINABLE MOBILITY COMMITTEE

EVALUATION OF THE POTENTIAL FOR SIGNIFICANT GHG EMISSION REDUCTIONS FROM ICES OPERATED ON LIQUID FUELS

CRC Project SM-1

Leaders: R. De Kleine
H. Hamje

Scope and Objectives

Given the uncertainty in the rate of uptake of battery electric vehicles (BEVs) and the speed of US grid decarbonization, this study aims to explore options available to ICE vehicles to accelerate the decarbonization of the US light duty vehicle fleet. The analysis considers internal combustion engine (ICE) vehicles and BEVs as complementary rather than in competition with each other in how they can contribute to the decarbonization of the light duty vehicle fleet by 2030.

Two broad categories of fuel decarbonization options were evaluated: drop-in fuels compatible with existing vehicles with no modifications (e.g. renewable gasoline) and non-drop in fuels in vehicles designed specially to take these fuels (e.g. flex fuel vehicles on E85). The following analysis was conducted:

- Vehicle stock modelling was used to assess how the makeup of the fleet would change over time and assess the potential penetration of vehicles able to use non-drop-in fuels.
- Fuel supply ramp up modelling was used to assess a realistic ramp up rate of both drop in and non-drop-in fuels.
- Well-to-wheel and lifecycle GHG analyses were then conducted to assess the potential contribution to decarbonization of drop-in and non-drop-in fuels .

The Project used 3 “study cases” to understand the potential decarbonization contribution of low carbon fuels:

- Baseline case = “business as usual,” which considers the fleet impact in 2030 of the use of a conventional gasoline blend (E10) in ICE vehicles and Section 177 weighted average grid mix for the BEVs. This aims to show the level of decarbonization without the impact of drop-in fuels and non-drop in fuels.
- Expected case = “what could be achieved?”, which considers how current trends in low carbon fuels could lead to reductions in ICE vehicle emissions. This aims to show the additional decarbonization that could be achieved with drop-in and non-drop-in fuels, based on a realistic rate of uptake of fuels and vehicles. Note: BEV and PHEV uptake assumed to be the same in Baseline and Expected cases.
- Aspirational case = “what would need to be achieved?”, which considers how an aspirational GHG emissions reduction target could be achieved through higher penetration of low carbon fuels and/or certain vehicle types.

Current Status and Future Program

Project SM-1 was performed by E4Tech and AVL, and was published on the CRC website in July 2024.

EVALUATION OF THE USE OF EVS FOR TRANSIENT GRID STORAGE (V2G) ON BATTERY LIFE

CRC Project SM-E-4/8

Leaders: E. Chapman
C. Brooks
I. Tibavinsky

Scope and Objectives

The objective of Project SM-E-4/8 is to model the battery life effects of V2G activity on top of ordinary EV battery usage such as mobility related discharge, slow and fast charging, and calendar aging. A variety of V2G strategies are possible and their effects on battery life can be modeled. The model would include the effects of various ordinary uses as described above. The end product should be the identification of V2G cycles that, when coupled with certain mobility and charging usages, result in a battery deteriorating below the warranty requirement and identification of the salient modes of deterioration.

The contractor will research a variety of likely V2G duty cycles for use in the model; these may include full grid load leveling, peak shaving as well as V2Building. The contractor will have an up-to-date battery use and life model and will layer the V2G duty cycles on a variety of existing vehicle use and charging scenarios based upon Level 2 and higher power DC Fast Charging . The model will simulate up to 8 years of use and, if possible, include calendar aging.

The battery model will be of the Newman 2PD type with variables populated from the characteristics of a real cell. It will model carbon anode and higher nickel NMC or NCA/NMCA cathode batteries and have multiple degradation modes. The modeled battery will have 75kWh of capacity and the failure threshold is 70% performance. The maximum rate of V2G discharge is 10 kW. Knowing there are many possible use case scenarios, it is expected that the contractor and CRC will decide upon a design of experiments matrix that is achievable for the time of performance.

Current Status and Future Program

Project SM-E-4/8 is being conducted by the University of Michigan. The Final Report is expected to be released in early 2025.

CARBON RETURN ON INVESTMENT FOR ELECTRIFIED VEHICLES

CRC Project SM-E-20

Leaders: M. Przybylo
X. He

Scope and Objectives

The objective of Project SM-E-20 is to evaluate the carbon return on investment (CROI) for a variety of battery sizes in the different vehicle electrification strategies.

The project modeled the carbon intensity for producing batteries based on size and battery technology (i.e. mineral content) using real world data from a variety of vehicle models. These data will be combined with an in-use average driving calculation to determine the actual carbon return on investment (CROI). The project will include PHEV (plug-in hybrid vehicles) and BEV (battery electric vehicles) vehicle configurations, with models from a selection of automobile manufacturers. The size of the battery and driving habits of the average driver will help to determine the true potential CO2 benefit.

Current Status and Future Program

Project SM-E-20 was conducted by the National Renewable Energy Laboratory. The Final Report, titled "Analyzing Potential Greenhouse Gas Emissions Reductions from Plug-In Electric Vehicles: Report for CRC Project, "Carbon Return on Investment for Electrified Vehicles" was published by NREL, and a link was posted to the CRC website in December 2024. A Committee-authored Executive Summary will also be published in early 2025.

SUSTAINABLE MOBILITY COMMITTEE

V2X REQUIREMENTS TO SUPPORT THE SAE J1634 SHORT MULTI-CYCLE TEST AND SETTING INITIAL SOC FOR PLUG-IN HYBRID ELECTRIC VEHICLES

CRC Project SM-E-18 / E-142

Leaders: E. Chapman
S. Decarteret
M. Yassine
M. Al-Hadrasi

Scope and Objectives

Evaluate potential industry standard V2X communication protocols (such as ISO 15118-20 and SAE J2836). Provide a comparison of protocol options and identify a recommended protocol. Develop guidelines, procedure, quality checks, and best practices to perform the SAE J1634 (April 2021) EV battery discharge utilizing the recommended V2X protocol. This shall include requirements for the vehicle battery discharge control, communication between vehicle and battery cycler, and battery cycler control.

Identify methods for "SOC conditioning" (charging or discharging battery to a setpoint) to address a host of situations for both BEVs and PHEVs. Manual methods currently exist using a chassis dyno (SAE J2908 and/or SAE J1711) and/or standard charging equipment. Include what is possible with manual methods, a combination of manual and automatic, and fully automatic methods. Describe what procedures, equipment or new features are needed for each with the preferred goal of providing safe, unsupervised charging or discharging to a pre-determined SOC set-point with automatic termination of power flow when the target SOC is reached."

SUSTAINABLE MOBILITY COMMITTEE

Current Status and Future Program

Project SM-E-18 / E-142 was performed in partnership between the CRC Sustainable Mobility and Emissions Committees; the research was performed by SwRI. The Final Report was posted to the CRC website in July 2024.

SUSTAINABLE MOBILITY COMMITTEE

CHARGING PLAZA LOAD ANALYSIS AND FORECAST

CRC Project SM-E-16

Leaders: E. Chapman
I. Tibavinsky
V. Raj-Mohan

Scope and Objectives

Project SM-E-16will explore how the growing diversity of vehicle charging capabilities, charging behavior, or 'styles', impacts load shape and peak demand and thus, the site host utility bill. Further, the research will explore different approaches to optimizing operational costs through on-site storage, customer pricing signals (demand response, throttling, or rewards programs), or other to-be-determined methods. Using scenario-based Excel models to estimate the frequency and duration of a charging station reaching its nameplate capacity, the research will evaluate the practical feasibility and estimated cost-effectiveness of different approaches (e.g., storage vs managed charging). Insights from this modeling effort can be used to inform system design and pricing strategies.

The modeling will also allow for the exploration of site level utilization and how utilization may change over time with increasing levels of EV's (Electric Vehicles) and EV charging. The model can be used to evaluate the profitability of different charging stations based on defined scenarios (e.g., monthly utilization, when/ how they are used). Results from the scenario analysis will provide guidance on how a retail charging plaza could mature / evolve over time as utilization increases or remains low depending on its scenario (e.g., urban vs rural, remote, etc.). Finally, insights from the utilization modeling exercises will inform the viability of rural and remote DDCFC (DC Fast Charging) stations and identify the potential need for supportive subsidy or other incentives (state, local, or federal).

The contractor will build an Excel-based model to "simulate" plaza level charging station use, load shape, peak demand, and utility bills. If available, the model will be informed based on real-world data, statistical models, and empirical assumptions. The contractor will build several scenarios of future charging plaza operations based on vehicle charging characteristics and different charging styles.

The model will produce results that include:

- Typical and outlier load shapes for different charging scenarios
- Presentation of different future scenarios for plaza level utilization
- Utility bills based on utility tariffs
- Quantitative and qualitative considerations for different approaches to mitigating peak demand events (e.g., storage, price signals, throttling, curtailing, etc.)

Current Status and Future Program

Project SM-E-16 was performed by the Smart Electric Power Alliance (SEPA); the Final Report was published on the CRC website in July 2023.

SUSTAINABLE MOBILITY COMMITTEE

RESEARCH IN SUPPORT OF FUTURE FUEL SPECIFICATIONS

CRC Project SM-F-5

Leaders: M. Sheehan
M. Przybylo

Scope and Objectives

The goal of Project SM-F-5 is to maintain and/or broaden the scope for liquid fuels in a lower carbon future.

This effort will examine opportunities to alter current specifications for transportation fuels to enable lower fuel carbon intensity while remaining relevant to modern/future vehicles. It is intended to explore both: (a) those properties that could be changed to enable increased use of renewables, and (b) those parameters that could be limiting changes in petroleum (and renewable) fuel manufacturing processes and process efficiency improvements that might also reduce carbon intensity. This effort will be undertaken from a holistic perspective, i.e., one that explores those property and performance specifications deemed necessary to support incremental changes in engine, vehicle, and fuel requirements that increase total energy efficiency/reduce total carbon intensity, evaluated on a wells-to-wheels system-wide basis.

Current Status and Future Program

Project SM-F-5 was awarded to SwRI, and is in progress. A Final Report is expected to be published in early 2025.

SUSTAINABLE MOBILITY COMMITTEE

SUSTAINABILITY AND LOCAL AIR QUALITY IMPACTS OF FUTURE ELECTRIFICATION AND NEW VEHICLE EMISSION REGULATION SCENARIOS IN THE U.S.

