Response to Mark Jacobson E85 Study [1]

Mark Jacobson of Stanford University has recently published his analysis of E85, which purports to show that E85 blends will increase ozone-related deaths. There are several major problems with his analysis.

Summary of Issues

- Conflicts with: analysis conducted by U.S. EPA, the California Air Resources Board (ARB), the National Renewable Energy Lab (NREL) and the South Coast Air Quality Management District (SCAQMD).
- Scenario Tested Not Real World: Assumes that E85 will completely replace gasoline as the predominant motor fuel by 2020. While perhaps an interesting and important scenario to run, it is misleading to imply that more people will perish from this one scenario. Also claims to accurately predict highly uncertain air quality scenarios in an incredibly expanded timeline (2020).
- Controversial Core Assumptions: Depends on several core assumptions that are not well-supported in the air quality control community, including: (1) less ozone forming pollution will *increase* ozone; (2) E85 reduces vehicle NOx emissions by 30 percent; and, (3) vehicles and fuels will not become more advanced in the next 13 years.
- Ignores Critical Data: Fails to consider: (1) the role of E85 in reducing evaporative hydrocarbon emissions; (2) recent critical updates to emissions inventories from ARB and other agencies.
- Misrepresents Role of Acetaldehydes: Assumes acetaldehyde emissions will lead to an increase in PAN emissions, which will thereby lead to greater ozone levels. This assumption directly conflicts with California Air Resources Board data and real world experiences in Brazil.
- Suspect Toxics Analysis: While his modeling methodology is sophisticated, his modeling inputs (i.e. assumptions) are based on outdated vehicle data from 1991, when cars were not certified to operate on E85 fuels.
- Unbalanced Life Cycle Approach: In estimating the full life cycle impacts of the respective fuels, the study completely ignores well-established life cycle analysis models, such as the U.S. Department of Energy's GREET model.

> "However, because of the uncertainty in future emission regulations, it can be concluded with confidence only that E85 is unlikely to improve air quality over future gasoline vehicles."
>
> " . . . [b]ecause both gasoline and E85 emission controls are likely to improve, it is unclear whether one could provide significantly more emission reduction than the other."
>
> - Mark Z. Jacobson, *Effects of Ethanol (E85) versus Gasoline Vehicles on Cancer and Mortality in the United States*

[1] Special thanks to Paul Wuebben of the South Coast Air Quality Management District (SCAQMD) and Dr. Gary Whitten of Smog Reyes, Inc. for providing valuable insight into the technical questions raised by the Jacobson report and air quality modeling in general. Neither individual has formally endorsed this summary document.

Conflicts with U.S. EPA Analysis and Other Agencies

E85 and other high blend ethanol/gasoline fuels warrant further analysis. However, Jacobson's study already stands in stark contrast to work done by U.S. EPA, the California Air Resources Board (ARB), the National Renewable Energy Lab (NREL) and the South Coast Air Quality Management District (SCAQMD). Consider, for example, the following table released by NREL:

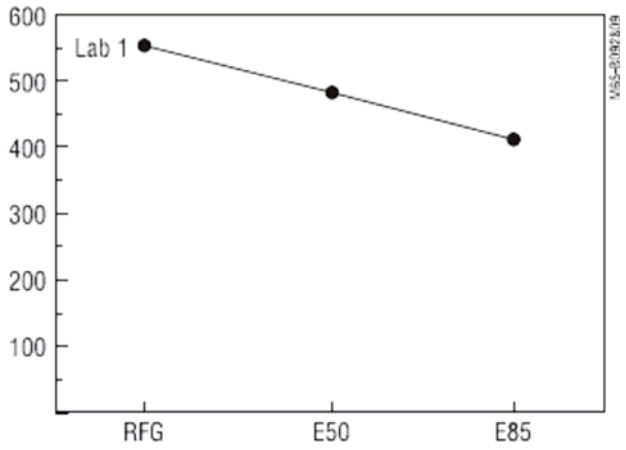


Figure 10: Lumina VFV Ozone Forming-Potential ($mg/O_3/mi$)

Fundamental Premise of Study Misleading

Professor Jacobson assumes that E85 will completely replace gasoline as the predominant motor fuel by 2020. Not even the most optimistic ethanol supporters suggest that this is possible; 1 percent of today's vehicles are E85 certified. While it may have been useful to model this scenario among many others, it is questionable from a public advocacy perspective to base definitive predictions about increased death rates on one highly uncertain and unlikely 2020 scenario.