CRC Project SM-F-2 / A-134

Leaders: J. Anderson
S. Winkler
H. Hamje

Scope and Objectives

Assess the trends in air quality (ozone, NO_2, PM_{10}, PM2.5, CO, CO_2) of several selected US urban areas and regions for various scenarios (2030-2035) involving different assumptions regarding: (a) the future penetration of electrified vehicles in the on-road light-duty vehicle fleet, (b) the mix of fuels (i.e., gasoline/diesel, biodiesel, ethanol) needed to operate internal combustion engine-equipped vehicles (ICEVs) and generate electricity for electrified vehicles; and (c) emissions levels for future light-duty ICEVs. Model the change in well-to-wheels CO_2 emissions associated with the same future scenarios. Determine and compare the incremental CO_2 and air quality impacts of high and low vehicle electrification scenarios. Consider CO_2, PM2.5, PM10, NOx, ozone, CO, non-methane hydrocarbons, methane, oxygenates, etc. Compare cases to each other and/or to air quality and climate objectives, or other metrics.

- Identify and select at least 4 US urban areas and/or regions for which adequate underlying emissions inventory (and other) data exist to support air quality modeling and:
    - Construct a base year scenario.
    - Construct at least 3 alternative future year scenarios that will serve as reference case, a high vehicle

electrification case, and a low vehicle electrification case.

- For each of the locales/regions selected:
    - Model the well-to-wheels CO2 emissions for EV and ICEV associated with each scenario described above.
    - Determine and compare the incremental CO_2 and air quality impacts related to the future scenarios and to the base year.
    - Compare cases to each other and to air quality and climate objectives.

Current Status and Future Program

Project SM-F-2 / A-134 was performed by the University of Houston. The Final Report was published as an article in the February 2024 issue of *Science of the Total Environment*, under the title: "Air quality and health co-benefits of vehicle electrification and emission controls in the most populated United States urban hubs: Insights from New York, Los Angeles, Chicago, and Houston." An Executive Summary for this project was published on the CRC website in November 2024.

SUSTAINABLE MOBILITY COMMITTEE

ASSESS THE BATTERY-RECHARGING AND HYDROGEN REFUELING INFRASTRUCTURE NEEDS, COSTS AND TIMELINES REQUIRED TO SUPPORT REGULATORY REQUIREMENTS FOR LIGHT-, MEDIUM-, AND HEAVY-DUTY ZERO-EMISSION VEHICLES

CRC Project SM-CR-9

Leaders: T. French
A. Lubawy
M. Przybylo
H. Hamje

Scope and Objectives

To support the growing zero-emission vehicles (ZEV) fleet that is expected because of recent rulemaking, electric recharging and hydrogen refueling infrastructure expansion will be necessary. While this infrastructure is not required by regulation, several incentives exist to encourage it, such as National Electric Vehicle Infrastructure (NEVI) grants for plug-in vehicle charging, and Charging and Fueling Infrastructure (CFI) grants for electric, natural gas, propane, and hydrogen. Both are funded by the 2021 Infrastructure Investment and Jobs Act (IIJA).

Understanding the scope, cost, and timelines for developing this ZEV infrastructure will assist in planning and inform policy development.

All stakeholders desire to achieve accelerated deployments of ZEVs through the optimized allocation of available federal funding. In that regard, and for the first time, there are multiple clean powertrain options providing various impacts to the customer and the supporting infrastructure. The effect of powertrain electrification on the electrical grid and potential hydrogen production/distribution, combined with a progressing portfolio of diverse energy sources, is extremely complex and may present challenges or opportunities that were unexpected. Understanding the comprehensive implications of electric charging and hydrogen expansion will help guide decision-making. Toward that end, an assessment was made of the scope of the ZEV infrastructure that will be needed to support the envisioned transition to light-duty, medium-duty, and heavy-duty ZEVs.

Current Status and Future Program

Project SM-CR-9 was co-sponsored by the Truck and Engine Manufacturers Association (EMA). The project was awarded to ICF. An initial Final Report focused on the requirements of a proposed rule was published in early September 2023 before the rule was finalized and was accompanied by a CRC Executive Summary and a fact sheet for Medium-Duty and Heavy-Duty Vehicles. Supplementary reports were published in association with the main study that examines the sensitivity of the findings to the technology mix and highlights from a county-level analysis. An updated Research Report that adjusts the analysis for the final rulemaking will be published on the CRC website in early 2025.

SUSTAINABLE MOBILITY COMMITTEE

CARBON SOURCES FOR E-FUELS

CRC Project SM-CR-2023-1

Leaders: S. Pansare
S. McConnell
M. Traver
D. Lau

Scope and Objectives

- Task 1 CO_2 Sources: Define, identify, and quantify global CO_2 sources with potential for use as feedstock for E-fuels.
- Task 2 Supply Review: Understand the key drivers and scenarios influencing CO2 supply for E-fuel production.
- Task 3 E-fuel Production: Technology review of current and emerging E-fuel production pathways.
- Task 4 Priority CCU-enabled E-fuel Production Process Pathways: Understand how each production pathway maps to different CO2 sources.
- Task 5 Global CCU-enabled E-fuel Hubs: Define drivers for E-fuel hub locations.
- Task 6 Techno-economic Analysis: Estimate the E-fuel production costs for the E-fuel hubs.
- Task 7 Lifecycle Carbon Analysis: Quantify ranges of life cycle CO2e emissions of the short-listed pathways used to produce E-fuels.
- Task 8 E-fuel Hub Case Studies: Deep-dive into key E-fuel hub locations, demand, and how E-fuel deployment could be supported.

Current Status and Future Program

Project SM-CR-2023-1 is being conducted in partnership with the Oil and Gas Climate Initiative (OGCI). The project was awarded to Ricardo. A Final Report is expected to be published in early 2025.

LITERATURE REVIEW OF MODELS USED FOR BIOFUELS GHG EMISSIONS MODELING AND COMPARISON OF RESULTS ON SOME COMMONLY AVAILABLE FUELS

CRC Project SM-LCA-17

Leaders: R. De Kleine
X. He

Scope and Objectives

The objective of Project SM-LCA-17 would be to review various commonly used available models/approaches, identify sources of uncertainty and attempt to understand differences in results produced by these models for some common fuels and feedstocks.

This project was in the form of a literature review which contrasted and compared the features of various models in use by different organizations and highlighted model differences. It also compared results generated by these models for several fuel pathways selected to represent commonly available fuels (e.g., renewable diesels and gasolines, biodiesels, alcohols etc.) derived primarily from various agricultural feedstocks (e.g., corn, soybean, canola, rapeseed) as well as one or two pathways selected to represent fuels derived from non-agricultural feedstocks (e.g., lignocellulosic sources, used cooking oils, animal fats, etc.). The study attempted to identify and explain the sources of differences in the results.

Current Status and Future Program

Project SM-LCA-17 was performed by Trinity Consultants. The Final Report was published on the CRC website in October 2024.

SUSTAINABLE MOBILITY COMMITTEE

SUSTAINABLE MOBILITY WORKSHOPS

Leaders: H. Hamje
E. Chapman

Scope and Objectives

The 1st Sustainable Mobility Workshop was held December 13-15, 2022, hosted by the National Renewable Energy Laboratory. (NREL) in Colorado. There were 144 attendees from 16 countries, with 32 speakers over the course of the event. Supporters of the Workshop included NREL, Afton, Aramco, Deutz, the National Institute of Standards and Technology, and the Southwest Research Institute.

The Workshop featured these Sessions/Panels:

- Life Cycle Analysis
- MD/HD/Offroad/Marine
- Electrification - Policy Updates and Infrastructure
- Electrification- EV Fluids / Battery Recycling / Supply Chain
- Electrification-Battery Modeling / Durability & Safety / Security
- Novel Carbon Reduction Strategies
- Fuels

The 2nd Sustainable Mobility Workshop was a collaboration with the Society of Automotive Engineers International (SAE) and their Energy and Propulsion Conference & Exhibition in November 2023 in South Carolina. The SMC Leadership team developed the following Executive Panels for the event:

- Moving to Low Net Carbon
- Sustainability
- Propulsion Alternatives

SUSTAINABLE MOBILITY COMMITTEE

The 3rd Sustainable Mobility Workshop was a collaboration with SAE and their Energy and Propulsion Conference & Exhibition in November 2024 in Ohio. The CRC Leadership developed the following technical sessions for the event:

- Life Cycle Assessment of Electric Vehicle Charging
- Novel Carbon Reduction Opportunities in the Biomass Value Chain
- Infrastructure
- Battery and Range Characterization
- Low Carbon and Renewable Fuels to Support Carbon Reduction

Current Status and Future Program

The Life Cycle Analysis Working Group is planning their next biennial Workshop in 2025. The next technical event for the entire Sustainable Mobility Committee is anticipated to be held in 2026.

SUSTAINABLE MOBILITY COMMITTEE

CRC WORKSHOP ON LIFE CYCLE ANALYSIS OF TRANSPORTATION FUELS

CRC Project No. SM-LCAW

Leaders: R. De Kleine
D. Vu
A. Levy

Scope and Objective

CRC has hosted biennial, invitation-only Life Cycle Analysis of Transportation Fuels (LCA) Workshops, starting in 2009 at Argonne National Laboratory (ANL) near Chicago. Each workshop was attended by more than 100 LCA experts from government, industry, academia, and non-governmental organizations (NGOs). Past workshop summaries and proceedings are posted on the CRC website. The latest workshop was held October 3-5, 2023. The goals of the workshop were to:

- Outline technical needs arising out of policy actions and ability of LCA analysis to meet those needs.
- Identify data gaps, methodology issues, areas of uncertainties, validation/verification, model transparency, and data quality issues.
- Identify research results and activities that have come to light in the past two years that have helped to close data gaps previously outlined as outstanding issues.
- Establish priorities for directed research to narrow knowledge gaps and gather experts' opinions on where scarce research resources would best be spent.

The 2023 Workshop was co-sponsored by Argonne National Laboratory, Canadian Fuels Association, Clean Fuels Alliance America, Renewable Fuels Association, SCS Global Services, Union of Concerned Scientists, and the U.S. Environmental Protection Agency.

SUSTAINABLE MOBILITY COMMITTEE

Current Status and Future Program

A summary article for the 2023 LCA Workshop can be found on the CRC website. The next Workshop is being planned for October 2025, to be hosted by Argonne National Laboratory.

PART THREE

RELEASED REPORTS

2020

CRC Project No.	Title	Publication /NTIS Accession No.
AVFL-26	Future Gasoline Engine Technologies and High Octane Fuels for Reducing Fuel Consumption and GHG Emissions, Parts A & B	PENDING
AVFL-27-2	Improved Method for the Measurement of Full and Partial Heat of Vaporization of Gasoline and Ethanol/Gasoline Blends Executive Summary	PENDING
E-123	On-Road Remote Sensing of Automobile Emissions in the Chicago Area: Fall 2020	PB2021100674
E-123	On-Road Remote Sensing of Automobile Emissions in The Denver Area: Winter 2020	PB2021100675
E-123-4	Revisit Inspection and Maintenance Evaluation using Historical U.S. Remote Sensing Measurements	PENDING
E-131	Studying Capabilities and Limitations of Vehicle Telematics Data	PENDING

RELEASED REPORTS – 2023 -2024

2021

CRC Project No.	Title	Publication /NTIS Accession No.
A-120	Empirical Analysis of Historical Air Quality and Emissions Information to Develop Observationally Based Models of Ozone-VOC-NOx Relationships in Southern California	PENDING
A-123	Uncertainty in Ozone Changes from Control Strategy Implementation	PB20251 00252
A-124	Evaluation of O3 Patterns and Trends in 8 Major Metropolitan Areas in the U.S.	PENDING
AV-29-20	A Review of Current Experimental and Correlation Methods to Determine the Calorific Energy Content of Liquid Fuels	PENDING
AVFL-35	Advanced Combustion Literature Survey	PENDING
CM-138-19	Development of a Revised Engine Based Test for Determining the Effect of Spark Ignition Fuel Properties on Combustion and Vehicle Driveability	PB202510 0257

DP-07-16-01	Identification of Potential Parameters Causing Corrosion of Metallic Components in Diesel Fuel Underground Storage Tanks	PB2025100256
E-127-1	Analysis and Review of DHA Methods used in CRC Oxygenated Gasoline Emissions Projects E-94-2, E-94-3, and E-129	PENDING
RW-107-2	An Improved Index for Particulate Matter Emissions (PME)	PB2025100255
RW-115	E-15 Fuel Survey January and July 2020	PB2025100259
RW-117	On-Road Remote Sensing of Automobile Emissions in the Fresno, CA Area: Spring 2021	PB2025100261
RW-118	Re-locating the FEAT data Repository to the University of Denver Library	PB2025100260

RELEASED REPORTS – 2023 -2024

2022

CRC Project No.	Title	Publication /NTIS Accession No.
A-121-1 and 2	Measurement of Volatile Chemical Products (VCPs) in Los Angeles and Biogenic vs. Anthropogenic VOC Analysis During Peak Ozone Events in the SoCAB	PENDING
A-126	Ability of Models to Reproduce the Observed Changes in Ozone in the SoCAB due to Emissions Reductions from COVID-19	PENDING
AV-18-18	The Quality of Aviation Fuel Available in the United Kingdom – Annual Survey 2015	PENDING
AV-27-18	Measurement of Aviation Fuel Properties Relevant for the Estimation of V/L Ratio Parameter Calculation	PENDING
AVFL-29-2	Effect of Detailed Hydrocarbon Analysis (DHA) Development on Particulate Matter Index (PMI) Variability	PB202510 0262
AVFL-37	Thermal and Electrical Properties of Lubricants for HEV/EV Applications	PENDING
CM-138-20	Development of Automated Driveability Rating System Using Trick Car and User's Guide	PENDING
DP-06-20	Evaluation of Diesel Fuel Haze Resulting from Water Content	PENDING

E-119-3 HEAT	On-Road Remote Sensing of Automobile Emissions in the Phoenix Area: Spring 2021	PENDING
E-119-3 OPUS	On-Road Remote Sensing of Automobile Emissions in the Phoenix Area: Spring 2021	PENDING
E-119-3 DU	On-Road Remote Sensing of Automobile Emissions in the Phoenix Area: Spring 2021	PENDING
E-129-2	Alternative Oxygenate Effects on Emissions	PENDING
E-136	Engine, Aftertreatment, and Fuel Quality Achievements to Lower Gasoline Vehicle PM Emissions: Literature Review and Future Prospects	PENDING

2023

CRC Project No.	**Title**	**Publication /NTIS Accession No.**
A-129	Maximum Ozone Concentrations in Inland California: Contributions from Background Ozone, Urban Ozone Transport, Agriculture and Wildfires	PENDING
AV-20-20	Determination of Heat of Vaporization and Creating Enthalpy Diagrams for Several Common Jet Fuels and Aviation Gasolines	PENDING

RELEASED REPORTS – 2023 -2024

AV-24	Marathon Petroleum Troubleshooting Guide for Jet Fuel Thermal Stability	PENDING
AVFL-32	Effects of knock intensity measurement technique and fuel chemical composition on the research octane number (RON) of FACE gasolines: Part 2 – Effects of spark timing	*Fuel*, Vol. 342, June 15, 2023 https://doi.org/10.1016/j.fuel.2023.127694
AVFL-34	Detailed Compositional Comparison of Hydrogenated Vegetable Oil with Several Diesel Fuels and their Effects on Engine-out Emissions	*SAE International Journal of Fuels and Lubricants*, December, 07, 2022 https://doi.org/10.4271/04-16-03-0015
AVFL-36 / CM-137-19	Impact of MON on Engine Performance	PENDING
AVFL-39	Lube Effect on Catalyst and Gasoline Particulate Filter Aging: Literature Review	PENDING
AVFL-45	Impact of Thermal Conditioning on Battery Pack Efficiency and associated Lifetime Range and fully-burdened GHG Reduction: Literature Review	PENDING
E-119-3a	Remote Sensing Device (RSD) Statistical Analysis	PENDING

E-122-2	Light Duty PEMS Phase 2: Engine Technology and Fuel Property Investigation	PENDING
E-133	Fuel Effects on Particulate Matter Index Vapor Pressure, and Ethanol Content on Emissions	PENDING
RW-105	Roadside Measurement of Evaporative and PM Emissions	PENDING
RW-107-3a	Validation of New PMI Index Formula - Phase 2	PENDING
RW-120	Characterization of Fuel Impacts on Heavy-Duty Low Nox Engine Emissions	PENDING
SM-E-16	Charging Plaza Load Analysis and Forecast	PENDING

<u>2024</u>

CRC Project No.	Title	Publication /NTIS Accession No.
A-131	11th CRC Mobile Source Air Toxics Workshop Summary	PENDING
E-135	Tier 3 GDI Vehicle Technologies Effects on Particle Emissions Operating with Different Fuels	PENDING
E-140	Low Nox and NMOG	PENDING

RELEASED REPORTS – 2023 -2024

CM-136-20	Develop Precision Statements for Oxidation Stability Test Methods ASTM D525 and ASTM D7525 / Correlation Study Between Instruments Between Operating Range 240-1440 Minutes	PENDING
DP-04-22	Fuel Research Using the Internal Diesel Injector Deposit (IDID) Rig	PENDING
SM-1	Evaluation of the Potential for Significant GHG Emissions Reductions from ICEs Operation on Liquid Fuels	PENDING
SM-CR-9	Assess the Battery-Recharging and Hydrogen-Refueling Infrastructure Needs, Cost and Timelines Required to Support Regulatory Requirements for Light-, Medium-, and Heavy-Duty Zero-Emission Vehicles	PENDING
SM-E-18/E-142	V2X Requirements to Support the SAE J1634 Short Multi-Cycle Test and Setting Initial SOC for Plug-in Hybrid Electic Vehicles	PENDING

The primary source for CRC reports is:
National Technical Information Service, U.S. Department of Commerce 5285 Port Royal Road, Springfield, VA 22161; wwww.ntis.gov Phone: 800-553-6847; when ordering a report, be certain to include the NTIS Accession Number.

"PENDING" reports are available now on CRC website, www.crcao.org.

The 2020 - 2022 reports were completed and submitted to NTIS for an Accession Number in as listed in the 2020 - 2022 CRC Annual Reports. Due to COVID-19 related delays, the NTIS Accession numbers are still PENDING.

PART FOUR

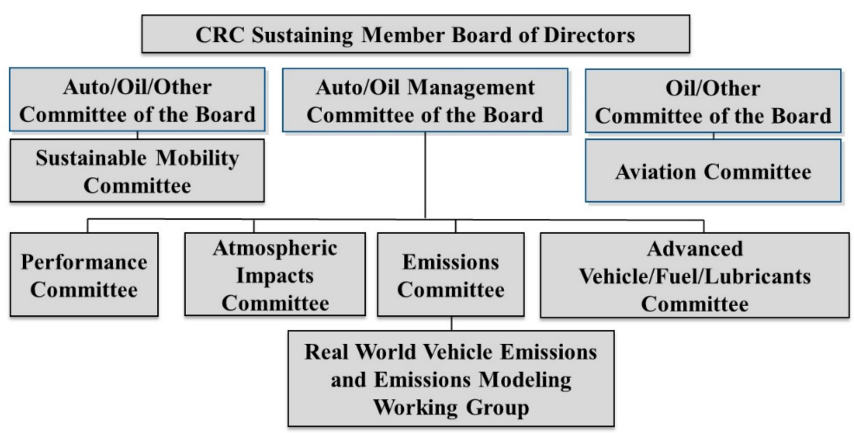
ORGANIZATION AND MEMBERSHIP

ORGANIZATION – 2023-2024

The sustaining members of the CRC are the American Petroleum Institute (API) and a consortium of automobile manufacturers (Stellantis, Mercedes Benz, Ford, General Motors, Honda, Nissan, Toyota, and Volkswagen). For nearly 80 years, CRC has provided the means for the automotive and petroleum industries to study problems of mutual interest. The objective of CRC, as stated in our Charter, is:

> To encourage and promote the arts and sciences by directing scientific cooperative research in developing the best possible combinations of fuels, lubricants, and the equipment in which they are used, and to afford means of cooperation with the Government on matters of national interest within this field.

CRC manages a range of technical projects designed to keep pace with today's rapidly-changing technology. Industry sponsors support approved projects by equal contributions from the industries directly concerned. Industry and the Government develop projects through committees comprised of their engineers and scientists.



ORGANIZATION

Technical direction in each subject area is handled by an appropriate committee that closely supervises the progress of groups under its jurisdiction. The CRC Board of Directors is responsible for general policy and operation, including providing financial support, manpower, and laboratory facilities.

The diversity of the organizations participating in the various CRC committee activities can be seen in the remainder of this section. Committees and their working groups are made up of professionals of the highest technical competence in their areas.