Jacobson's Final Conclusions Extremely Uncertain

Air quality modelers generally do not attempt to forecast emissions more than a few years into the future, because of statistical and regulatory uncertainties. Professor Jacobson is clearly overreaching; trying to make definitive predictions where definitive data does not exist. His alarmist statements appear to conflict with the report itself, which states that, "*because of the uncertainty in future emission regulations, it can be concluded with confidence only that E85 is unlikely to improve air quality over future gasoline vehicles*."

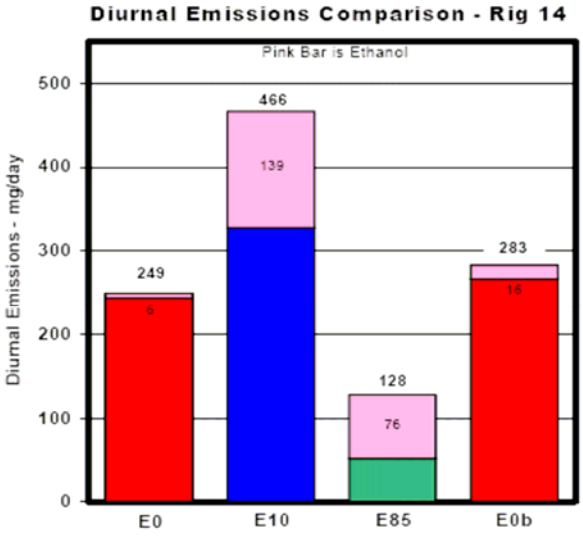
Core Assumptions Are Controversial & Not Well Supported

The main driver of Jacobson's ozone analysis is his assumption that E85 will reduce vehicle NOx emissions by ~ 30 percent, and that this NOx decrease will result in an ozone (smog) *increase*. Both of these foundational assumptions are highly controversial in the air quality community. With regard to the impact of E85 on vehicle emissions, a recent California Energy Commission (CEC) analysis concluded that, "*[a] review of the*

certified emission levels of 2005 FFV models sold in California reveals minor differences between the E85-versus-gasoline emissions of oxides of nitrogen (NOx), non-methane organic gases (NMOG) and carbon monoxide (CO), with very low emission levels of these pollutants on either fuel."[2] Regarding the impact of NOx on smog, SCAQMD modeling shows the value of mass NOx emissions reductions for smog control.

Ignores Critical Data

Professor Jacobson asserts that his emissions inventories are "high resolution." In fact, there are major questions about his assumptions. First, they are based on fuels that are now obsolete (MTBE blends). Second, the 2002 National Emissions Inventory database on which Jacobson bases many of his assumptions does not include recent data from ARB. Third, the study ignores "permeation" (evaporative hydrocarbon emissions) data recently released by the Coordinating Research Council (CRC). His assertion that E-85 vehicles *"increase non-methane hydrocarbons"* is therefore highly questionable.[3]



In addition, ARB test data for 2005 MY vehicles indicate that Flex Fuel Vehicles (FFVs) – vehicles actually certified to run on E85 – and gasoline vehicles both provide substantial compliance margins relative to NOx and NMOG:

Vehicle Model	Fuel	NOx (CA std.=0.14)	NMOG (CA std.=0.10)	CO (CA std. =3.4)
2005 Ford Taurus	E85	0.03	0.047	0.6
	Gasoline	0.02	0.049	0.9
2005 Mercedes-Benz C 240	E85	0.01	0.043	0.2
	Gasoline	0.04	0.028	0.3
Source: California Air Resources Board, On-Road New Vehicle and Engine Certification Program, Executive Orders; http://www.arb.ca.gov/msprog/onroad/cert/cert.php				