CRC is not involved in regulation, hardware or fuel development, nor in setting standards. CRC has only one real mandate, and that is to add to the scientific base that may be useful in technology coordination and appropriate regulation. CRC final reports are made publicly available and are used by industry to help ensure optimum compatibility and customer satisfaction with its products and by industry, government, and the public to enhance joint achievement of clean air.

CRC has two basic types of research programs:

Cooperative research programs – where scientists from various organizations come together to conduct cooperative research. This method utilizes the expertise from industry, government, and academia to develop and conduct experimental research programs. The results of these programs are made publicly available through written technical publications.

Contract research programs – where CRC conducts research by contract with independent research laboratories. Requests for Proposal are issued to leading research organizations and universities to carry out specific research programs. Committees composed of industry and government representatives design these programs. The committees evaluate the proposals, and the research is carried out under the monitorship of the committees. Reports that document the results of the study are made publicly available through written technical publications on the CRC website.

ORGANIZATION

CRC's Auto/Oil Committee of the Board of Directors oversees the cooperative research summarized in this report. Board membership is comprised of seven representatives from the petroleum industry and nine representatives from the automobile companies. Each industry has one vote on this committee, and each side must agree on matters concerning research priorities and funding before a project goes forward.

This organizational structure ensures research programs that are relevant to both industries as they change their products to comply with the provisions in the U.S. Clean Air Act Amendments or other regulations that affect the industries. Industry believes that making improvements in air quality can best be achieved through a sound understanding of the scientific issues. Industry working together with involvement from appropriate Government agencies is an effective approach to obtain technical information needed to achieve environmental and other vehicle performance goals.

MEMBERSHIP

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G. Lilik	ExxonMobil	D. Warm	Ford

E-130 PANEL

B. Just, Leader	API

E. Chapman	General Motors	S. McConnell	Marathon Petroleum Corp.
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R. Lewis	Marathon Petroleum	J. Zhu	ExxonMobil
M. McCarthy	Toyota		

MEMBERSHIP

E-134 PANEL

M. Henderson, Co-Leader	Honda
P. Loeper, Co-Leader	Chevron

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E-135 PANEL

G. Lilik, Co-Leader	ExxonMobil

E. Chapman	General Motors	M. Moore	Stellantis
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P. Loeper	Chevron		

E-137 PANEL

B. Morlan, Co-Leader	Chevron
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J. Jetter, Co-Leader	Honda

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G. Gunter	Phillips 66	M. Przybylo	Toyota
M. Henderson	Honda	J. Salyers	General Motors
B. Just	API	I. Tibavinsky	Mercedes-Benz
R. Lewis	Marathon Petroleum Corp.	J. Zhu	ExxonMobil
G. Lilik	ExxonMobil		

MEMBERSHIP

E-140 PANEL

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D. Harrison	Ford	I. Tibavinsky	Mercedes-Benz
M. Henderson	Honda	M. Yassine	Stellantis
P. Loeper	Chevron		

E-143 PANEL

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M. Moore, Co-Leader — Stellantis

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J. Jetter	Honda	C. Rabideau	Chevron
H. Kwon	Toyota	I. Tibavinsky	Mercedes-Benz
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R. Lewis	Marathon Petroleum	S. Winkler	Ford
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MEMBERSHIP

E-144 PANEL

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G. Lilik	ExxonMobil
M. Litsey	Mercedes-Benz
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I. Tibavinsky	Mercedes-Benz
M. Van Nieuwstadt	Ford
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V. Gauba	Shell	T. Teller	Volkswagen
G. Gunter	Phillips 66	I. Tibavinsky	Mercedes-Benz
M. Henderson	Honda	D. Torres	Volkswagen
J. Jetter	Honda	J. Velasco	Volkswagen
B. Just	API	A. Voice	Aramco
Y. Khan	Cummins	D. Warm	Ford
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R. Lewis	Marathon Petroleum Corp.		

34TH AND 35TH REAL WORLD EMISSIONS WORKSHOP ORGANIZING COMMITTEE

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D. Choi	EPA	H. Vreeland	EPA
Y. Khan	Cummins	R. Yatavelli	CARB
A. Kotz	NREL	S. Yoon	CARB

MEMBERSHIP

RW-121 / CM-138-22 PANEL

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A. Iqbal	Stellantis
J. Jetter	Honda
K. Johnson	Shell
R. Lewis	Marathon Petroleum Corp.
G. Lilik	ExxonMobil
B. Morlan	Chevron
V. Reilly	General Motors
I. Tibavinsky	Mercedes-Benz
A. Voice	Aramco
J. Zhu	ExxonMobil

RW-121A PANEL

P. Loeper, Co-Leader Chevron
M. Moore, Co-Leader Stellantis

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J. Eckstrom	BP
P. Geng	General Motors
L. Gremillion	Motiva
G. Gunter	Phillips 66
M. Henderson	Honda
A. Iqbal	Stellantis
J. Jetter	Honda
B. Just	API
R. Lewis	Marathon Petroleum Corp.
G. Lilik	ExxonMobil
V. Reilly	General Motors

MEMBERSHIP

E-145 PANEL

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I. Tibavinsky, Co-Leader	Mercedes-Benz

E. Chapman	General Motors
V. Gauba	Shell
G. Gunter	Phillips 66
M. Henderson	Honda
J. Jetter	Honda
B. Just	API
R. Lewis	Marathon Petroleum Corp.
G. Lilik	ExxonMobil
P. Loeper	Chevron
S. McConnell	Marathon Petroleum Corp.
M. Moore	Stellantis
M. Przybylo	Toyota
P. Searles	API
A. Voice	Aramco

MEMBERSHIP

ADVANCED VEHICLE/FUEL/LUBRICANTS COMMITTEE

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I. Tibavinsky, Co-Chair — Mercedes-Benz

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M. Henderson	Honda	B. Raney-Pablo	Ford
A. Ickes	Chevron	P. Searles	API
A. Iqbal	Stellantis	R. Sutschek	Volkswagen
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T. Jensen	Volkswagen	J. Waldman	General Motors
J. Jetter	Honda	X. Yu	Aramco

FUEL FOR ADVANCED COMBUSTION ENGINES (FACE) WORKING GROUP

S. McConnell, Co-Chair	Marathon Petroleum Corp.
I. Tibavinsky, Co-Chair	Mercedes-Benz

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A. Aradi	Shell
T. Bays	PNNL
E. Chapman	General Motors
A. Chausalkar	ExxonMobil
M. Foster	BP
R. Gieleciak	NRCAN
S. Goldsborough	ANL
G. Gunter	Phillips 66
A. Ickes	Chevron
A. Iqbal	Stellantis
B. Just	API
N. Killingsworth	LLNL
T. Klein	Nissan
R. Lewis	Marathon Petroleum Corp.
M. Przybylo	Toyota
M. Moore	Stellantis
C. Mueller	SNL
B. Raney-Pablo	Ford
M. Ratcliff	NREL
S. Sluder	ORNL
D. Splitter	ORNL
J. Waldman	General Motors
S. Wagnon	LLNL
X. Yu	Aramco

MEMBERSHIP

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H. Hahn, Co-Leader	Chevron

M. Blumenfeld	ExxonMobil	G. Parker	Lubrizol
M. Bushey	ExxonMobil	M. Raney	General Motors
M. Chiappelli	Infineum	A. Ritchie	Infineum
C. Cleveland	Afton Chemical	R. Sutschek	Volkswagen
F. Cooney	General Motors	H. Tang	Stellantis
T. Cushing	General Motors	I. Tibavinsky	Mercedes Benz
J. Evans	Infineum	J. Vilardo	Phillips 66
A. Gauer	General Motor	A. Washington	Phillips 66
G. Gunter	Phillips 66	A. Willis	Infineum
S. Halley	Lubrizol	A. Zack	General Motors
T. Kowalski	Toyota	R. Zdrodowski	Ford
S. McConnell	Marathon Petroleum Corp.	K. Zreik	General Motors

MEMBERSHIP

AVFL-29-3 PANEL

G. C. Gunter, Co-Leader	Phillips 66
V. Reilly, Co-Leader	General Motors
S. Goralski, Co-Leader	General Motors

B. Alexander	BP
J. Anderson	Ford
K. Bardwell	Total Energies
P. Broughton	Marathon Petroleum
M. Castaneda	Ecopetrol
B. Chakraborty	Paclp
E. Chapman	GM
A. Chausalkar	ExxonMobil
K. Childress	SwRI
J. Cohan	ARB
D. Crider	Windward Analytical
C. Dossett	P66
J. Dozier	GM
U. Freckmann	Shell
A. Furler-Grant	Innotech Alberta
I. Gabrel	VW
M. Garbalena	Valero
P. Geng	General Motors
A. Gujar	Thermofisher
A. Hall	NR Canda
S. Harvie	FCL
M. Henderson	Honda
S. Heppes	SGS
C. Huang	Jas
A. Iqbal	Stellantis
J. Jetter	Honda.
H. Jones	Marathon Petroleum Corp.
B. Kadulski	Gage Products
C. Kelly	Leco
A. Klinkenberger	Daimler
K. Knowles	Phillips 66
R. Lewis	Marathon Petroleum Corp.
P. Loeper	Chevron
S. McConnell	Marathon Petroleum Corp.
C. McFarland	Envantage
R. Meneghini	Separation Systems
H. Moes	DaVinci
M. Moore	Stellantis
R. Polimera	Total
A. Prefontaine	Innotech Alberta
D. Sanchez	SwRI
D. Sanchez	SwRI
F. Schröder	HCS
M. Scussel	Gage Products
S. Shutfless	HCS
H. Sola-Soto	US EPA
S. Tapp	Coryton
I. Tibavinsky	Mercedes Benz
J. Titterington	Corelab
L. Tran	Innotech Alberta
B. Tushar	Shell
A. Voice	Aramco
D. Wispinski	Vuv Analytics
N. Yee	Chevron
X. Yu	Aramco
Z. Zhong	SG

MEMBERSHIP

AVFL-32 PANEL

S. McConnell, Co-Leader — Marathon Petroleum Corp.

J. E. Anderson	Ford Motor Co.
E. M. Chapman	General Motors
D. M. DiCicco (ret.)	Ford Motor Co.
M. Foster	BP
D. Ganss	Nissan
G. C. Gunter	Phillips 66
E. Hillawi	Nissan
J. Holland	Phillips 66
M. Hussain	Phillips 66
A. Ickes	Chevron Energy Techn
S. Mabutol	Mitsubishi Mtrs R&D Am.
D. Nagashima	Honda
J. Mengwasser	Shell Global Solutions
C. S. Sluder	ORNL
R. Sutschek	Volkwagen
M. B. Viola(ret.)	General Motors
J. Wellhousen	Phillips 66

AVFL-33 PANEL

E. M. Chapman, Co-Leader — General Motors
G. C. Gunter, Co-Leader — Phillips 66

J. Anderson	Ford
C. Balki	GM
D. Boese	Infineum (ret)
A. Chausalkar	ExxonMobil
S. Halley	Lubrizol
M. Henderson	Honda
A. Ickes	Chevron
A. Iqbal	Stellantis
K. Kress	Phillips 66
P. Loeper	Chevron
M. McCarthy	Toyota
S. McConnell	Marathon Petroleum Corp.
J. Mengwasser	Shell
M. Moore	Stellantis
I. Tibavinsky	Mercedes Benz
X. Yu	Aramc

AVFL-36/ CM-137-19-1 PANEL

A. Iqbal, Co-Leader	Stellantis
S. McConnell, Co-Leader	Marathon Petroleum Corp.

B. Alexander	BP	D. H. Lax(ret.)	API
J. E. Anderson	Ford Motor Co.	T. Leone	Ford Motor Co.
A. Aradi	Shell	R. P. Lewis	Marathon Petroleum Corp.
E. M. Chapman	General Motors		
S. R. Golisz	ExxonMobil	G. K. Lilik	ExxonMobil
G. C. Gunter	Phillips 66	L. McQuinn	Ford
J. Holland	Phillips 66	P. M.Najt	General Motors
M. Hussain	Phillips 66	M. Przybylo	Toyota
A. Ickes	Chevron	B. Raney-Pablo	Ford
C. Jones(ret.)	General Motors	X. Yu	Aramco Americas

AVFL-38 PANEL

R. P. Lewis, Co-Leader	Marathon Petroleum Corp.

J. T. Bays	PNNL	S. Lehmann	PNNL
E. M. Chapman	General Motors	Z. Li	LANL
A. Chausalkar	ExxonMobil	S. McConnell	Marathon Petroleum Corp.
R. Gieleciak	CanmetENERGY	J. Moran	PNNL
S. Goralski	General Motors	L. Morrison	ExxonMobil
G. C. Gunter	Phillips 66	M. Przybylo	Toyota
W.M. Kim	ExxonMobil	M. B. Viola(ret.)	General Motors
D. H. Lax(ret.)	API		

MEMBERSHIP

AVFL-39 PANEL

A. K. Gangopadhyay(ret.), Co-Leader	Ford Motor Co.
G. C. Gunter, Co-Leader	Phillips 66

D. H. Blossfeld	General Motors
E. M. Chapman	General Motors
A. Chausalkar	ExxonMobil
M. Deegan	Ford Motor Co.
M. Henderson	Honda
A. Ickes	Chevron
R. I. Johnson	General Motors
C. Lambert	Ford Motor Co.
C. Laufer	Infineum
D. H. Lax(ret.)	API
P. Loeper	Chevron
S. McConnell	Marathon Petroleum Corp.
T. Na	General Motors
M. Patel	Chevron
C. Thomas	General Motors
A. Voice	Aramco
M. B. Viola (ret.)	General Motors
K. Zreik	General Motors
M. Zumbaugh	General Motors

AVFL-39-2 / E-139-2 PANEL

G. C. Gunter, Co-Leader	Phillips 66
N. Tyrer, Co-Leader	General Motors

R. Brezny	MECA	S. McConnell	Marathon Petroleum Corp.
E. Chapman	General Motors	C. Mui	Ford
A. Chausalkar	ExxonMobil	M. Patel	Chevron
M. Deegan	Ford	B. Raney-Pablo	Ford
H. Hahn	Chevron	A. Strzelec	USCAR
M. Henderson	Honda	C. Thomas	GM
A. Ickes	Chevron	J. Velasco	Volkswagen
J. Jetter	Honda	A. Voice	Aramco
R. Johnson	General Motors	D. Warm	Ford
A. Joshi	ClearFlame Engine Technologies	A. Washington	Philllips 66
		A. Willis	Infineum
B. Just	API	A. Willis	Infineum
S. Li	General Motors	X. Yu	Aramco
G. Lilik	ExxonMobil	K. Zreik	General Motors
P. Loeper	Chevron	M. Zumbaugh	General Motors

AVFL-40 PANEL

S. McConnell, Co-Leader	Marathon Petroleum Corp.
J. Waldman, Co-Leader	General Motors

E. M. Chapman	General Motors	A. Hoth	ANL
G. C. Gunter	Phillips 66	A. Ickes	Chevron
J. Holland	Phillips 66	R. Sinur	CFR Engines
		M. B. Viola(ret.)	General Motors

MEMBERSHIP

AVFL-44 PANEL

E. M. Chapman, Co-Leader	General Motors
S. McConnell, Co-Leader	Marathon Petroleum Corp.

C. Allen	Denso
A. Aradi	Shell
K. Baumgard	SNL
A. Chausalkar	ExxonMobil
N. Cho	John Deere
D. Dou	John Deere
F. Elias	Denso
S. Fenwick	Clean Fuels
B. Geisick	John Deere
M. Gonzalez	General Motors
M. Goto	Denso
G. Gunter	P66
S. Halley	Lubrizol
M. Henderson	Honda
S. Howell	Marc Iv
A. Ickes	Chevron
A. Klingbeil	WabTec
R. Lewis	Marathon Petroleum Corp.
P. Miles	SNL
C. Mueller	SNL
D. Nehmer	John Deere
R. Ogren	John Deere
D. Palacios	Denso
J. Pizzo	Denso
R. Proctor	SNL
M. Przybylo	Toyota
B. Raney-Pablo	Ford
T. Schoeffler	Daimler Truck
T. Shipp	Cummins
K. Siddq	US DOE
G. Singh	US DOE
K. Stork	US DOE
J. Sulaski	Denso
I. Tibavinsky	Mercedes Benz
J. Waldman	General Motors
R. Wilson	SNL
X. Yu	Aramco

AVFL-45 PANEL

V.R. Mohan, Co-Leader	Shell
I. Tibavinsky, Co-Leader	Mercedes-Benz

J. Anderson	Ford
A. Aradi	Shell
C. Brooks	Honda
E. Chapman	General Motors
A. Chausalkar	ExxonMobil
A. Ickes	Chevron
A. Iqbal	Stellantis
J. Jetter	Honda
R. Lewis	Marathon Petroleum Corp.
S. McConnell	Marathon Petroleum Corp.
M. Przybylo	Toyota
B. Raney-Pablo	Ford
D. Richardson	General Motors
P. Searles	API

MEMBERSHIP

ATMOSPHERIC IMPACTS COMMITTEE

C. Rabideau, Co-Chair	Chevron
S. Winkler, Co-Chair	Ford

E. Chapman	GM
B. Ghosh	Phillips 66
H. Hamje	ExxonMobil
K. Hamza	Toyota
B. Just	API
T. Klein	Nissan
M. Moore	Stellantis
G. Myers	Marathon Petroleum Corp.
D. Nagashima	Honda
M. Przybylo	Toyota
R. Sutschek	Volkswagen
T. Teller	Volkswagen
F. Turatti	Toyota
Z. Yan	Aramco

ATMOSPHERIC IMPACTS WORKING GROUP

C. Rabideau, Co-Chair	Chevron
S. Winkler, Co-Chair	Ford

Z. Adelman	LADCO
D. Choi	US EPA
T. French	EMA
J. Geidosch	US EPA
M. Gupta	FAA
M. Janssen	LADCO
T. Kuwayama	ARB
S. Lee	AQMD
R. Mathur	US EPA
K. Sargeant	US EPA
S. Tanrikulu	BAAQMD
T. Teller	Volkswagen
Z. Yan	Aramco
C. Yanca	US EPA
J. Zietsman	TAMU

A-114/RW-111 PANEL

M. E. Moore, Co-Leader — Stellantis

J. Geidosch	US EPA	G. F. Myers	Marathon Petroleum Corp.
M. Hays	US EPA	R. Purushothaman	Caterpillar
T. Kuwayama	CARB	M. R. Smith	Navistar
P. Loeper	Chevron	D. Vu	Marthon Petroleum Corp
B. Murphy	US EPA		

A-125 PANEL

C. Rabideau, Co-Chair — Chevron
B. Ghosh, Co-Chair — Phillips 66

T. A. French	EMA	E. Praske	SCAQMD
M. Janssen	LADCO	S. Winkler	Ford
T. Kuwayama	CARB	D. Vu	Marathon Petroleum Corp.
D. H. Lax(ret.)	API		

MEMBERSHIP

A-128 PANEL

B. Ghosh, Co-Chair	Phillips 66
G.F. Myers, Co-Chair	Marathon Petroleum Corp.

T. A. French	EMA	T. Kuwayama	CARB
H. Hamje	ExxonMobil	C. Rabideau	Chevron
M. Janssen	LADCO	S. Winkler	Ford

.

A-129 PANEL

C. Rabideau, Co-Chair	Chevron
S. Winkler, Co-Chair	Ford Motor Co.

K. Hamza	Toyota	M. E. Moore	Stellantis
H. D. Hamje	ExxonMobil		

MEMBERSHIP

A-132 PANEL

B. Ghosh, Co-Chair	Phillips 66
S. Winkler, Co-Chair	Ford

E. M. Chapman	General Motors	M. Przybylo	Toyota
T. Kuwayama	CARB	C. Rabideau	Chevron
G. F. Myers	Marathon Petroleum Corp.		