[2] *Tom McDonald, CEC, ISAF, 2005*
[3] CRC, 65-3 study, http://www.crcao.com/

Misrepresents Role of Acetaldehydes

Professor Jacobson assumes that acetaldehyde emissions will lead to an increase in PAN emissions that will in turn lead to greater ozone levels. This assumptions directly conflicts with ARB observations: *"Despite the acetaldehyde increase associated with higher ethanol blends, levels of PAN and its cousin, PPN are not predicted to vary … in 2003 [fuels] … PAN has dropped by a factor of 10 over the past 3 decades, apparently due to reductions in all hydrocarbons under California's ozone control program … Even in Brazil, where ethanol and acetaldehyde emissions are very high, these compounds are not the major contributors to PAN formation."*[4]

Suspect Toxics Analysis

It is well recognized that gasoline exhaust contains higher levels of benzene and 1,3 butadiene in comparison to E-85 exhaust, while E85 is generally associated with higher formaldehyde and acetaldehyde levels. Most experts have concluded that, because benzene and 1,3 butadiene are far more toxic than formaldehyde and acetaldehyde, gasoline emissions are more toxic to humans. Professor Jacobson utilizes a highly sophisticated modeling approach, but relies on 1991 vehicle data for establishing inputs to the model (there were virtually no cars certified for E85 use in 1991). The report also seems to ignore that formaldehyde emission rates from recent FFV certification results indicate that formaldehyde emissions from both gasoline and E-85 are well controlled by latest catalyst technology, and both fuel / technology combinations provide a substantial margin of compliance with ARB's strict 15 milligram per mile HCHO (formaldehyde) standard, as shown below:[5]

Mercedes FFV C 240 and C 320 2005 MY Certification *						
	NMOG (g/mi)		**NOx (g/mi)**		**HCHO (mg / mile)**	
	50K Cert.	**50k standard**	**50K Cert.**	**50k standard**	**50K Cert.**	**50k standard**
E-85	0.043	0.1	0.01	0.14	0.4	15
RFG2 (w / MTBE)	0.028	0.1	0.04	0.14	0.3	15
ARB Cert level	LEV / ULEV					
EPA Cert level	Bin 8					

Table Source: South Coast Air Quality Management District

Does Not Account for Vehicle Advancements

Professor Jacobson mentions but does not incorporate likely vehicle advancements into his analysis. Significant benefits could arise from optimized E-100 or E85 vehicles, which will be able to take advantage of unique properties of ethanol, such as its much higher latent heat of vaporization, which allows for cooler and denser and hence more efficient charge density in the combustion chamber. Leaner engine operation, coupled

[4] See California Air Resources Board, Proposed Phase 3 Gasoline Regulations, Final Statement of Reasons <http://www.arb.ca.gov/regact/carfg3/fsor.pdf>, p. 9-10.

[5] *Executive Order A-003-0287, March 12, 2004.*

with higher compression ratios, can also lead to further improvements in efficiency, as demonstrated in the Saab 9-3 and in SAE papers by Lotus.[6]

Ignores Climate Change Impacts

The Jacobson study completely dismisses the impact of climate change (and increased ambient temperatures) on public health and increased ozone formation. The "business as usual" approach (unmitigated petroleum consumption) is becoming an increasing threat to public health and the environment. There is no adjustment for this impact. Argonne National Laboratories estimates that E85 use could reduce greenhouse gas emissions from vehicles by 29 percent using today's ethanol production technology. New efficiencies and the development of cellulosic ethanol production could result in greenhouse gas reductions from E85 in the vicinity of 86 percent.

[6] "Alcohol-Based Fuels in High Performance Engines", SAE paper for 2007 Fuels and Lubes Meeting, paper offer 07SFL-105 [prepublication reference].