A-133 PANEL

E. M. Chapman, Co-Chair	General Motors
G.F. Myers, Co-Chair	Marathon Petroleum Corp.
C. Rabideau, Co-Chair	Chevron

T. French	EMA	M. Janssen	LADCO
B. Ghosh	P66	T. Kuwayama	ARB
K. Hamza	Toyota	S. Lee	AQMD

A-135 PANEL

G.F. Myers, Co-Chair	Marathon Petroleum Co.
S. Winkler, Co-Chair	Ford

E. Chapman	GM	B. Just	API
B. Ghosh	P66	C. Rabideau	Chevron
K. Hamza	Toyota	Z. Yan	Aramco
M. Janssen	LADCO		

MEMBERSHIP

A-136 PANEL

C. Rabideau, Co-Chair	Chevron
S. Winkler, Co-Chair	Ford

T. French	EMA	M. Janssen	LADCO
B. Ghosh	Phillips 66	B. Koo	BAAQMD
K. Hamza	Toyota		

PERFORMANCE COMMITTEE

A. Iqbal, Co-Chair	Stellantis (2023)
R.P. Lewis, Co-Chair	Marathon Petroleum Corp.
B. Raney-Pablo, Co-Chair	Ford

B. Alexander	BP
S. Broughton	Marathon
E. Chapman	GM
T. D'Ambrosi	Volkswagen
J. Eckstrom	BP
D. Ganss	Nissan
E. Glass	Volkswagen
L. Gremillion	Motiva
G. Gunter	Phillips 66
J. Jetter	Honda
K. Johnson	Shell
B. Just	API
T. Klein	Nissan
S. Lopes	General Motors
M. McCarthy	Toyota
M. Moore	Stellantis
D. Nagashima	Honda
M. Przybylo	Toyota
V. Reilly	GM
S. Rubin-Pitel	ExxonMobil
P. Searles	API
M. Sheehan	Chevron
R. Sutschek	Volkswagen
T. Teller	Volkswagen
I. Tibavinsky	Mercedes Benz
Y. Xu	ExxonMobil
X. Yu	Aramco

MEMBERSHIP

GASOLINE DEPOSIT GROUP
(Project No. CM-136)

M. Sheehan, Co-Leader	Chevron
I. Tibavinsky, Co-Leader	Mercedes Benz

B. Alexander	BP	M. Miller	Sunoco
S. Broughton	Marathon	K. Mitchell	Consultant
K. Brunner	SwRI	F. Parsinejad	Chevron
R. Chapman	Fuel Quality Consultants	M. Przybylo	Toyota
J. Draper	Motiva	B. Raney-Pablo	Ford
I. Gabrel	HCS Group	D. Schoppe	Intertek
G. Gunter	Phillips 66	P. Searles	API
K. Johnson	Shell	J. Simnick	Simnick Consulting LLC
A. Kulinowski	Afton Chemical	K. Tan	ITW Professional Automotive Products
R. Lewis	Marathon Petroleum Corp.	Y. Xu	ExxonMobil
I. Mather	Haltermann	H. Zhao	Huntsman
A. McKnight	Innospec		

GASOLINE DEPOSIT PFI IVD ENGINE TEST WORKSTREAM
(Project No. CM-136-18-1)

B. Alexander, Co-Leader	BP
M. Sheehan, Co-Leader	Chevron

J. Ciaravino	GM	B. Raney-Pablo	Ford
K. Johnson	Shell	A. Rohlfing	Afton Chemical
J. Karwowski	BASF	D. Schoppe	Intertek
A. Kulinowski	Afton Chemical	G. Szappanos	Lubrizol
R. Lewis	Marathon	I. Tibavinsky	Mercedes Benz
S. Nair	BASF	Y. Xu	ExxonMobil

MEMBERSHIP

FUEL DEGRADATION IN STORAGE (ASTM D525 vs D7525)
(Project No. CM-136-20 PANEL)

J. C. Eckstrom, Co-Leader	BP
E. English, Co-Leader	FQS, Inc.
R. Lewis	Marathon Petroleum Corp.

B. Alexander	BP	S. Rubin-Pitel	ExxonMobil
G. Gunter	Phillips 66	M. Sheehan	Chevron
A. Iqbal	Stellantis	J. Simnick	Simnick Consulting LLC
B. Just	API	I. Tibavinsky	Mercedes Benz
M. Moore	Stellantis	Y. Xu	ExxonMobil
B. Raney-Pablo	Ford		

MEMBERSHIP

GASOLINE COMBUSTION GROUP
(Project No. CM-137)

B. Raney Pablo, Co-Leader	Ford Motor Co.
B. Alexander, Co-Leader	BP

T. Briggs	SwRI
S. Broughton	Marathon
K. Brunner	SwRI
R. Chapman	Fuel Quality Consultants
I. Gabrel	HCS Group
R. George	BP
L. Gremillion	Motiva
G. Gunter	Phillips 66
C. Hamer	PCS Instruments
A. Iqbal	Stellantis
F. Khan	Nissan
R. Lewis	Marathon Petroleum Corp.
A. McKnight	Innospec
J. Mengwasser	Shell
M. Miller	Sunoco
K. Mitchell	Consultant
P. Morgan	SwRI
M. Przybylo	Toyota
V. Reilly	General Motors
S. Rubin-Pitel	ExxonMobil
D. Schoppe	Intertek
M. Sheehan	Chevron
J. Simnick	Simnick Consulting LLC
A. Swarts	SwRI
K. Tan	ITW Professional Automotive Products
Y. Xu	ExxonMobil
X. Yu	Aramco

ALTERNATIVE TO TEL
Project No. CM-137-21 PANEL

B. Raney-Pablo, Co-Leader	Ford Motor Co.
S. Rubin-Pitel, Co-Leader	ExxonMobil

D. Atwood	FAA	M. Jordan	PBF Energy
G. Bell-Eunice	Phillips 66	D. Kadlecek	Exxon Mobil
J. Bizub	Consultant	R. Legg	SwRI
L. Campbell	Marathon Petroleum Corp.	R. Lewis	Marathon Petroleum Corp.
A. Clark	BP	E. Lodrigueza	Phillips 66
D. Faedo	Camcom	B. Logan	Phillips 66
R. Gaughan	Consultant	R. Manchiraju	CFR Engines
R. Gill	Energy Institute	M. Renz	Dixie Services
G. Gunter	Phillips 66	M. Rumizen	FAA
D. Hogan	Consultant	R. Terschek	ROFA
J. Holland	Phillips 66		

MEMBERSHIP

VOLATILITY GROUP
(Project No. CM-138)

D. Kovach	BP
A. Iqbal	Stellantis

S. Broughton	Marathon Petroleum Corp.
K. Brunner	SwRI
K. Davis	RFA
J. Draper	Motiva
I. Gabrel	HCS Group
L. Gremillion	Motiva
G. Gunter	Phillips 66
F. Khan	Nissan
R. Lewis	Marathon Petroleum Corp.
K. Mitchell	Consultant
M. Przybylo	Toyota
B. Raney-Pablo	Ford
S. Rubin-Pitel	ExxonMobil
D. Schoppe	Intertek
P. Searles	API
M. Sheehan	Chevron
J. Simnick	Simnick Consulting LLC

DIESEL PERFORMANCE GROUP
(Project No. DP)

G. C. Gunter, Co-Leader	Phillips 66
S. Lopes, Co-Leader	General Motors

H. Ahari	Stellantis
B. Alexander	BP
T. Bera	Shell
S. Broughton	Marathon Petroleum Corp.
A. Cayabyab	CARB
R. Chapman	Fuel Quality Consultants
J. Draper	Motiva
E. English	FQS
I. Gabrel	HCS Group
R. George	BP
B. Goodrich	B. E. Goodrich Consulting
C. Hamer	PCS Instruments
D. Hess	Consultant
R. Jennings	Consultant
K. Johnson	Shell
I. Johnson	Daimler Truck
F. Khan	Nissan
J. Klopfenstein	Cummins
D. Kozub	Daimler
A. Kulinowski	Afton Chemical
R. Leisenring	Consultant
R. Lewis	Marathon Petroleum Corp.
R. Long	PEI
R. McCormick	NREL
K. Mitchell	Consultant
A. Morin	VeryOne
J. Morris	Navistar
N. Mukkada	Chevron
S. Nair	BASF
J. Porco	Gage Products
M. Przybylo	Toyota
B. Raney-Pablo	Ford
S. Rubin-Pitel	ExxonMobil
K. Salem	Lubrizol
D. Schoppe	Intertek
P. Searles	API
M. Seuberling	Daimler Truck
M. Sheehan	Chevron
J. Simnick	Simnick Consulting LLC
J. Stolis	Flint Hills Resources
A. Swarts	SwRI
K. Tan	ITW Professional Automotive Products
V. Tran	Infineum
J. VanScoyoc	CP Chem

MEMBERSHIP

DP - LOW TEMPERATURE OPERABILITY PANEL
(Project No. DP-02)

S. Broughton, Leader — Marathon Petroleum Corp.

A. Belly	Innospec	R. Lewis	Marathon Petroleum Corp.
J. Chandler	Consultant	S. Lopes	General Motors
E. English	Consultant	K. Mitchell	Consultant
S. Golisz	Innospec	N. Mukkada	Chevron
G. Gunter	Phillips 66	S. Rubin-Pitel	ExxonMobil
D. Hess	Consultant	K. Salem	Lubrizol
C. Hodge	Consultant	P. Searles	API
R. Jennings	Consultant	V. Tran	Infineum
A. Kulinowski	Afton Chemical		

DP – IDID DEPOSIT PANEL
(Project No. DP-04-22)

G. C. Gunter, Leader — Phillips 66

J. Anderson	PACCAR	R. Lewis	Marathon Petroleum Corp.
S. Broughton	Marathon Petroleum Corp.	S. Lopes	General Motors
E. English	FQS	K. Salem	Lubrizol
G. Gunter	Phillips 66	J. VanScoyoc	CP Chem
R. Jennings	Consultant	J. Ward	Intertek
J. Klopfenstein	Cummins	Y. Xu	ExxonMobil
A. Kulinowski	Afton Chemical		

MEMBERSHIP

DP – FUEL CLEANLINESS PANEL
(Project No. DP-06)

G. C. Gunter, Leader — Phillips 66
S. Lopes, Leader — General Motors

S. Broughton	Marathon Petroleum Corp.
C. Burbank	Cummins
R. Chapman	Fuel Quality Consultants
J. Eichberger	Fuels Institute
E. English	FQS
S. Fenwick	Clean Fuels
R. Haerer	US EPA
J. Hove	Fuels Institute
R. Leisenring	Consultant
R. Lewis	Marathon Petroleum Corp.
R. Morgan	Choice Analytical
N. Mukkada	Chevron
F. Passman	BCA
S. Pollock	Steel Tank
S. Rubin-Pitel	ExxonMobil
K. Salem	Lubrizol
P. Searles	API

MEMBERSHIP

DP – FUEL CORROSION PANEL
(PROJECT NO. DP-07)

B. Just, Leader API

T. Bera	Shell
P. Beu	Wawa
S. Broughton	Marathon Petroleum Corp.
J. Eckstrom	BP
J. Eichberger	Fuels Institute
E. English	FQS
S. Fenwick	Clean Fuels
G. Gunter	Phillips 66
R. Haerer	US EPA
S. Hernandez	Chevron
J. Hove	Fuels Institute
M. Kass	ORNL
R. Lewis	Marathon Petroleum Corp.
R. Long	PEI
R. McNutt	Sigma
K. Moriaty	NREL
N. Mukkada	Chevron
F. Passman	BCA
S. Pollock	Steel Tank
B. Raney-Pablo	Ford
B. Renkes	Fiberglass Tank and Pipe
S. Ryzyi	Ford
P. Searles	API

MEMBERSHIP

DP – BIODIESEL AND RENEWABLE DIESEL PANEL
(Project No. DP-05)

R.Jennings, Leader	Consultant
S. Lopes, Leader	General Motors
G. Gunter, Leader	Phillips 66

B. Alexander	BP
T. Bera	Shell
F. Bradley	Counsulant
S. Broughton	Marathon Petroleum Corp.
J. Eckstrom	BP
E. English	FQS
S. Fenwick	Clean Fuels
J. Franklin	Intertek
I. Gabrel	HCS Group
B. Goodrich	B. E. Goodrich Consulting
A. Iqbal	Stellantis
B. Just	API
J. Klopfenstein	Cummins
A. Kulinowski	Afton Chemical
M. Leuck	Neste
R. Lewis	Marathon Petroleum Corp.
R. McCormick	NREL
J. Morris	Navistar
N. Mukkada	Chevron
B. Raney-Pablo	Ford
K. Salem	Lubrizol
R. Sutschek	Volkswagen
I. Tibavinsky	Mercedes Benz
V. Tran	Infineum
J. Vega	Intertek

MEMBERSHIP

AVIATION FUELS COMMITTEE
STEERING COMMITTEE

A. Carico, Chair	Airlines for America
Z. West	UDRI

G. Andac	GE Aerospace
D. Atwood	FAA
D. Baniszewski	DLA Energy
J. Bauldreay	Bauldreay Jet Fuel Consulting Ltd
J. Belieres	Boeing
G. Benner	Facet Filtration
H. Bennis	Shell
J. Burgazli	Innospec
T. Capil	NASA
A. Carico	Airlines for America
A. Clark	BP
E. Corporan	US Air Force
B. Culbertson	Honeywell
D. Cyr	Chevron
C. Doucet	Air TOTAL
J. Doyle	FAA
P. Eversley	Shell Aviation
J. Gammon	Gammon Tech
T. Gleaves	Defence Strategic Fuels Authority
J. Green	CITGO
A. Hobday	Rolls-Royce
M. Hunnybun	Energy Institute
B. Just	API
D. Kadlecek	ExxonMobil
R. Kamin	US Navy
J. Klettlinger	NASA
I. Kosilkin	Boeing
E. Lodrigueza	Phillips 66
T. Loegel	US Navy
A. McDaniel	Pratt & Whitney
T. Owen	FAA
D. Parmenter	AirBus
J. Sheridan	Marathon Petroleum Corp.
J. Silvas	CITGO
J. Stolis	Flint Hills Resources
M. Thom	Baere Aerospace
B. Urban	Marathon Petroleum Corp.
Z. West	UDRI
P. Wilkins	DLA Energy
P. Wrzesinski	FAA Technical Center

SUSTAINABLE MOBILITY COMMITTEE (SMC)

E. Chapman, Co-Leader	General Motors
H. Hamje, Co-Leader	ExxonMobil

T. Alger	UL
M. Al-Hudrasi	Stellantis
J. Anderson	Ford
T. Auvil	EPRI
A. Behr	UL
R. Bennick	BP
J. Bouchard	Aramco
V. Bradley	Clean Fuels Alliance America
M. Bradley	Volkswagen
R. Brezny	MECA
C. Brooks	Honda
S. Chhaya	EPRI
G. Conway	Southwest Research Institute
R. De Kleine	Ford
S. Decarteret	General Motors
S. Fenwick	Clean Fuels Alliance America
T. French	EMA
B. Frick	Volkswagen
M. Geller	MECA
X. He	Aramco
M. Henderson	Honda
S. Hines	Southwest Research Institute
S. Hotz	Southwest Research Institute
S. Howell	Clean Fuels Alliance America
A. Iqbal	Stellantis
J. Jetter	Honda
B. Just	API
T. Klein	Nissan
J. Klopfenstein	Cummins
T. Leone	Southwest Research Institute
M. Leuck	Neste
S. Lopes	General Motors
A. Lubawy	Toyota
M. McCarthy	Toyota
S. McConnell	Marathon Petroleum Corp.
M. Moore	Stellantis
J. Northrup	Marathon Petroleum Corp.
S. Panova	EPRI
S. Pansare	Phillips 66
M. Przybylo	Toyota
V. Raj Mohan	Shell
R. Sallinen	Neste
B. Schmidt	John Deere
P. Searles	API
M. Seuberling	Daimler Truck
M. Sheehan	Chevron
B. Sobecki	Daimler Truck
I. Tibavinsky	Mercedes Benz
M. Traver	Aramco
A. Triana-Padilla	Wabtec
C. Trobaugh	Cummins
D. Vuilleumier	Chevron
C. Wallner	Mercedes Benz
E. Wiens	Deutz
S. Winkler	Ford
M. Yassine	Stellantis

MEMBERSHIP

FALL 2024 SMC/SAE WORKSHOP ORGANIZING COMMITTEE

C. Brooks	Honda	S. McConnell	Marathon Petroleum Corp.
E. Chapman	General Motors	M. Moore	Stellantis
R. De Kleine	Ford	M. Przybylo	Toyota
B. Fayyaz-Najafi	Chevron	I. Tibavinsky	Mercedes Benz
T. French	EMA	M. Traver	Aramco
H. Hamje	ExxonMobil		
T. Klein	Nissan		

SM-1 PANEL

H. Hamje, Co-Leader	ExxonMobil
R. De Kleine, Co-Leader	Ford

P. Aquino	Honda	T. Leone	Southwest Research Institute
R. Bennick	BP	S. McConnell	Marathon Petroleum Corp.
J. Bouchard	Aramco	M. Moore	Stellantis
M. Bradley	Volkwagen	S. Pansare	Phillips 66
C. Brooks	Honda	M. Przybylo	Toyota
E. Chapman	General Motors	V. Raj Mohan	Shell
J. Ciaravino	General Motors	P. Searles	API
D. Cleary	Aramco	M. Sheehan	Chevron
T. French	EMA	I. Sutherland	General Motors
M. Geller	MECA	I. Tibavinsky	Mercedes Benz
P. Geng	General Motors	M. Traver	Aramco
A. Iqbal	Stellantis	A. Voice	Aramco
J. Jetter	Honda	C. Wallner	Mercedes Benz
J. Klopfenstein	Cummins		
T. Leone	SwRI		

MEMBERSHIP

SUSTAINABLE MOBILITY COMMITTEE (SM-HCR)
HYDROGEN AND CARBON REDUCTION WORKING GROUP

S. M. McConnell, Co-Leader	Marathon Petroleum
M. Traver, Co-Leader	Aramco Americas
T. Klein, Co-Leader	Nissan
A. Lubawy, Co-Leader	Toyota

J. Anderson	Ford
A. Behr	UL
M. Boloor	Toyota Research Institute
V. Bradley	Clean Fuels Alliance America
M. Bradley	Volkswagen
R. Brezny	MECA
C. Brooks	Honda
E. Chapman	General Motors
C. Daniel	BP
T. French	EMA
M. Geller	MECA
H. Hamje	ExxonMobil
B. Kanach	ExxonMobil
S. Lopes	General Motors
M. Moore	Stellantis
S. Pansare	Phillips 66
M. Przybylo	Toyota
V. Raj Mohan	Shell
R. Sari	Aramco
P. Searles	API
M. Sheehan	Chevron
I. Tibavinsky	Mercedes Benz

MEMBERSHIP

SM-CR-9 PANEL

T. French, Co-Leader	EMA
A. Lubawy, Co-Leader	Toyota
Melissa Przybylo, Co-Leader	Toyota
H. Hamje, Co-Leader	ExxonMobil

J. Anderson	Ford	S. Lopes	General Motors
M. Boloor	Toyota Research Institute	S. McConnell	Marathon Petroleum Corp.
C. Brooks	Honda	V. Raj Mohan	Shell
E. Chapman	General Motors	R. Sari	Aramco
M. Geller	MECA	P. Searles	API
K. George	Marathon Petroleum Corp.	I. Tibavinsky	Mercedes Benz
		M. Traver	Aramco
B. Kanach	ExxonMobil	E. Wood	National Renewable Energy Laboratory
D. Kieffer	EMA		

SM-CR-2023-01 PANEL

M. Traver, Co-Leader	Aramco
S. McConnell, Co-Leader	Marathon Petroleum Corp.
S. Pansare, Co-Leader	Phillips 66
T. Klein, Co-Leader	Nissan
D. Lau, Co-Leader	OGCI

M. Boloor	Toyota Research Institute	S. McConnell	Marathon Petroleum Corp.
M. Bradley	Volkswagen	M. Moore	Stellantis
V. Bradley	Clean Fuels Alliance America	S. Pansare	Phillips 66
		M. Przybylo	Toyota
E. Chapman	General Motors	I. Tibavinsky	Mercedes Benz
B. Frick	Volkswagen	M. Traver	Aramco
T. Klein	Nissan	D. Vuilleumier	Chevron
L. Mahoney	Toyota Research Institute		

MEMBERSHIP

SUSTAINABLE MOBILITY COMMITTEE (SM-E)
ELECTRIFICAITON WORKING GROUP

C. Brooks, Co-Leader	Honda R&D Am.
E. Chapman, Co-Leader	General Motors
I. Tibavinsky, Co-Leader	Mercedes Benz
M. Przybylo, Co-Leader	Toyota

T. Alger	UL
J. Anderson	Ford
A. Bansod	Daimler Truck
M. Boloor	Toyota
M. Bradley	Volkswagen
C. Brooks	Honda
E. Chapman	General Motors
D. Cun	Honda
T. French	EMA
T. Garrick	General Motors
K. George	Marathon Petroleum Corp.
H. Hamje	ExxonMobil
B. Hartmann	Ford
X. He	Aramco
A. Iqbal	Stellantis
J. Jetter	Honda
B. Kanach	ExxonMobil
H. Kindl	Ford
T. Klein	Nissan
C. Klein	Marathon Petroleum Corp.
S. Lopes	General Motors
A. Lubawy	Toyota
S. McConnell	Marathon Petroleum Corp.
S. Panainte	Mercedes Benz
S. Pansare	Phillips 66
M. Przybylo	Toyota
V. Raj Mohan	Shell
P. Searles	API
M. Sheehan	Chevron
I. Tibavinsky	Mercedes Benz
S. Vedula	Daimler Truck
S. Vijayaraghavan	Daimler Truck
C. Wallner	Mercedes Benz
A. Warm	Ford

MEMBERSHIP

SM-E-16 PANEL

E. Chapman, Co-Leader	General Motors
I. Tibavinsky, Co-Leader	Mercedes Benz
V. Raj-Mohan, Co-Leader	Shell

J. Anderson	Ford
M. Bradley	Volkswagen
C. Brooks	Honda
D. Cun	Honda
X. He	Aramco
K. Kar	ExxonMobil
S. McConnell	Marathon Petroleum Corp.
S. Pansare	Phillips 66
M. Przybylo	Toyota

SM-E-4/8 PANEL

E. Chapman, Co-Leader	General Motors
C. Brooks, Co-Leader	Honda
V. Raj-Mohan, Co-Leader	Shell

J. Anderson	Ford
M. Bradley	Volkswagen
T. Garrick	General Motors
B. Hartmann	Ford
J. Jetter	Honda
K. Kar	ExxonMobil
H. Kindl	Ford
S. Lopes	General Motors
A. Lubawy	Toyota
S. McConnell	Marathon Petroleum Corp.
M. Moore	Stellantis
M. Przybylo	Toyota
P. Searles	API
E. Temeche	Mercedes Benz
I. Tibavinsky	Mercedes Benz
C. Wallner	Mercedes Benz
A. Warm	Ford
J. Wuttke	Stellantis
A. Zettel	General Motors

MEMBERSHIP

SM-E-18 / E-142 PANEL

E. Chapman, Co-Leader	General Motors
S. Decarteret, Co-Leader	General Motors
M. Yassine, Co-Leader	Stellantis
M. Al-Hadrasi, Co-Leader	Stellantis
M. Duoba, Co-Leader	Argonne National Laboratory
S. McConnell, Co-Leader	Marathon Petroleum Corp.
M. Henderson, Co-Leader	Honda
C. Brooks, Co-Leader	Honda

V. Barragan	General Motors
M. Bradley	Volkswagen
J. Brown	US EPA
T. D'Ambrosi	Volkswagen
J. Eckstrom	BP
C. Fox	General Motors
G. Gunter	Phillips 66
R. Hart	CARB
A. Hawe	Ford
R. Haya	Nissan
T. Kamijo	Nissan
T. Klein	Nissan
T. Korhumel	Toyota
N. Kothari	General Motors
H. Le	CARB
R. Lewis	Marathon Petroleum Corp.
P. Loeper	Chevron
S. Lopes	General Motors
Y. Ma	CARB
G. Mikailian	CARB
M. Przybylo	Toyota
M. Ralya	Toyota
E. Schauer	EPA
B. Schmidt	John Deere
L. Seiter	Ford
I. Tibavinsky	Mercedes Benz
C. Wallner	Mercedes Benz
M. Yassine	Stellantis
A. Zettel	General Motors

MEMBERSHIP

SM-E-20 PANEL

M. Przybylo, Co-Leader	Toyota
X. He, Co-Leader	Aramco

A. Behr	UL	T. Klein	Nissan
M. Boloor	Toyota	A. Lubawy	Toyota
M. Bradley	Volkswagen	M. Machala	Toyota
C. Brooks	Honda	V. Raj Mohan	Shell
E. Chapman	General Motors	B. Schmidt	John Deere
R. De Kleine	Ford	I. Tibavinsky	Mercedes Benz
B. Frick	Volkswagen	D. Vu	Marathon Petroleum Corp.
K. Hamza	Toyota		
K. Kar	ExxonMobil	C. Wallner	Mercedes Ben

MEMBERSHIP

SUSTAINABLE MOBILITY COMMITTEE (SM-F) FUELS WORKING GROUP

M. Moore, Co-Leader	Stellantis
S. McConnell, Co-Leader	Marathon Petroleum Corp.

T. Alger	UL
J. Anderson	Ford
A. Aradi	Shell
R. Bennick	BP
S. Berry	EMA
M. Bradley	Volkswagen
V. Bradley	Clean Fuels Alliance America
R. Brezny	MECA
E. Chapman	General Motors
S. Fenwick	Clean Fuels Alliance America
M. Geller	MECA
H. Hamje	ExxonMobil
S. Howell	Clean Fuels Alliance America
J. Jetter	Honda
B. Kanach	ExxonMobil
T. Klein	Nissan
J. Klopfenstein	Cummins
S. Lopes	General Motors
A. Lubawy	Toyota
S. McConnell	Marathon Petroleum Corp.
M. Moore	Stellantis
S. Pansare	Phillips 66
Y. Pei	Aramco
M. Przybylo	Toyota
V. Raj Mohan	Shell
B. Raney-Pablo	Ford
R. Sari	Aramco
P. Searles	API
M. Seuberling	Daimler Truck
M. Sheehan	Chevron
B. Sobecki	Daimler Truck
I. Tibavinsky	Mercedes Benz
M. Traver	Aramco
D. Vuilleumier	Chevron

MEMBERSHIP

SM-F-2 / A-134 PANEL

J. Anderson, Co-Leader	Ford
S. Winkler, Co-Leader	Ford
H. Hamje, Co-Leader	ExxonMobil

B. Alexander	BP
R. Bennick	BP
M. Bradley	Volkswagen
R. Brezny	MECA
E. Chapman	General Motors
M. Geller	MECA
K. Hamza	Toyota
X. He	Aramco
J. Jetter	Honda
B. Kanach	ExxonMobil
J. Ketterer	General Motors
T. Klein	Nissan
J. Klopfenstein	Cummins
A. Lubawy	Toyota
S. McConnell	Marathon Petroleum Corp.
M. Moore	Stellantis
G. Myers	Marathon Petroleum Corp.
S. Pansare	Phillips 66
Y. Pei	Aramco
M. Przybylo	Toyota
C. Rabideau	Chevron
V. Raj Mohan	Shell
B. Raney-Pablo	Ford
R. Sari	Aramco
P. Searles	API
M. Sheehan	Chevron
I. Tibavinsky	Mercedes Benz
M. Traver	Aramco
Z. Yan	Aramco

MEMBERSHIP

SM-F-5 PANEL

J. Anderson, Co-Leader	Ford
S. Winkler, Co-Leader	Ford
H. Hamje, Co-Leader	ExxonMobil

R. Bennick	BP
S. Berry	EMA
R. Brezny	MECA
E. Chapman	General Motors
C. Daniel	BP
S. Fenwick	Clean Fuels Alliance America
S. Goralski	General Motors
H. Hamje	ExxonMobil
J. Jetter	Honda
K. Johnson	Shell
B. Just	API
B. Kanach	ExxonMobil
J. Klopfenstein	Cummins
T. Leone	Southwest Research Institute
S. Lopes	General Motors
A. Lubawy	Toyota
S. McConnell	Marathon Petroleum Corp.
R. McCormick	National Renewable Energy Laboratory
M. Moore	Stellantis
S. Pansare	Phillips66
Y. Pei	Aramco
M. Przybylo	Toyota
B. Raney-Pablo	Ford
P. Searles	API
M. Seuberling	Daimler Truck
M. Sheehan	Chevron
B. Sobecki	Daimler Truck
I. Tibavinsky	Mercedes Benz
M. Traver	Aramco
D. Vuilleumier	Chevron

MEMBERSHIP

SUSTAINABLE MOBILITY COMMITTEE (SM-LCA)
LIFE CYCLE ANALYSIS WORKING GROUP

D. Vu, Co-Leader	Marathon Petroleum Corp.
R. De Kleine, Co-Leader	Ford Motor Co.

A. Behr	UL
M. Boloor	Toyota
J. Bouchard	Aramco
M. Bradley	Volkswagen
V. Bradley	Clean Fuels Alliance America
E. Chapman	General Motors
G. Conway	Southwest Research Institute
J. Cook	BP
R. De Kleine	Ford
M. Fulton	FedEx
X. He	Aramco
X. He	Phillips 66
A. Iqbal	Stellantis
K. Johnson	Shell
C. Kim	Ford
T. Klein	Nissan
S. Kuusisto	Neste
T. Leone	SwRI
A. Levy	Environmental Protection Agency
S. Lopes	General Motors
A. Lubawy	Toyota
A. Mabutol	Mitsubishi
M. Moore	Stellantis
S. Pansare	Phillips 66
P. Searles	API
L. Sotomayor	ExxonMobil
I. Tibavinsky	Mercedes Benz
D. Vu	Marathon Petroleum Corp.
D. Vuilleumier	Chevron
A. Zack	General Motors

MEMBERSHIP

LCA WORKSHOP ORGANIZING COMMITTEE

D. Vu, Co-Leader	Marathon Petroleum Corp.
R. De Kleine, Co-Leader	Ford

H. Alve	Neste
A. Baily	DOE-BETO
A. Behr	UL
V. Bradley	Clean Fuels Alliance America
C. Brooks	Honda
S. Curran	ORNL
S. Eskandarifar	RNCanada
X. He	Phillips 66
B. Heard	National Acadmies of Science
T. Hepner	RFA
S. Herman	Cargill
M. Herman	Iowa Soybean Association
K. Johnson	Shell
M. Langholtz	ORNL
A. Levy	Environmental Protection Agency
J. Martin	Union of Concerned Scientists
C. Murphy	UC Davis
D. O'Grady	Canadian Fuels
S. Ohrel	EPA
A. Oldani	FAA
A. Prabhu	CARB
S. Richman	RFA
C. Scown	UC Berkeley, Lawrence Berkeley National Lab
G. Seber Olcay	ICCT
L. Sotomayor	ExxonMobil
A. Strzelec	USCAR
M. Wang	ANL

SM-LCA-17 PANEL

X. He, Co-Leader	Phillips 66
R. De Kleine, Co-Leader	Ford

A. Behr	UL
V. Bradley	Clean Fuels Alliance America
M. Fulton	FedEx
X. He	Phillips 66
K. Johnson	Shell
T. Leone	SwRI
S. Lopes	General Motors
M. Moore	Stellantis
P. Searles	API
L. Sotomayor	ExxonMobil
D. Vu	Marathon Petroleum Corp.
D. Vuilleumier	Chevron
A. Zack	General Motors